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16. ABSTRACT

Rest areas are a countermeasure for fatigue; what role do they play in fatigue-related freeway collisions? The present study spatially evaluates fatigue collisions.

In California, of 2,203,789 highway collisions recorded between 1995 and 2005, fatigue collisions accounted for 1.3% ('strict' definition of fatigue) and 9.7% ('expanded' definition). Collisions in the vicinity of rest areas were investigated using two different approaches:

1. 10-miles up/downstream of rest areas
2. Distance traveled from rest areas

Sample t-tests indicated that both fatigue and non-fatigue collisions decreased statistically significantly downstream of rest areas. Collisions due to fatigue tended to decrease immediately downstream of rest areas, then climbed after about 30 miles from rest areas, while non-fatigue collisions remained the same. Binomial tests confirmed that the percentage of fatigue collisions further than 30 miles from rest areas was significantly higher.

The study also compared ramps at rest areas to other ramps and found that trucks were the primary vehicle type involved in rest area ramp collisions. 'Parked, parking' movements caused the highest number of collisions on ramps at rest areas, compared with 'proceeding straight' movements for other ramps. The comparison revealed that some rest areas had too few parking spots.

Finally, the study explored the growth of *informal rest areas:* shoulders frequented by truck drivers when other safe stopping opportunities do not exist. The study analyzed collision rates at informal rest area ramps and determined that the rates were higher, on average, than at other ramps. Analysis of fatigue related collisions adjacent to informal rest areas provided mixed results regarding the efficacy of informal rest areas in reducing highway collisions. However, higher incidence of fatigue-related collisions at these locations supports the need for additional rest areas.

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Rest Areas – Reducing Accidents Involving Driver Fatigue

Ipsita Banerjee, Joon ho Lee, Kitae Jang, Swati Pande, David Ragland

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Rest Areas

Reducing Accidents Involving Driver Fatigue

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Ipsita Banerjee, Joon ho Lee, Kitae Jang,
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Caltrans
Traffic Safety Center
Setting New Directions in Traffic Safety
CALIFORNIA PATH

Rest Areas, Reducing Accidents Involving Driver Fatigue

The mission of the UC Berkeley Traffic Safety Center is to reduce traffic fatalities and injuries through multi-disciplinary collaboration in education, research and outreach. Our aim is to strengthen the capability of state, county, and local governments, academic institutions and local community organizations to enhance traffic safety through research, curriculum and material development, outreach and training for professionals and students.

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May 11, 2009

Rest Areas
Reducing Accidents Involving Driver Fatigue

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Under sponsorship from Caltrans and California PATH

Caltrans

Traffic Safety Center
Setting New Directions in Traffic Safety

CALIFORNIA PATH

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TABLE OF CONTENTS

FIGURES

TABLES

1. EXECUTIVE SUMMARY

Though there have been numerous studies regarding the effect of fatigue on traffic collisions, there is still little empirical understanding of how rest areas, which are a countermeasure for fatigue, play a role in fatigue-related freeway collisions. The present study evaluates fatigue collisions from a spatial perspective in an attempt to understand the relationship between rest areas and fatigue collisions.

The study first summarized the general characteristics of fatigue-related collisions. Out of 2,203,789 total collisions occurring between 1995 and 2005, fatigue collisions accounted for more than 1.3% (using a 'strict' definition of fatigue) and 9.7% (using an 'expanded' definition) of total collisions in California. Both fatigue and non-fatigue collisions in the vicinity of rest areas in California were then investigated using two different approaches:

1. Spatial analysis on collisions within 10-miles up/downstream of rest areas
2. Spatial analysis on collisions as a function of distance traveled from rest areas

The findings generated from two sample t-tests indicated that the number of both fatigue and non-fatigue collisions decreased statistically significantly downstream of rest areas. It was also found that the number of collisions due to fatigue tended to decrease immediately downstream of rest areas, while suddenly increasing after about 30 miles from rest areas, while non-fatigue collisions remained the same. Two sample binomial tests confirmed that the percentage of fatigue collisions further than 30 miles from rest areas was significantly higher than for collisions 30 miles or less from rest areas. This phenomenon is consistent with a possible assumption that drivers become significantly exhausted about 30 miles downstream of rest areas.

Safety Roadside Rest Area Exit Sign

The study also explored all collision factors for collisions occurring in the vicinity of rest areas and their ramps, and compared them with collision characteristics from collisions occurring in the vicinity of ramps *not* associated with rest areas. The comparison revealed that trucks were the primary vehicle type involved in rest area ramp collisions. 'Parked, parking' movements caused the highest number of collisions on ramps connected to rest areas, compared with 'proceeding straight' movements for all other ramps. The comparison also revealed that some rest areas had an inadequate number of parking spots, resulting in unsanctioned ramp parking activities.

Finally, the study explored the growth of *informal rest areas:* shoulders adjacent to ramps and mainlines frequented by truck drivers when other safe stopping opportunities do not exist. The study analyzed collision rates at informal rest area ramps and determined that the rates were higher, on average, than collision rates at designated rest area ramps or ramps unaffiliated with rest areas. These findings suggest that, on average, informal rest area ramps are less safe compared with other ramps. Analysis of fatigue-related collisions adjacent to informal rest areas provided mixed results regarding the efficacy of informal rest areas in reducing highway collisions. However, the higher incidence of fatigue-related collisions at these locations supports the need for additional rest areas.

2. INTRODUCTION

This study seeks to improve traffic safety and mobility for California highway users by analyzing characteristics of fatigue-related crashes. The potential for risk reduction is substantial. Not only do these crashes tend to be more severe, they are also likely to be underreported. Each fatality crash costs millions of dollars. Even a modest reduction in such collisions would result in large savings and improved highway safety.

In addition, fatigue-related collisions have a major economic impact. For example, there have been occurrences of commercial-vehicle fatigue collisions destroying bridges over interstate highways, causing major disruption to the transportation system and to the economy. Fatigue-related bus crashes have been catastrophic. These crashes capture the interest of the public, requiring an inordinate proportion of limited resources to address their aftermaths. Successful measures to prevent them or to minimize their impact will substantially decrease these undesirable costs.

Fatigue-related crashes are particularly hazardous in highway work zones, where Caltrans, highway patrol, and contract employees are particularly vulnerable.

This study attempts to provide more accurate estimates of fatigue-related collision rates and the efficacy of rest areas in reducing the risk of crashes related to driver fatigue.

Shoulder Downstream of Closed Rest Area

Chapter 3 of this report discusses previous efforts to determine the relationship between fatigue and traffic collisions. Chapter 4 explains the ‘strict’ and ‘expanded’ definitions of fatigue used in the present study. Chapter 5 summarizes general characteristics of fatigue-related collisions. Chapter 6 presents a spatial analysis of collisions within 10 miles up/downstream of rest areas, and is followed in Chapter 7 by a spatial analysis of collisions as a function of distance from rest areas. Chapters 8, 9, and 10 respectively discuss the effect of rest area closures on fatigue related accidents, fatigue ramp analysis, and informal truck stops. The report ends with concluding remarks in Chapter 11.

Note that this report summarizes the key findings of the present study regarding fatigue collisions; the results from additional detailed analyses can be found in the appendices.

3. LITERATURE REVIEW

3.1 Introduction

Generally, sleep is a neurobiological activity with predictable patterns. Disruption of these patterns, especially the circadian processes (24-hour rhythms that control our sleep/wake cycles), sleep fragmentation, or sleep restriction and loss can result in a diminished capacity to perform everyday tasks such as driving, via impairments to reaction time, vigilance, attention, and information processing (NCSDR/NHTSA). In the extreme, it can also lead to drivers falling asleep while behind the wheel. The National Highway Traffic Safety Administration (NHTSA) makes the distinction between "fatigue" and "inattention," in which fatigue is defined as a "disinclination to continue" a particular task; in the case of driving, it is not so much disinclination to driving as it is a "progressive withdrawal of attention to the tasks required for safe driving." This is characterized as inattention, which is a product of fatigue and other factors such as "preoccupation or distractions inside the vehicle" (NCSDR/NHTSA).

To better understand the problems associated with fatigue, the study included a review of the relevant literature using online literature research databases including *ScienceDirect, PubMed*, and *TRIS Online* (Transportation Research Information Services). For the purpose of the review, references have been divided into five main categories, with the number of references shown in parentheses:

1. Characteristics and magnitude of fatigue-related crashes (43)
2. Effect of fatigue on performance (7)
3. Causes of fatigue (18)
4. Countermeasures (29)
5. Effect of rest areas on fatigue & necessary characteristics of rest areas (50)

3.2 Characteristics and Magnitude of Fatigue-Related Collisions

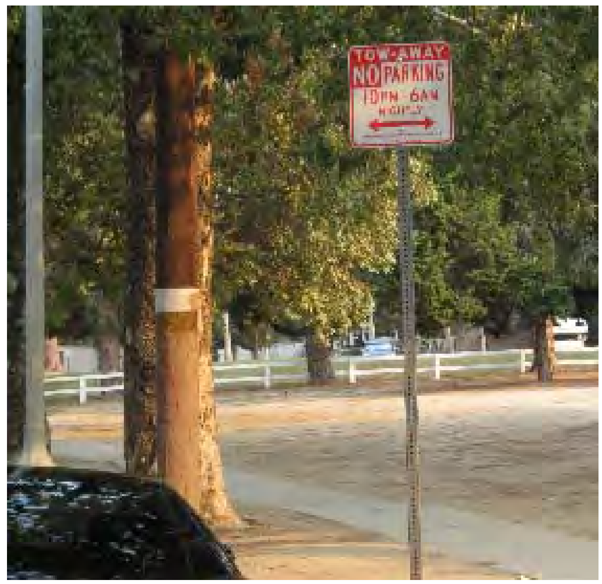
The National Sleep Foundation's 2005 *Sleep in America* poll reported that 60% of adult drivers—about 168 million people—said they had driven a vehicle while feeling drowsy in the past year, and more than one-third had actually fallen asleep at the wheel.

Rajaratnam and Jones (2004) contend that sleepiness is now regarded as the largest identifiable and preventable cause of accidents in all modes of transportation. Many articles reveal that fatigue-caused collisions result in higher injury and death rates (e.g., Bunn et al. 2005, Connor et al. 2002. and Garbarino et al. 2001).

The magnitude of fatigue-related collisions may be severely underestimated because it is difficult to objectively measure the role that fatigue plays in any particular traffic collision. Identifying fatigue-related crashes is also made difficult by the "absence of a universally accepted definition of fatigue" (Dobbie 2002).

The exact definition of a fatigue-related crash is subjective and can vary in different jurisdictions; certain characteristics are identified as contributors to fatigue-related collisions. According to the NHTSA website, an archetypical collision related to sleepiness has the following characteristics:

- The problem occurs during late night/early morning or mid afternoon.
- The crash is likely to be serious.
- A single vehicle leaves the roadway.
- The crash occurs on a high-speed road.
- The driver does not attempt to avoid a crash.
- The driver is alone in the vehicle.



Local Parking Restrictions Limit Options

Other researchers support the validity of some of these characteristics. Horne noted that most single-vehicle crashes occurred without any prior braking, and that their highest incidence occurred between 2:00 a.m. and 6:00 a.m. and between 2:00 p.m. and 4:00 p.m. (Horne 1995). Similarly, Sagberg used a regression model to determine that the "strongest predictor variable" is the time at which a collision occurred, and that "the odds of fatigue or sleep being involved increases by a factor of six" if the collision occurred between midnight and 6:00 a.m. (Sagberg, 1999). Australian researchers developed their own operational definition of fatigue, identifying fatigue-related crashes as occurring in "head-on collisions where neither vehicle was overtaking at the time of the crash," and during what they called the "critical times" of midnight to 6:00 a.m. and 2:00 p.m. to 4:00 p.m. (Dobbie 2002).

3.3 Effect of Fatigue on Performance

In their report about the effects of sleep deprivation among physicians, Weinger and Ancoli-Israel (2002) reported on two meta-analyses that summarize the cognitive performance effects of one or more nights of reduced sleep. In general, "the studies suggest that sleep-deprived subjects performed 1.4 standard deviations below that of controls. Sleep deprivation had the greatest impact on mood and cognitive tasks and less, but still significant, impact on motor tasks."

A study by Fairclough and Graham (1999) assessing the relative impact of partial sleep deprivation and full sleep deprivation on a two-hour simulated driving test compared with an alcohol impairment (BAC = 0.07%) revealed that "the full sleep deprivation and alcohol group exhibited a safety-critical decline in lane-keeping performance. The partial sleep deprivation group exhibited only non-critical alterations in primary task performance."

For a study of 114 drivers (half over the age of 30, and half under) who stopped at a rest area on a freeway, participants completed a questionnaire about their journey and their sleep/wake patterns. They then performed a 30-minute test on a driving simulator. The results showed that fatigued drivers performed significantly worse than controls on the driving test. Age and duration of driving were the main factors associated with decreased performance (Philip, Taillard et al. 2003).

3.4 Causes of Fatigue

While the overriding cause of driver fatigue is sleep loss, NHTSA lists a number of chronic predisposing factors and acute situational factors that increase the risk of drowsy driving and related crashes:

- *Driving patterns*, including: driving between midnight and 6 a.m.; driving a substantial number of miles each year and/or a substantial number of hours each day; driving in the mid-afternoon hours (especially for older persons); and driving for long times without taking a break.
- *Use of sedating medications*, especially prescribed anxiolytics, hypnotics, tricyclic antidepressants, and some antihistamines.
- *Untreated or unrecognized sleep disorders*, especially sleep apnea syndrome (SAS) and narcolepsy.
- *Consumption of alcohol*, which interacts with and adds to drowsiness.

Stutts, Wilkins, et al. (2003) report that, “drivers in sleep-related crashes were more likely to work multiple jobs, night shifts, or other unusual work schedules. They averaged fewer hours of sleep per night, reported poorer quality sleep, were less likely to feel they got enough sleep, were sleepier during the day, drove more often late at night, and had more prior instances of drowsy driving. Compared with drivers in non-sleep-related crashes, they had been driving for longer periods of time, had been awake more hours, and had slept fewer hours the night before.” These findings are echoed by a number of other authors, including Streff and Spradlin (2000), Brill et al. (2003), and Brown (1994).

Many drivers violate work-hour rules. Federal regulations allow commercial drivers to drive a maximum of ten hours before requiring an eight-hour period of rest. In addition, drivers are not allowed to work for more than 70 hours in an eight-day period. In a 1992 study by Braver et al., nearly three-quarters of the drivers surveyed said they violated the “hours-of-service” rule and about two-thirds admitted to exceeding the 70-hour limit permitted under regulations. Braver identified economic factors as the primary reason for violation of these rules, citing factors including but not limited to “tight delivery schedules and low payment rates.” (Braver et al. 1992)

3.5 Countermeasures

Many drivers in fatigue-related accidents are unaware of their fatigue at the time of collision. There are several categories of countermeasures found in driver fatigue literature including education, regulation of commercial driving hours, technology, and—the most obvious countermeasure—sufficient rest. While techniques such as exposure to cold air, turning on the radio, and eating are popular, they are only effective—at best—for a short time (Horne and Reyner 1999). Two countermeasures that have been shown to be effective are consumption of caffeine and taking a short nap (De Valck and Cluydts 2001, Garbarino et al. 2004).

The Rest Area Forum (1999) stressed education as an important means of addressing driver fatigue. Most focus groups concluded that additional fatigue studies need to be conducted, with results "targeted to receivers, shippers, carriers, insurance companies and drivers." While some drivers stated that there is a real shortage of parking at rest areas, others responded that drivers are not adequately notified or informed of truck parking at rest areas. The forum found that some drivers "miss stops entirely." Consequently, improving signage for rest areas was one of the most popular recommendations, using such methods as "corridor signage, ITS technology displaying real-time information, uniform logo signage, uniform lists and maps of truck rest areas, and a radio channel/national information line" to provide information (FHWA 1999).

Closed Safety Roadside Rest Area

The California Department of Transportation recognized the need to develop a plan to maintain and expand its network of eighty-eight roadside rest areas initially created beginning in 1962. In 2002, the California Department of Transportation Journal released a *Master Plan for Safety Roadside Rest Areas* to "guide their renovation and upgrading and for adding new [rest areas] where feasible." The study recommended constructing eighty new rest areas in addition to creating "prime goals" for rest areas including increased safety, security, aesthetics, access, and opportunities for development (Berthelsen, 2002).

Brown (1997) noted that while there are several reasons for giving serious consideration to technological countermeasures, "their reliability under real traffic conditions is largely unproven and they could be used by unscrupulous drivers to support the continuation of journeys that should have been terminated because of human impairment."

Horne and Reyner in their 1999 study concurred, stating that "the only safe countermeasure to driver sleepiness, particularly when the driver reaches the stage of fighting sleep, is to stop driving, and—for example, take a 30 minute break encompassing a short (< 15 minute) nap or coffee (about 150 mg caffeine), which are very effective particularly if taken together. Exercise is of little use." It has also been shown that a 15-20 minute nap is the "most effective way of rejuvenating" a driver (Garder *2002*).

As early as 1979, a study by Clark recommended that a driver sit comfortably because "an incorrect posture can restrict oxygen intake." He also recommended ten-minute stops every hour, checking "vehicle instruments [to] mark the time," and that "companionship is the best solution for boredom." (Clark 1979).

3.6 Effect of Rest Areas on Fatigue & Necessary Rest Area Characteristics

As discussed above, one of the factors identified by NHTSA as increasing the risk of drowsy driving and related crashes is driving for a long period without taking a break. Rest areas were created as early as 1919 on state and interstate highways as a means of providing motorists with a place to rest without having to leave the highway (King 1989). However, often rest areas are closed for maintenance or—during severe weather conditions—filled to capacity with other motorists. As a result, some truck drivers must resort to finding another location at which to park and rest, or must continue driving without rest.

A 1996 study of public rest areas conducted by the Federal Highway Administration (FHWA) identified a shortfall of over 28,000 truck parking spaces across the country. Surveys of commercial drivers found that "90%…perceived that there is a shortage of truck parking facilities, particularly for long-term or overnight parking." A majority of those surveyed also preferred private truck stops for long-term or overnight stops, while for short-term parking, a majority preferred public rest areas. The report noted, however, that while private expansion of truck parking spaces may help ease the tight squeeze on parking, public and private rest areas are not necessarily "direct substitutes for each other," but are "complementary." The FHWA study added that the cost of providing enough parking for truck drivers could range from "$489 to $629 million dollars," and that failing to "solve the truck parking shortage could pose significant risks to the traveling public by forcing tired drivers to continue driving, or park in inherently dangerous locations such as ramps and shoulders." (FHWA 1996) This claim was supported by a 1996 study by the American Trucking Association, which found evidence that "increasingly, truck drivers seeking rest are parking illegally along highway shoulders and entrance and exit ramps, rather than at either public rest areas or private truck stops." (ATA 1996)

In June 1999, the Rest Area Forum was held in Atlanta, Georgia to discuss the "availability and safety of parking for commercial vehicles." Discussion included the issue of instituting time limits at rest areas. Those in favor of time limits argued that allowing truck drivers to stay in their parking spaces for as long as they wanted would reduce turnover and force drivers who could not find adequate parking spaces to park unsafely on the side of the highway or continue driving to the next rest area, increasing the possibility of a fatigue-related collision. Those opposed to time limits argued that imposing time limits on drivers would interrupt critical sleeping times. Stakeholders also stated that elected officials sometimes introduce city ordinances that limit the time window during which truck deliveries can take place. These policies, along with shippers requiring prompt or quick deliveries "impose unreasonable delivery schedules" that may contribute to fatigue-related collisions (FHWA 1999).

Additional research has identified inconsistent spacing between rest areas. The Montana Rest Area Plan noted that rest areas were built alongside highways while the highways were being constructed, but ranged anywhere between twenty and eighty miles apart.

A Michigan State University study (1999) found a correlation between rest area distances and the rate of single-vehicle collisions. While the study focused on the public rest areas commonly found on interstate routes (compared with U.S. and state highways, which feature many private truck stops) and did not confirm a causal relationship in the findings, the study did find that "the greater the distance between rest areas, the higher the percentage of single vehicle truck crashes." The research team created a 'hazard model with a conditional probability format' that found a "significant" increase in single vehicle truck collisions once the distance between rest areas exceeded 30 miles. Moreover, most single vehicle truck collisions occurred between the hours of midnight and 8:00 a.m., which is when truck rest areas are used heavily and "when truck driver fatigue would most likely be a contributing factor" (Taylor 1999).

Truck Parked on the Side of the Highway

Other studies have also identified problems correlating truck rest areas and fatigue. In a survey of truck drivers in New York in 1997, about four-fifths of respondents said that they were not able to find parking at night; many of these drivers admitted to falling asleep at the wheel. When asked why they did not use public rest areas, slightly over half of respondents cited inadequate parking, and others mentioned time limit enforcements, prostitution, solicitation, lack of security, and poor quality or expensive food (Koklanaris 2000). Fatigue was also voted the number one concern at the FHWA Truck and Bus Safety Summit held in 1995 (Graham 1998).

In 2002, a study by Chen, et al. analyzed the needs and preferences of truck drivers. The survey of over two thousand drivers sought to "determine how truck drivers plan for and address their parking needs and how truck drivers select when, where, and at which facilities they park." Many of the self-identified "long-haul drivers" stated that they preferred rest areas that "provide food, fuel, restrooms, phones, and showers." Moreover, safety and convenience were also considered important factors. Drivers tended to favor private rest areas over public rest areas except when the drivers needed to nap for a short period of time (Chen et al. 2002).

The optimal distance between rest areas has been a subject of debate. The Rest Area Forum recommended adopting a "uniform spacing standard" for rest areas. The Montana Rest Area Plan (WTI 1999) states that in 1985 Montana identified 70 miles as the target spacing on roadways with over 750 vehicles per day or 100 miles on roadways with over 1000 vehicles a day, but Montana currently recommends a spacing of 54 miles, or the length of one hour of travel time. The Minnesota DOT identified a spacing of 50 miles as "desirable." The American Association of Highway and Transportation Officials recommend a distance of 60 miles between rest areas (Perrault 2008).[1] This is similar to the findings from Garder's study of truck drivers, which determined that a distance of 55 miles would be ideal. However, a University of Maine study claimed the distance covered in one hour is too long, and recommended a 30-mile spacing between stops (Garder 2002).

There is also debate regarding the elimination of rest areas as a cost-saving measure. Over 50% of Garder's survey participants stated that saving money should not be accomplished by closing down existing rest areas. However, younger surveyed travelers approved of closing some rest areas, as long as the money saved from closing them was reinvested into the improvement of remaining rest areas (Garder 2002).

A detailed examination of rest areas could be a critical component in efforts to reduce traffic collisions or other crashes that occur as a result of driver fatigue. As noted earlier, drowsy driving and related crashes may be a result of driving for long periods of time without resting. Commercial truck drivers who drive hundreds of miles daily often fall into this category. Many existing studies have identified inadequate parking and resting facilities for drivers, as well as a correlation between single vehicle collisions and the distance between rest areas, as issues that need to be addressed. Creating a strategy or plan for supplying additional parking via expansion or improvement of the rest area network will add to this body of research and could be crucial in improving the safety of all drivers.

A detailed annotated bibliography is included in Appendix 1.

The following chapter explains the definitions of fatigue collisions used in the present study.

[1] Perrault, Michael. "Yucaipa plan for I-10 rest area gets Calimesa's attention." *The Press Enterprise.* January 5, 2008.

4. DEFINITIONS OF FATIGUE COLLISIONS

Collision data were extracted from the California Highway Patrol's (CHP) Statewide Integrated Traffic Records System (SWITRS). From this database, collisions associated with driver fatigue were selected based on two different definitions: "strict" and "expanded" fatigue collisions. For the strict definition, only those collisions coded as 'fatigue-related' or those in which the party was coded as 'sleepy/fatigued' were identified as fatigue-related. The expanded definition, however, also includes all collisions in which the party was at fault, but was not drunk or speeding, experienced no vehicle defect, and either ran off the road, crossed into an opposing lane or struck anothervehicle/fixed object between the hours of 2 a.m. and 6 a.m. or 2 p.m. and 4 p.m. Note that the datasets defined here are used in the analyses presented in chapters 5, 6, and 7.

4.1 Strict Definition Fatigue Collisions

Strict definition fatigue collisions are those that satisfy either one of the following criteria:

- Primary collision factor is reported as "fell asleep"
- Party type indicates a driver was fatigued

The party information in the second criterion is obtained from the SWITRS party table. The variable specifically considered is "pdrug" or Party Drug Physical. This variable indicates the physical state of the persons involved in the collision; whether they were influenced by drugs other than alcohol, had any physical impairment, or were sleepy or fatigued. A value of 'I' indicates that the party involved in the collision was sleepy or fatigued.

4.2 Expanded Definition Fatigue Collisions

The expanded definition of fatigue collisions includes those in which the party was at fault, was not drunk or speeding, experienced no vehicle defect, and either ran off the road, crossed into an opposing lane or struck another vehicle/fixed object between the hours of 2 a.m. and 6 a.m. or 2 p.m. and 4 p.m. According to previous research,[2] underreported fatigue collisions have a set of common features:

- Single vehicle collision
- Driver at fault, driver not intoxicated or speeding
- No defect in vehicle
- Vehicle either crossed into opposing lane or ran off road preceding the collision
- The vehicle struck another moving or parked vehicle

[2] Horne, J. A. and L. A. Reyner (1995). "Sleep related vehicle accidents." Bmj **310**(6979): 565-7.
Sagberg, F. (1999). "Road accidents caused by drivers falling asleep." Accid Anal Prev **31**(6): 639-49.
Dobbie, K. (2002). Fatigue-Related Crashes: An Analysis of Fatigue-Related Crashes on Australian Roads Using an Operational Definition of Fatigue. A. T. S. Bureau, Commonwealth Department of Transport and Regional Services**:** 1-30.

Analyses of both the strict and expanded definitions of fatigue collisions were conducted for this study, in order to verify and account for previous findings indicating that fatigue collisions are underreported.

Table 1 summarizes the SWITRS variables used to identify fatigue collisions. The collision and party variables indicated in the table were examined and identified using a 'flag.' If the at fault party was found to be sleepy or fatigued, or if the primary collision factor was driver fatigue, the variable fatigue_flag1 was set to 1, if not it was set to 0. If a collision record satisfied all of the variables (other than primary collision factor = E and party drug physical = I), the collision was identified as potentially being a fatigue collision. For example, a single-vehicle collision in which the driver was at fault and was not intoxicated, there were no unusual weather or road conditions, the vehicle ran off the road or into an opposing lane, and in which the collision occurred either between 2 a.m. and 4 a.m. or 2 p.m. and 4 p.m. was identified as potentially being a fatigue collision.

Table 1. SWITRS Variables Used in Defining Fatigue Collisions

	Condition	SWITRS variable = value	Fatigue Definition
1	Primary Collision Factor	PCF = E (sleepy or fatigued)	IF 1 OR 2 = Strict Definition of Fatigue
2	Party Drug Physical	Pdrug = I (sleepy or fatigued)	
3	Weather Normal	Weather1 = A (clear)	Strict Definition of Fatigue OR (IF 3 AND 4 AND 5 AND 6 AND 7 AND 8 AND 9 AND 10) = Expanded Definition of Fatigue
4	Road Condition Normal	Rdcond1 = H (no unusual condition)	
5	Driver at Fault	Ptype = 1 at fault = Y	
6	Party Violation	Pviolcat NOT = 20 or 25 20: Driving or Bicycling Under the Influence of Alcohol or Drug 25: Unsafe Speed	
7	Other Associated Factor	Oaf1 NOT = K (vehicle defect)	
8	Motor Vehicle Involved in Collision	Involve = C, D, E, I or J C - Other Motor Vehicle D - Motor Vehicle on Other Roadway E - Parked Motor Vehicle I – Fixed Object	
9	Movement of Vehicle Preceding Collision	C - Ran Off Road N - Crossed Into Opposing Lane	
10	Time of Collision	2 a.m. to 4 a.m. OR 2 p.m. to 4 p.m.	

5. STATEWIDE FATIGUE-COLLISION ANALYSIS

Collision data for the eleven years between 1995 and 2005 were analyzed to find patterns in fatigue-related crashes. The data included crash severity, alcohol involvement, urbanicity, and yearly, monthly, and daily trends. For each of these analyses, fatigue-related collisions were identified following both the 'strict definition' and the 'expanded definition.'

A total of 2,203,789 casualty collisions were observed over the eleven-year period. According to the strict definition, 1.3% of these were classified as fatigue-related; while according to the expanded definition, 9.7% were classified fatigue-related. Of all the observed collisions, 1.7% were fatal, 5.4% involved major injury and 92.9% involved minor injury. Among fatigue-related collisions according to the strict definition, 2.7% were fatal, 9.0% involved major injury, and 88% involved minor injury. Thus, a greater percentage of fatigue-related collisions were fatal or involved major injuries compared with total crashes. However, when fatigue-related crashes were identified using the expanded definition, 1.9% were fatal, 5.4% involved major injury and 92.9% involved minor injury, approximating the overall percentages by severity for all crashes. Summarized crash severity data are listed in Appendix 2.

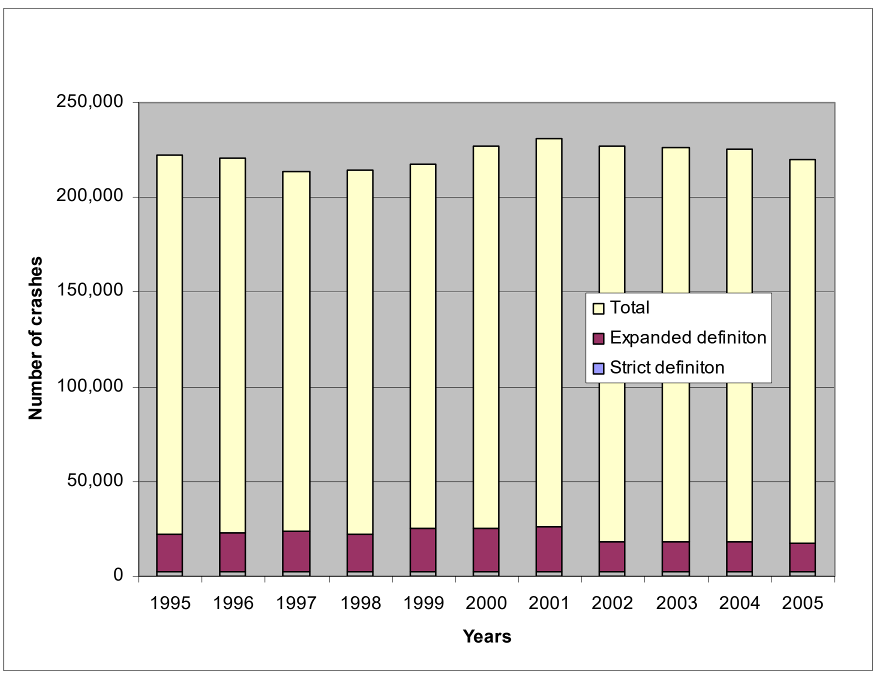


Figure 1. Trends in Collision Statistics, Overall and Fatigue-Related

Figure 1 shows trends in collisions for each year. The total number of collisions decreased in 1997 and then increased until 2001. After 2001, there was another progressive reduction. Between 1995 and 2001 fatigue-related collisions comprised a higher percentage of overall collisions. Since 2002, the proportion of fatigue-related collisions has declined, by 0.1 to 0.2% using the strict definition, and by 2.0 to 4.0% using the expanded definition. Coding methods may have changed in 2001.

The following subsections summarize the characteristics of fatigue-related collisions for each definition (strict and expanded). All tables referenced in this section, as well as more detailed information based on the expanded definition, can be found in Appendix 2.

Number of Collisions by Month

Using the strict definition, the number of fatigue-related collisions is highest during the summer months (June through August) and lowest in the winter months of January and February. The number of collisions remains high in late summer and early fall, i.e., August through October (198,789 in October) and is also high in the month of December. Furthermore, fatigue contributes to a higher percentage of collisions in the summer months than in the winter months (Table A2.5).

Using the expanded definition, the largest number of fatigue-related collisions occurs from July to October. These are also the months in which fatigue contributes the most to collisions. The lowest number of collisions occurs in January and February, and fatigue contributes the least to collisions during these months compared with all other months (Table A2.6).

Number of Collisions by Day of the Week

The total number of collisions on a given day of the week totaled over the eleven years ranged from 264,149 to 361,744. Fridays registered a higher number of crashes (361,744), and Sundays a lower number (264,149). However, fatigue contributed the least to collisions on Fridays (1.0%), and the most on Sundays (1.9%), following the strict definition. Saturdays also registered a high percentage (1.6%) of fatigue-related collisions (Table A2.7).

Fatigue-related collisions according to the expanded definition contributed to a higher percentage of all collisions on Saturdays (10.4%) and Sundays (11.3%) (Table A2.8).

Number of Collisions by Hour of the Day

Whereas the majority of collisions took place between 7 a.m. and 7 p.m., these were the hours during which fatigue contributed the least, from 0.4% to 0.9% following both the strict and the expanded definition. One exception under the expanded definition was during the two hours after 2 p.m., in which a very high percentage (43.0% to 43.2%) of the collisions were fatigue-related (Table A2.9). This is in the range of rates observed during the peak of fatigue-related collisions, between 2 a.m. and 6 a.m.

Using the strict definition, peak hours for fatigue-related collisions were between 3 a.m. and 6 a.m. (Table A2.10).

Primary Collision Factor

The most common primary collision factor for all observed crashes was unsafe speed, followed by factors involving automobile right-of-way, and improper turning. Confusion related to traffic signals and signs, and driving under the influence of alcohol or drugs were the next major factors. The highest number of fatigue-related collisions (strict definition) resulted from improper turning, followed by unsafe speed and driving on the wrong side of the road. Among these collision causes, fatigue (strict definition) contributed the most (2.9%) in collisions due to improper turning, followed by driving on the wrong side of the road (Table A2.11).

Under the expanded definition, the greatest number of fatigue-related collisions resulted from unsafe speed, followed by factors related to automobile right-of-way and improper turning. Of the total number of collisions for each category, fatigue was a contributing factor most often for collisions due to improper turning (13.8%), following too closely (10.5%), driving or bicycling under the influence of drugs or alcohol (10.4%) and unsafe speed (10.1%) (Table A2.12).

Truck Collisions
Truck collisions constituted 4.4% of the total number of collisions. Fatigue (strict definition) contributed to a higher percentage (1.9%) of truck collisions than to collisions of all vehicle types (1.3%) (Table A2.13).

According to the expanded definition, fatigue contributed to 11.3% of truck collisions compared with 9.7% of collisions of all vehicle types (Table A2.14).

Alcohol Involvement
Of all collisions, 10.9% involved alcohol. However, fatigue (strict definition) was a contributing factor in only 0.9% of alcohol-involved collisions, compared with 1.3% of all collision types (Table A2.15).

Following the expanded definition however, fatigue-related collisions contributed to 9.8% of alcohol–involved collisions compared with 9.7% for all collisions (Table A2.16).

Urbanicity
Of all collisions, 22.1% were rural. Fatigue (strict definition) contributed to more than twice the percentage (2.8%) of rural collisions than to all collisions (1.3%) (Table A2.17).

Similarly, following the expanded definition, fatigue contributed to 12.0% of rural collisions and to 9.7% of all collisions (Table A2.18).

State Highway Status
Of all collisions in which the highway status was known, 31.1% were on state highways. Fatigue (strict definition) contributed to a much higher number of collisions on state highways (2.2%) than to collisions overall (1.3%) (Table A2.19).

Fatigue contributed to a higher number of collisions on state highway (11.2%) than to collisions overall (9.7%) under the expanded definition as well. (Table A2.20).

Fatigued Party Culpability
In fatigue-related collisions of known culpability, 88.0% of the fatigued parties (strict definition) were found to be at fault (Table A2.21. Using the expanded definition, 98.9% of the fatigued parties were found to be at fault (Table A2.22).

Fatigued Party Road User Type
Using the strict definition, the fatigued party in 99.5% of the collisions was the driver, while only very rarely was the fatigued party a pedestrian or bicyclist (Table A2.23). Under the expanded definition, the fatigued party in 99.9% of the collisions was the driver (Table A2.24).

Fatigued Party Age
Drivers 15 to 24 years of age constituted the largest share (39.0%) of fatigued parties in fatigue-related collisions (strict definition). This was followed by drivers aged 25 to 34 (21.6%), aged 35 to 44 (15.4%), and aged 45 to 54 (10.4%). The rate continued to drop with age (Table A2.25). The same pattern was observed for fatigue-related collisions under the expanded definition. Drivers aged 15 to 24 years constituted 30.5% of fatigued parties in collisions, and the rate again decreased with each increasing age cohort (Table A2.26).

Fatigued Party Race
Race was not stated for a majority of fatigue-related collisions (68.7% in the strict definition case and 64.5% in the expanded definition case). Of the drivers whose race was known, 50.6% were white and 27.6% were Hispanic, when the strict definition was applied (Table A2.27). Under the expanded definition, 48.3% were white and 31.9% were Hispanic (Table A2.28).

Fatigued Party Sobriety
The sobriety of the driver was not known for 34.9% of the strict fatigue-related collisions. The percentage was much lower (4.9%) under the expanded definition, since this category included collisions in which the party was 'not drunk.' Under the strict definition, 88.3% of the fatigued parties of known sobriety had not been drinking, while only 4.8% had been drinking and were under the influence (Table A2.29). Under the expanded definition, 82.2% had not been drinking, while only 7.3% had been drinking and were under the influence (Table A2.30).

Restraint Use
Applying the strict definition, restraints were used in 91.0% of fatigue-related collisions (Table A2.31). Under the expanded definition this percentage was 94.6% (Table A2.32).

Fatigued Party Violation
The occurrence of a violation was known for approximately one-fourth of fatigue-related collisions. Of the known violations under the strict definition, 45.1% were due to improper turning, 23.5% to driving at an unsafe speed, and 18.8% were due to driving on the wrong side of road (Table A2.33). Using the expanded definition, 45.6% were due to

improper turning, 15.8% to driving on the wrong side of the road, and 6.3% to an unsafe lane change (Table A2.34).

Fatigued Party Preceding Movement

Under the strict definition, 41.6% of the fatigued parties ran off the road, while 37.3% were proceeding straight prior to the collision (Table A2.35). Using the expanded definition, 49.6% were proceeding straight prior to collision, 15.1% were making a left turn, and only 10.8% ran off the road (Table A2.36).

Fatigued Party Vehicle

Using the strict definition, 71.2% of the vehicles involved in fatigue-related collisions were passenger vehicles; under the expanded definition, the rate was 70.5%. Pickup or panel trucks comprised 21.3% (strict definition) and 18.8% (expanded definition) of the vehicles. (Table A2.37, Table A2.38).

6. SPATIAL ANALYSIS — WITHIN ±10 MILES OF REST AREAS

The spatial analysis presented here studied collision rates within 10 miles upstream and downstream of rest areas in both directions of I-5 (from Kern county to the Oregon border). The same spatial analysis was performed on collisions in both directions of SR-101. A total of 23 rest areas were included in the analysis, and results are presented in the appendix. Fatigue-related and non-fatigue-related collisions were compared in the analysis, excluding collisions that were Property-Damage-Only (PDO).

Detailed information regarding location, direction, county and postmile of rest areas on I-5 was extracted from multiple sources including the Caltrans website, TASAS geometry database, and CalNexus. Collision data were extracted from the California Highway Patrol's Statewide Integrated Traffic Records System (SWITRS) from 1995-2005. From this database, strict and expanded fatigue collisions were analyzed.

6.1 Methodology

To identify spatial patterns of fatigue collisions, collision rates were calculated every 0.2 mile interval from strict and expanded fatigue datasets. Collision rates are defined as follows:

The collision rate defined here represents the number of collisions per 100 million (vehicle miles traveled. represents Annual Average Daily Traffic, the annual average number of daily vehicles traveling in both directions. To obtain a traffic volume for a single direction, was divided by 2. data from 2006 was used for analysis (Source: Caltrans http://traffic-counts.dot.ca.gov/2006all.htm, last accessed on 05/07/08).

To balance statistical fluctuations inherent in the spatial distribution of collisions across segments, the collision rates in every 0.2 mile segment were then smoothed out by a moving average with a 2-mile window that averaged one mile upstream and downstream of each segment.

6.2 Results for I-5

Collision rates per mile on all freeway segments were totaled across both directions, and then divided by the total number of collisions (i.e., a total sample of 23 collisions would represent 11 from northbound and 12 from southbound). These aggregated results are presented in Figures 2 and 3. Figure 2 shows the results of strict definition fatigue collisions and all other collisions and Figure 3 shows the results of expanded definition fatigue collisions and all others. The traffic in the figures is shown moving from left to right. In each figure, a thin curve denotes fatigue-related collisions and a dotted curve represents other collisions. The y-axis on the left shows the rates of other collisions; the right y-axis shows the rates of either strict or expanded definition fatigue collisions. Location 0 in the x-axis indicates the location of rest areas. Horizontal lines in the figures indicate average collision rates of fatigue-related or other collisions.

The figures show that strict and expanded definition fatigue collision rates decrease slightly downstream of rest areas with no visible changes in collision rates due to other factors. In general, curves for fatigue-related collisions lie above the horizontal lines (the averages) upstream of rest areas, but this pattern is reversed downstream of rest areas. The aggregated results suggest that rest areas are effective in reducing drivers' fatigue.

Figure 4 shows the percentage of strict and expanded definition fatigue collisions per 0.2-mile segment. Strict definition fatigue collisions are denoted by solid curves, while expanded definition collisions are represented by dotted curves. Horizontal lines show the average percentage of both types of fatigue collisions over 20 miles. The percentages of both strict and expanded definition fatigue collisions decrease downstream of rest areas.

Results of the analysis of individual freeway segments on I-5 can be found in the data appendix.

Figure 2. Strict Definition of Fatigue:
Aggregated Collision Results of 23 Rest Areas Over 11 Years

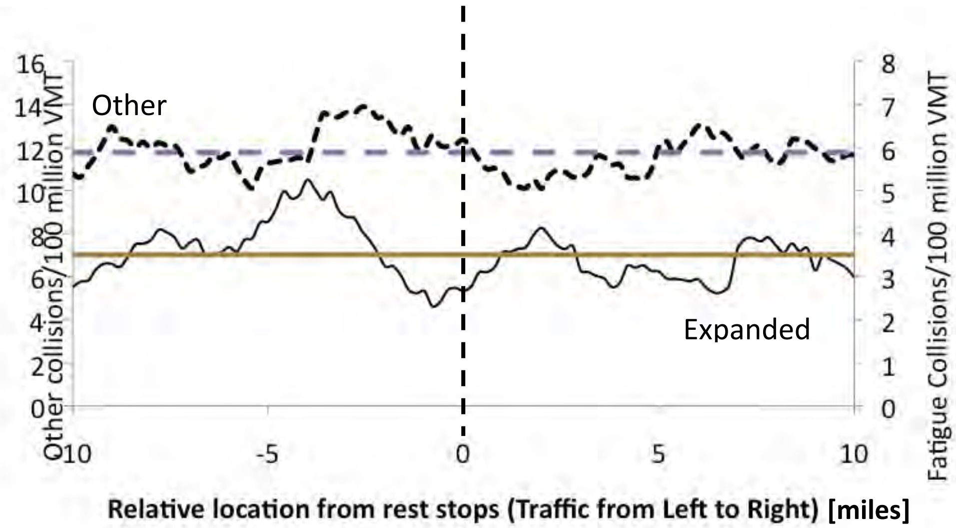


Figure 3. Expanded Definition of Fatigue: Aggregated Collision Results of 23 Rest Areas Over 11 Years

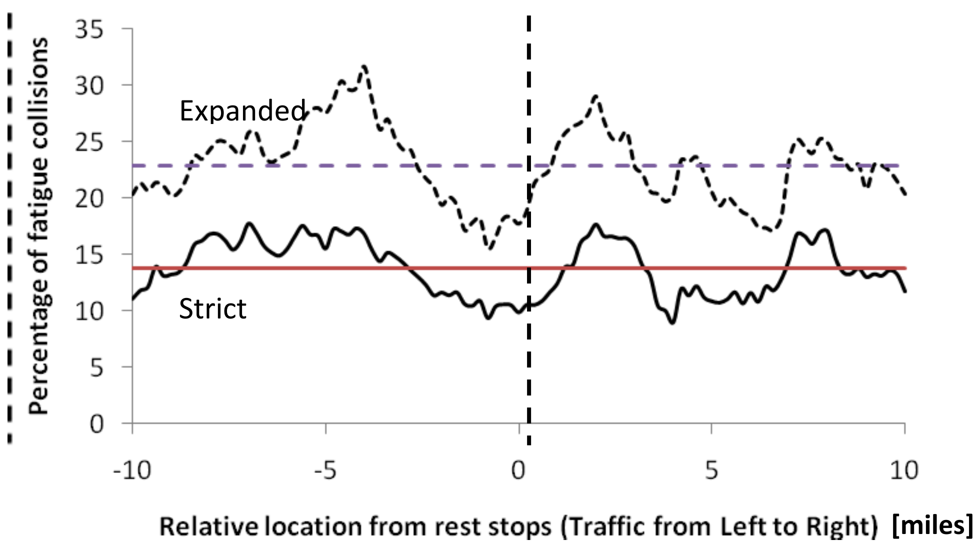


Figure 4. Percentage of Aggregated Strict and Expanded Definition Fatigue Collisions, Northbound

Figures 2, 3, and 4 show that fatigue collision rates decrease downstream of rest areas. To measure the statistical significance of these changes, two sample t-tests were performed on the collision rate data; their results are shown in Table 2.

The t-test assumes that the underlying random variables follow a normal distribution. Note that the aggregated collision rate data (per 0.2 mile) are comprised of the average of 25 rest areas, and therefore closely follow normal distributions as stated in Central Limit Theorem. But to further ensure the normality, the cumulative distributions (CDF) of the samples were compared with normal distributions (see data appendix) and Kolmogorov-

Smirnov tests[3] were performed. The visual comparison of two CDF indicate that the distribution of the data generally follow the normal distribution. In addition, the p-values of Kolmogorov-Smirnov tests (shown in table 2) indicate that the normality assumption of the collision rates can be justified. Two-sample t-tests were then performed to determine whether the upstream and downstream collision rates differ significantly.

$$H_0 : \overline{R}_{-10} = \overline{R}_{+10}$$
$$H_1 : \overline{R}_{-10} > \overline{R}_{+10}$$

$$\text{Test statistics} = t = \frac{\overline{R}_{-10} - \overline{R}_{+10}}{\sqrt{\frac{SD_{-10}^2}{n_{-10}} + \frac{SD_{+10}^2}{n_{+10}}}}$$

Here, $\overline{R}_{-10}$ and SD_{-10} respectively indicate the mean and the standard deviation of the 0.2-mile average collision rates within 10 miles upstream of rest areas, and $\overline{R}_{+10}$ and SD_{+10} are the mean and the standard deviation of the 0.2-mile average collision rates within 10 miles downstream of rest areas. The number of samples for each direction is 50 (10 miles/0.2 mile). The test results (p-value) indicate that all four types of collision rates (strict fatigue, strict other, expanded fatigue, and expanded other) decreased significantly with a significance level of alpha=0.05. The results suggest that rest areas are effective in reducing the number of all types of collisions within a vicinity of 10 miles.

Table 2. Summary of Test Statistics for 10-Mile Up/Downstream Fatigue Collisions

	Strict Fatigue		Strict Other		Exp. Fatigue		Exp. Other	
	Up	Down	Up	Down	Up	Down	Up	Down
Mean	2.26	1.97	13.59	12.80	3.71	3.32	12.06	11.45
SD	0.4275	0.3629	1.0780	0.6626	0.7524	0.4031	0.9450	0.7606
P-value of Kolmogorov-Smirnov test for normality	0.2782	0.6808	0.1682	0.9031	0.9458	0.4213	0.6725	0.9597
t-stat of two-sample test	3.67		4.15		3.23		3.54	
P-value of two-sample t-test	***1.95E-04***		***3.57E-05***		***8.54E-04***		***3.10E-04***	

[3] The Kolmogorov-Smirnov test is used to ascertain whether samples follow a specific distribution (e.g., normal). For the normality test:
H_0, Null hypothesis: the data follow the normal distribution
H_1, Alternative hypothesis: the data do not follow the normal distribution
If p-value is lower than the level of significance (e.g.,0.05), then the null hypothesis is rejected.

Two sample t-tests were performed on the percentages of the average fatigue collision rates (per 0.2 mile) to determine whether they were significantly higher within 10 miles upstream than within 10 miles downstream.

$$H_0 : \overline{P}_{-10} = \overline{P}_{+10}$$
$$H_1 : \overline{P}_{-10} > \overline{P}_{+10}$$

$$\text{Test statistics} = t = \frac{\overline{P}_{-10} - \overline{P}_{+10}}{\sqrt{\frac{SD_{-10}^2}{n_{-10}} + \frac{SD_{+10}^2}{n_{+10}}}}$$

Here, $\overline{P}_{-10}$ and SD_{-10} respectively indicate the mean and the standard deviation of the 0.2-mile average percentages of collision rates within 10 miles upstream of rest areas, and $\overline{P}_{+10}$ and SD_{+10} are the mean and the standard deviation of the 0.2-mile average percentages of collision rates within 10 miles downstream of rest areas. The number of samples for each direction was 50 (10 mile/0.2 mile).

The results of the t-tests are shown in Table 3. The percentages of strict fatigue collision rates become lower downstream of rest areas, at a 0.05 significance level. For the expanded definition fatigue collisions, there were no significant differences between downstream and upstream.

Table 3. Summary of Test Statistics for 10-Mile Up/Downstream Fatigue Collisions

	Percentage, Strict Fatigue		Percentage, Expanded.Fatigue	
	Up	Down	Up	Down
Mean	14.27	13.30	23.43	22.51
SD	2.4430	2.3322	3.8474	2.8294
P-value of Kolmogorov-Smirnov test for normality	0.3873	0.5244	0.9679	0.9868
t-stat of two-sample test	2.0196		1.3562	
P-value of two-sample t-test	***0.0231***		***0.0891***	

To further confirm that the percentages of fatigue collisions within 10 miles upstream were significantly higher than those within 10 miles downstream, two sample binomial tests were performed on the collision data.

$$H_0 : p_{-10} = p_{+10}$$
$$H_1 : p_{-10} > p_{+10}$$

$$\text{Test statistics} = z = \frac{p_{-10} - p_{+10}}{\sqrt{\frac{p_{-10} \times (1 - p_{-10})}{n_{-10}} + \frac{p_{+10} \times (1 - p_{+10})}{n_{+10}}}}$$

In the equation, p_{-10} indicates the percentage of fatigue collisions within 10 miles of rest areas and p_{+10} represents the percentage of fatigue collisions beyond 10 miles of rest areas. The data used here are not the collision rates, but the number of fatigue and non-fatigue collisions within 10 miles of rest areas. The data and the results of the binomial test are shown in Tables 4 and 5. The results indicate that the percentage of fatigue collisions within 10 miles downstream are significantly lower than for 10 miles upstream, with 0.05 significance level, suggesting that rest areas are effective in reducing the number of fatigue collisions.

Table 4. Test Statistics on Aggregated Strict Fatigue and Other Collisions

	# of Fatigue Collisions	# of Non-Fatigue Collisions	Percentage of Fatigue Collisions
10 miles upstream	255	1639	15.56 %
10 miles downstream	227	1727	13.14 %
		z statistics	2.1355
		p-value	0.016

Table 5. Test Statistics on Aggregated Expanded Fatigue and Other Collisions

	# of Fatigue Collisions	# of Non-Fatigue Collisions	Percentage of Fatigue Collisions
10 miles upstream	428	1462	29.28 %
10 miles downstream	403	1553	25.94 %
		z statistics	2.3068
		p-value	0.011

7. SPATIAL ANALYSIS — COLLISIONS AS A FUNCTION OF DISTANCE FROM REST AREAS

The spatial analysis in this chapter examines strict and expanded definition fatigue collisions, as well as collisions caused by other factors. The focus is on the spatial patterns of fatigue-related collisions between two successive rest areas; how distances traveled by drivers from rest areas influenced the likelihood of fatigue collisions.

7.1 Methodology

The objective of the present study is to qualitatively identify unique effects of drivers' fatigue on collision densities—the number of collisions per mile—between rest areas. For this purpose, *oblique* cumulative collision counts due to fatigue and non-fatigue factors were constructed between rest areas in each direction of I-5, 8, 10, and CA-101 in the following manner:

Step 1. Collisions that occurred in both directions between two rest areas were sorted by the distance drivers traveled between the origin rest area and the destination rest area.

Step 2. The cumulative counts of collisions due to fatigue and non-fatigue factors were constructed with the x-axis representing traveled distances from the origin rest area, as shown in Figure 5.

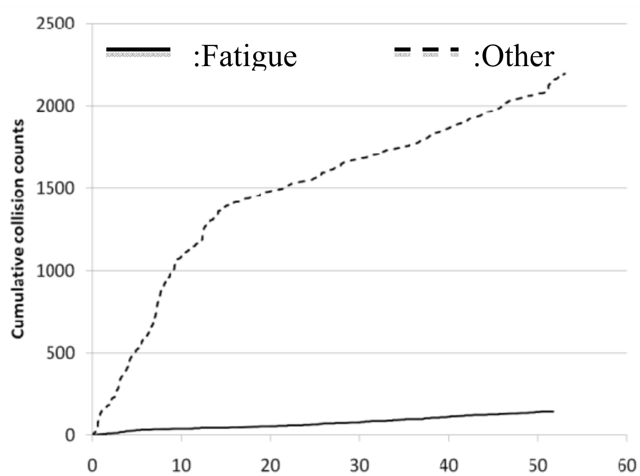


Figure 5. Cumulative Collision Counts Due to Fatigue and Non-Fatigue Factors

Step 3. A secondary vertical axis was added on the left for fatigue collisions. The number of non-fatigue collisions is significantly higher than that of fatigue collisions. As a result, if they are plotted in the same scale, changes in fatigue collisions are barely noticeable.

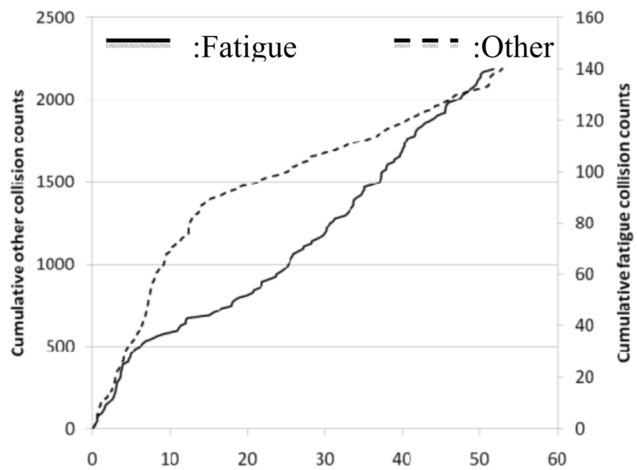


Figure 6. Comparison of Cumulative Collision Counts (Step 3)

Step 4. The cumulative count curves were plotted on an oblique coordinate system so that changes in the slopes (collision densities) of the curves were *amplified and visible to the naked eye.* This process involved subtracting a constant arbitrary collision rate from the cumulative counts:

$$C_{oblique}(d) = C_{original}(d) - q \times (d - d_0)$$

where

$C_{oblique}(d)$ = cumulative counts at a distance *d* in an oblique coordinate system
$C_{original}(d)$ = cumulative counts at a distance *d* from the step 2
q = a background rate, a constant arbitrary collision rate
d = distance from the origin rest area
d_0 = location of the origin rest area, which equals 0.

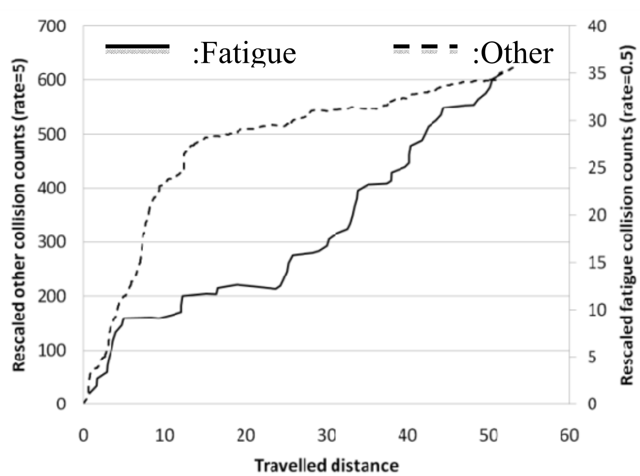


Figure 7. Oblique Cumulative Collision Counts (Step 4)

In the figures, traffic is shown moving from origin rest areas (where traveled distances are 0 in x-axes) to the right. Also, the y-axes of these plots should be interpreted with caution; they indicate cumulative collision counts minus $q \times (d - d_0)$, because of the rescaling process in step 4.

In addition, various factors such as Annual Average Daily Traffic (AADT) and geometric configurations influenced both fatigue and non-fatigue collisions, while drivers' fatigue affected only fatigue collisions. This study did not explicitly incorporate various factors in the analysis, but it implicitly isolates the effect of drivers' fatigue from other factors by comparing the cumulative counts of fatigue collisions with the non-fatigue counterpart. For example, if there was a change in the slope of the cumulative counts of fatigue collisions at a certain location, with no change in non-fatigue collisions (or vice versa), it was assumed that this difference was triggered solely by drivers' fatigue.

7.2 Analysis of Aggregated Collision Data

Collision data from 34 freeway segments of I-5, 8, 10, and CA-101 were aggregated to identify general spatial patterns of fatigue collisions. These freeway sections have different traffic volumes, number of lanes, and other geometric factors, however, it is assumed that these factors influence both fatigue and non-fatigue collisions. Therefore, if there is a unique spatial pattern found in fatigue collisions that does *not* appear in non-fatigue collisions, the difference is determined to be caused by driver fatigue. The purpose of this analysis is to identify a unique spatial pattern in fatigue collisions.

The length of freeway segments between two rest areas varied among the study sites, ranging from 21 miles to 335 miles. In the case of longer freeway segments, it is reasonable to assume that there are equivalent numbers of rest areas in between. In fact, FHWA (FAPG NS 23 CFR 752 Non-Regulatory Supplement) recommends the spacing of *an hour*'s driving time or less between two rest areas unless an extenuating circumstance can be established. To avoid possible distortions caused by including longer freeway sections without rest areas, collision data from 34 freeway segments with lengths of less than 80 miles between rest areas were aggregated into one dataset and then analyzed.

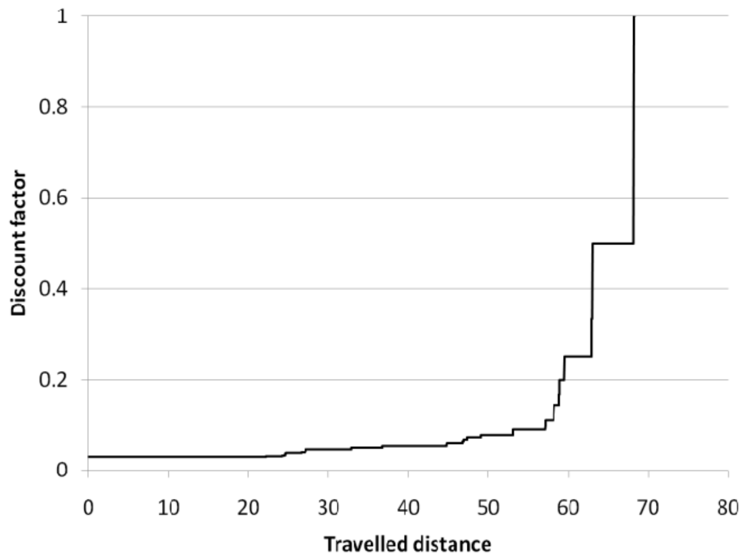


Figure 8. Discount Factors for Cumulative Collision Counts

In the aggregated dataset, all freeway segments generate collision data in the downstream vicinity of the origin rest area. However, as distance from the origin rest area increases, fewer freeway segments contribute to the data because of the differences in their lengths. For this reason, when collisions from such locations are weighted with the same extent –, collision densities in the aggregated dataset decrease as the traveled distance increases.

In light of this, discount factors (*1/the number of freeway segments longer than a certain distance*) were multiplied by cumulative numbers. Figure 8 shows the discount factors used in this study for the aggregated dataset. As Figure 8 shows, the discount factor up to 25 miles is 1/34, which is the reciprocal of the total number of freeway sections. The discount factor beyond 67 miles is 1, indicating that there was only one freeway segment of this length.

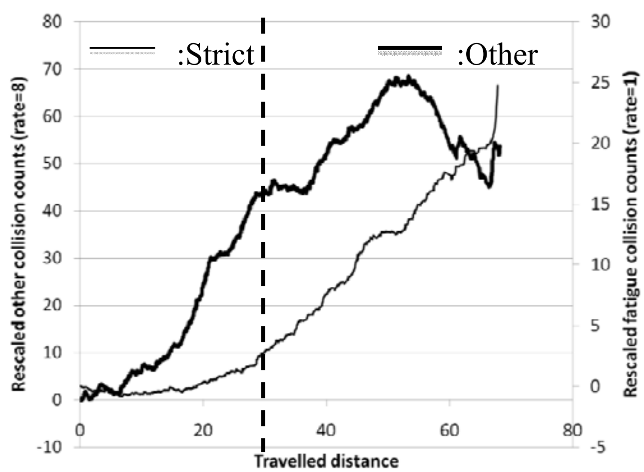


Figure 9. Oblique Cumulative Collision Counts Based on the Strict Definition

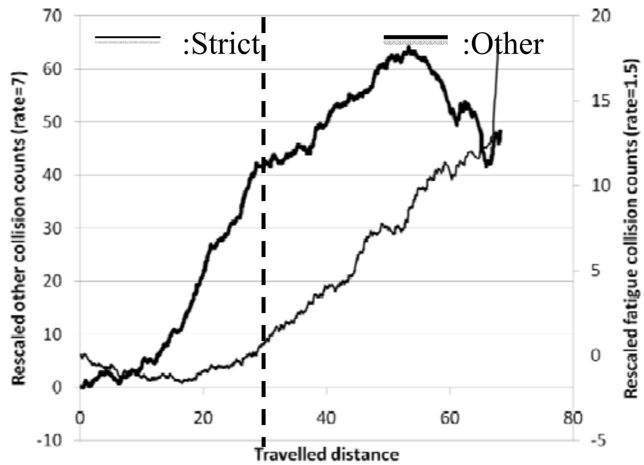


Figure 10. Oblique Cumulative Collision Counts Based on the Expanded Definition

Figures 9 and 10 were generated using the methods described above for the strict and expanded definitions of fatigue Thick curves represent collisions due to non-fatigue factors, while thin ones represent collisions due to fatigue. Two different background rates for fatigue and non-fatigue collisions are used because of higher non-fatigue collision densities. This difference in rates is used only for scaling purposes—changing slopes—and does not affect any data integrity.

In both figures, collision densities—the slope of the curves—of fatigue collisions increased at about 30 miles downstream from the origin rest area, while collision densities of non-fatigue collisions decreased. The dotted vertical lines in the figures indicate the location of the marked change in collision densities. One possible explanation for these phenomena is that drivers were more exhausted as they traveled further from rest areas, resulting in increased fatigue collision densities at about 30 miles downstream. The pattern was repeated in each freeway section and is discussed in greater detail in the appendix. When examined individually, the densities of fatigue-related collisions tended to increase at approximately 20 to 40 miles downstream of the origin rest area.

Interestingly, these collision patterns may be caused by geometric factors. It is possible that roadway environment and design within 30 miles of rest areas are significantly different from the environment and design beyond 30 miles downstream. It is likely that segments within 30 miles of rest areas are likely to be in urban, more densely populated areas, while areas beyond 30 miles are likely to be rural. This factor might cause the increases in fatigue collisions and the decreases in non-fatigue collisions beyond 30 miles of rest areas.

It is also possible that these phenomena may be triggered by inaccuracies in police reports. Drivers may be reported as fatigued in collisions that occur further downstream from rest stops, leading to the over-reporting of fatigue collisions and the under-reporting of non-fatigue collisions after 30 miles.

To determine the significance level of the changes in collision densities, two-sample t-tests were performed on fatigue collision density data per mile.

$$H_0 : \overline{D}_{-30} = \overline{D}_{+30}$$
$$H_1 : \overline{D}_{-30} < \overline{D}_{+30}$$

$$\text{Test statistics} = t = \frac{\overline{D}_{-30} - \overline{D}_{+30}}{\sqrt{\frac{SD_{-30}^2}{n_{-30}} + \frac{SD_{+30}^2}{n_{+30}}}}$$

Here, $\overline{D}_{-30}$ and SD_{-30} respectively designate the mean and the standard deviation of the 1-mile average fatigue collision densities within 30 miles downstream of rest areas, and $\overline{D}_{+30}$ and SD_{+30} represent the mean and the standard deviation of the 1-mile average fatigue collision densities beyond 30 miles downstream of rest areas. The data analyzed for this study were the averages (the sum) from the freeway segments, which approximated the normal distribution by Central Limit Theorem. The number of freeway segments decreased from 34 to 1 as traveled distances increased; when traveled distances were longer than 67 miles, the average collision densities were, in fact, based on only one freeway section, not the sum of random variables. Therefore, the collision densities beyond 67 miles were not likely to follow the normal distribution. For this reason, collision densities beyond 67 miles were truncated and eight strict definition fatigue collisions in this region were excluded.

T-test results with the findings of Kolmogorov-Smirnov tests are shown in Table 6. The test results (p-value) show that the average of the fatigue collision densities significantly increased beyond 30 miles downstream of rest areas.

Table 6. Summary of Test Statistics for 30-Miles Within/Beyond Rest Areas

	1-Mile Collision Densities, Strict Fatigue		1-Mile Collision Densities Expanded Fatigue	
	Within 30	Beyond 30	Within 30	Beyond 30
Mean	1.09	1.51	1.54	1.86
SD	0.2105	0.5167	0.2343	0.4499
P-value of Kolmogorov-Smirnov test for normality	0.2923	0.9515	0.6697	0.7607
t-stat of two-sample test	-4.4061		-3.7965	
P-value of two-sample t-test	***2.81E-0.5***		***1.81E-04***	

In addition, to determine whether there were any significant changes in the densities of other types of collisions, two-sample t-tests were performed on 1-mile non-fatigue collision density data.

$$H_0 : \overline{D}(o)_{-30} = \overline{D}(o)_{+30}$$
$$H_1 : \overline{D}(o)_{-30} > \overline{D}(o)_{+30}$$

$$\text{Test statistics} = t = \frac{\overline{D}(o)_{-30} - \overline{D}(o)_{+30}}{\sqrt{\frac{SD(o)^2_{-30}}{n_{-30}} + \frac{SD(o)^2_{+30}}{n_{+30}}}}$$

Here, $\overline{D}(o)_{-30}$ denotes the mean and $SD(o)_{-30}$ indicates the standard deviation of the 1-mile average non-fatigue collision densities within 30 miles downstream of rest areas, and $\overline{D}(o)_{+30}$ and $SD(o)_{+30}$ represent the mean and the standard deviation of the 1-mile average non-fatigue collision densities beyond 30 miles downstream of rest areas.

The results of the tests are shown in Table 7, and indicate that non-fatigue collision densities within 30 miles downstream are significantly higher than those beyond 30 miles, with a significance level of 0.05. This pattern was the opposite for fatigue collision densities.

Table 7. Summary of Test Statistics for 30-Miles Within/Beyond Rest Areas

	1-Mile Collision Densities, Strict Non-Fatigue		1-Mile Collision Densities, Expanded Non-Fatigue	
	Within 30	Beyond 30	Within 30	Beyond 30
Mean	9.78	8.88	8.68	7.70
SD	1.8069	2.3955	1.6815	2.2438
P-value of Kolmogorov-Smirnov test for normality	0.8016	0.8618	0.9025	0.5767
t-stat of two-sample test	2.0943		2.5018	
P-value of two-sample t-test	***0.0201***		***0.0075***	

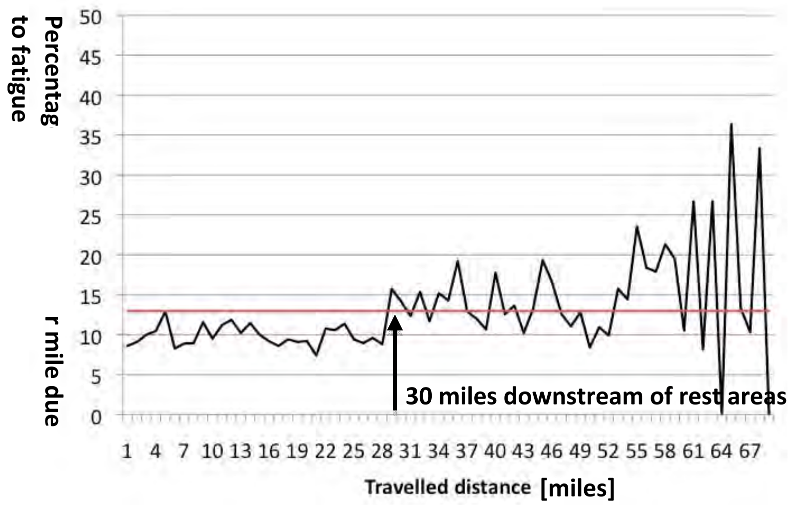


Figure 11. Percentage of Collisions, Strict Definition of Fatigue

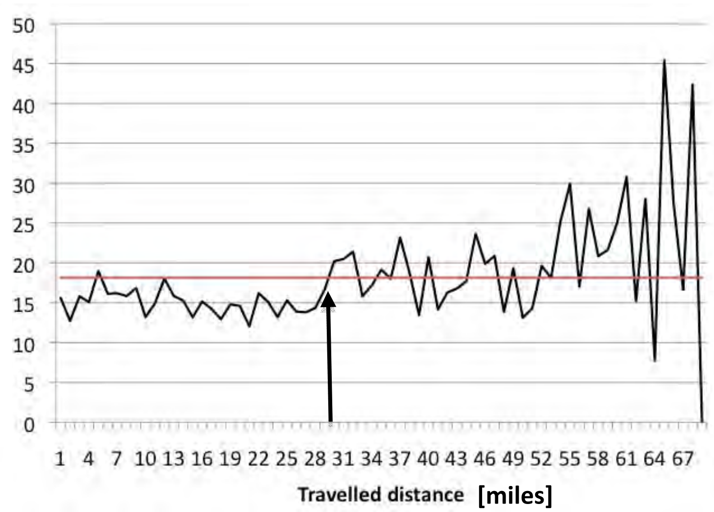


Figure 12. Percentage of Collisions, Expanded Definition of Fatigue: 34 Rest Areas, 11 Years Data

Figures 11 and 12 show the percentages of fatigue collisions in 1-mile intervals, from the strict and the expanded aggregated datasets. The percentage of non-fatigue collisions in each interval is 100% minus the percentage of fatigue collisions. Horizontal lines in the figures indicate the average percentage of fatigue collisions over the entire freeway segment. The figures reveal the same pattern shown in Figures 9 and 10. The percentage of fatigue collisions increased at about 30 miles downstream from the origin rest areas in both figures. Fluctuations at about 60 miles were caused by low sample sizes, which can be seen in Figure 8.

With these percentage data, two-sample binomial tests were performed to determine whether the percentage of fatigue collisions beyond 30 miles downstream from rest areas was significantly higher than the percentage within 30 miles downstream.

$$H_0 : p_{-30} = p_{+30}$$
$$H_1 : p_{-30} < p_{+30}$$

$$\text{Test statistics} = z = \frac{p_{-30} - p_{+30}}{\sqrt{\frac{p_{-30} \times (1 - p_{-30})}{n_{-30}} + \frac{p_{+30} \times (1 - p_{+30})}{n_{+30}}}}$$

In the above equation, p_{-30} indicates the percentage of fatigue collisions within 30 miles downstream of rest areas and p_{+30} represents the percentage fatigue collisions beyond 30 miles downstream of rest areas. The test statistics z follows standard normal distribution. The results of the statistical tests on strict and expanded fatigue collisions are shown in Tables 8 and 9. The results show that both p-values are almost 0. Therefore, the results of two-sample binomial tests indicate that the percentages of both types of fatigue collisions beyond 30 miles downstream of rest areas are significantly higher than those within 30 miles downstream.

Table 8. Fatigue and Non-Fatigue Collisions Within/Beyond 30 Miles of Rest Areas, Strict Definition: 34 Rest Areas, 11 Years Data

	# of Fatigue Collisions	# of Non-Fatigue Collisions	Percentage of Fatigue Collisions
Within 30 miles	1001	9017	11.10 %
Beyond 30 miles	706	4268	16.54 %
		z statistics	-8.87
		p-value	3.60E-19

Table 9. Fatigue and Non-Fatigue Collisions Within/Beyond 30 Miles of Rest Areas, Expanded Definition: 34 Rest Areas, 11 Years

	# of Fatigue Collisions	# of Non-Fatigue Collisions	Percentage of Fatigue Collisions
Within 30 miles	1413	7987	17.69 %
Beyond 30 miles	875	3739	23.40 %
		z statistics	-7.75
		p-value	4.71E-15

8. REST AREA CLOSURES

The impact of rest area closures could not be assessed in the present study due to lack of data.

Freeway	Name of Rest Area	Closure Information	Date Closed	District	County
15N	Valley Wells	Closed for upgrades, expected to open August 2008	April 2006	8	San Bernardino
15S	Valley Wells	Closed for upgrades, expected to open August 2008		8	San Bernardino
40E	John Wilkie	Closed for upgrades, expected to open May 2008	October 2006	8	San Bernardino
46E	Shandon	Closed for approximately 20 days from roughly September 21, 2004 to October 12, 2 004 for a roof repair project		5	San Luis Obispo
101S	Moss Cove	1/4/2006	August 2006	1	Mendocino
101N	Irvine Lodge	Partially closed from 1/4/2006. Temporary lighting and portable facilities provided at Irvine Lodge truck parking area.	May 2006	1	Mendocino

Source: http://www.dot.ca.gov/hq/maint/ra/Statewide.htm, accessed on August 2008.

9. FATIGUE RAMP ANALYSIS

An analysis of ramp collisions on I-5 was completed as part of this study, using 11 years of data (1994–2004) from TASAS. For the analysis, the number and characteristics of collisions associated with on- and off-ramps connected to rest areas were compared with those occurring on all other ramps on I-5. Highway collisions that occurred outside of the vicinity of ramps were not included. Also, collisions in Caltrans Districts 7, 11 and 12 (LA, SD and ORA counties) were excluded from this analysis due of a lack of rest areas in those districts. TASAS data assigns a code to denote Intersection/Ramp Accident Location. The location of each ramp location code is schematically represented in Figure 13, and the location codes are described as follows:

- **IRL#1:** Collisions that occurred *within 50 feet of the ramp exit*; marked as "ramp intersection (exit) collisions."

- **IRL#2:** Collisions located on the ramp, *but not within 50 feet of either the entrance or the exit of the ramp*; marked "ramp collision."

- **IRL#3:** Collisions that occurred *within 50 feet of the ramp entrance;* marked "ramp entry collision."

- **IRL#4:** Collisions that occurred on the *intersection of the ramp area and the cross street of the ramp*. In cases of ramps connecting to rest areas, this is often the location of the rest area. As will be addressed in the next analysis, these collisions contribute to a majority of ramp collisions and have different characteristics compared with collisions at other locations on ramps. These locations include rest area parking lots, which produce a higher rate of collisions than other locations due to parking activities.

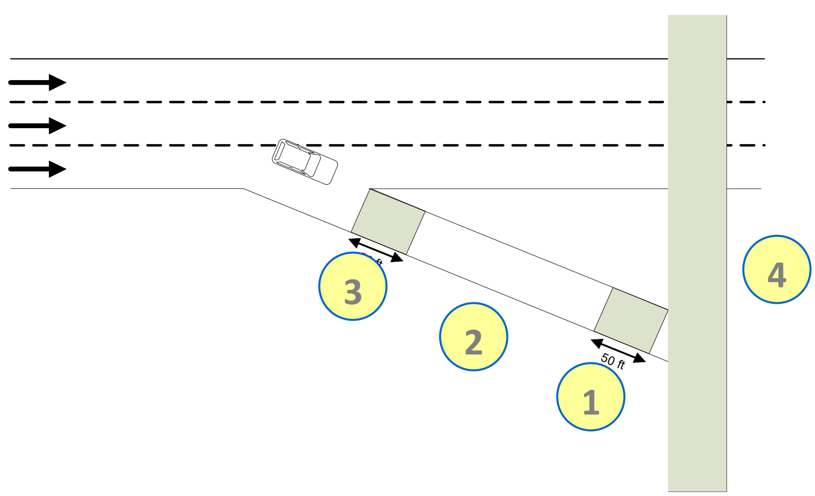


Figure 13. Ramp Location Code (IRL) From TASAS Data

Table 10 summarizes collisions on ramps connected to rest areas and all other ramp collisions. The total number of collisions on ramps connected to rest areas was substantially lower than the total number of collisions on all other ramps due to the relatively small number of ramps that are connected to rest areas. However, the number of collisions per ramp for ramps connected to the rest areas, 4.4, is relatively close to the number of collisions per ramp for all the other ramps, 6.8.

By excluding IRL#4 collisions, the number of collisions per ramp on the rest area ramps drops to 1.0, and the number of collisions per ramp for all the other ramps drops to 4.3.

Table 10. Summary of Collisions on Ramps Connected to Rest Areas and Collisions at All Other Ramps

	Other Ramps	Rest Area Ramps
Total # of collisions	5641	367
Total # of ramps	826	83
Collision per ramp	6.8	4.4
Total # of collisions except IRL#4	3580	84
Collision per ramp except IRL#4	4.3	1.0

Detailed analysis of collisions in rest areas, which is presented in the data appendix, reveals that trucks were the primary vehicle type involved in rest area ramp collisions. The primary collision factor was 'other,' followed by 'improper turns.' The primary type of collision was a 'sideswipe' collision followed by 'hit object' collisions. This order of importance was altered when IRL#4 collisions were excluded from the data. 'Parked, parking' movement caused the maximum number of collisions in rest areas compared with 'proceeding straight' movement on other ramps. However, by excluding IRL#4 collisions, 'proceeding straight' movement also caused the most collisions on rest area ramps, although collisions still remained highly correlated to parking activities (parked, parking, backing) compared with collisions on ramps not connected to rest areas. This implies that some rest areas are deficient in available parking spaces, resulting in possible unsanctioned parking activities in connected on/off-ramp areas. While parking on ramps at rest areas may be illegal, continuing to drive while drowsy may also be illegal if it violates commercial vehicle driving hours or leads to a fatigue-related accident. With inadequate available parking, drivers face difficult choices.

10. INFORMAL TRUCK STOPS

California Highway Patrol has compiled a list of locations that, although not formally designated as rest areas, are used by truck drivers for that purpose. Large numbers of trucks are parked for extended periods on the ramps at these locations. In this chapter, the characteristics of truck collisions on ramps and on the highway in the vicinity of these ramps are analyzed.

10.1 Ramp Collisions

As in the earlier ramp analysis, TASAS 1994–2004 data was used for this analysis. Table 11 lists the locations of these informal rest areas along with the number of ramps on which collisions took place, the total number of collisions, and the number of truck collisions on these ramps. Fatigue-related collisions were negligible. This dataset contains information about primary collision factor but not about party physical, drug use, or other information used to identify collisions according to the expanded definition of fatigue. Therefore, the only fatigue-related collisions identified in this dataset are those in which the primary collision factor was listed as ‘fell asleep.’

The rate of collisions per ramp on informal rest area ramps varied from 1 to 16.5, with an average of 7.5. This compares with a rate of 4.4 collisions per ramp (Table 10) for formal rest areas, and 6.8 when IRL#4 collisions were included, as was the case in this analysis. These results indicate that more collisions occur on informal rest area ramps than on formal rest area ramps. The informal rest area ramp locations recording the highest collision rates were on I-5 at South French Camp Road, I-80 at Red Top Road, and I-80 at Abernathy Road.

Table 11 shows that between one and four of the ramps at these locations recorded collisions. The number of collisions varied from one at U.S. Route 101 at Wild Horse Road, to 67 at I-5 at South French Camp Road. Three of the four informal rest areas on I-5 experienced truck collisions, contributing to over 25% of the total collisions. The percentage of truck collisions on the ramps varied from none (Highway 101 at Wild Horse Road, and I-80 at Kidwell Road) to 44% (I-5 at West Turner Road, and I-5 at Hood Franklin Road).

Fatigue-related collisions were rare at these locations. Only one out of nine collisions recorded at I-5 at West Turner Road had a primary collision factor of ‘fell asleep.’

Table 11. Locations and Collision Characteristics of Informal Rest Areas

Route & Direction	County/ Nearest City	Interchange	Postmile	Number of Collisions on Ramps /Number of Ramps With Collisions	Number of Collisions Per Ramp	Number of Truck Collisions on Ramps
80 West & East	Solano/ Cordelia	Interstate 80 and Red Top Road	11.39	47/4	11.75	8
80 East	Solano/ Cordelia	Interstate 80 and Abernathy Road	16.14	47/4	11.75	6
80 West & East	Solano/ Dixon	Interstate 80 and Pedrick Road	39.73	14/4	3.5	2
80 West & East	Solano/ Dixon	Interstate 80 and Kidwell Road	41.25	3/2	1.5	0
5 West & East	Sacramento/ Lodi	Interstate 5 and Hood Franklin Road	8.49	9/3	3	4
5 West & East	Sacramento/ Lodi	Interstate 5 and Twin Cities Road	2.13	20/4	5	5
5 West & East	San Joaquin/ Lodi	Interstate 5 and West Turner Road	41.67	9/3	3	4
5 West & East	San Joaquin/ Stockton	Interstate 5 and South French Camp Road	22.54	67/4	16.75	8
101 North & South	Monterey/ King City	Highway 101 and Wild Horse Road	37.31	1/1	1	0
				217/29	7.48	

'Proceeding straight' was the movement type that resulted in the largest number of collisions for all the informal rest area ramps. At only two of the nine locations, other movement types contributed to a larger percentage of collisions, 'ran off road' (67%) for I-80 at Kidwell and 'slowing stopped' (23%) for I-5 at Hood Franklin Road. The other major contributors were 'making left turns,' contributing to 25% of the collisions at I-5 at Twin Cities Road, and 26% at Interstate 5 at South French Camp Road. The percentage of collisions due to parking activities varied from none (I-80 at Kidwell Road, and Highway 101 at Wild Horse Road) to 57% at I-80 and Pedrick Road. Analysis of ramps on I-5 revealed that 31% of collisions were related to parking activity (parked, parking, backing, slowing, stopping, stopped) on ramps connected to rest areas excluding IRL#4 collisions, and 51% were related to parking activity when IRL#4 collisions were included. Collisions due to parking activity represented 21% of collisions for all other ramps when IRL#4 collisions were excluded, and 18% including IRL#4 collisions. For formal rest areas on I-5, 11% of collisions were due to parking activities excluding IRL#4 collisions and 26% of collisions were due to parking activities for rest area ramps including IRL#4 collisions. For the other ramps, 1% of collisions were due to parking both excluding and including IRL#4 collisions. Pie diagrams showing the contribution of the various movement types to collisions are included in Appendix 5.

It is clear that a large number of collisions on rest area ramps are due to proceeding straight and parking activities. Collisions designated as IRL#4 constitute a large percentage of collisions due to parking activities. In comparison, informal rest area ramps experience an even greater percentage of collisions due to parking activities.

10.2 Fatigue-Related Highway Collisions at Informal Rest Areas

This analysis was conducted using eleven years of SWITRS data from 1996 to 2006. Fatigue-related truck collisions (strict and expanded definitions) along U.S. Route 101 in Monterey County, I-5 in Sacramento County, I-5 in San Joaquin County and I-80 in Solano County were plotted along the postmiles. Informal rest area locations, formal rest area locations and truck weigh stations were marked in order to observe their effects on the number of highway collisions. The plots and a summary table for the plots, showing strict definition fatigue-related collisions are included in the appendix and show the informal rest area as a mile-long segment along which on- and off-ramps would be present.

Kidwell Road on eastbound I-80 recorded a three-collision location as well as a one-collision location within one mile. The entire segment of eastbound route 80 between Red Top Road and Kidwell Road recorded a high frequency of collisions, including a number of two and three-collision locations. Red Top Road, Abernathy and the postmile-16 truck weigh station, and Kidwell Road experienced decreases in the collision rate at or near the rest areas. Southbound I-5 and West Turner Road recorded four collisions within one mile. The segment of southbound interstate 5 in San Joaquin County also recorded a high number of collisions, with higher collision rates closer to informal rest areas. Eastbound I-80 and Red Top Road, as well as northbound I-5 and Hood Franklin Road, recorded two collisions within one mile of the informal rest area location. The segment of northbound I-5 in Sacramento County recorded comparatively fewer collisions. While it recorded no collisions within a one-mile segment of the earlier informal rest area location, Twin Cities Road, it recorded many collisions in and around the Hood Franklin Road location.

10.3 Summary of Findings

The effect of informal rest areas on collision rates is unclear, and varies by location. In some cases (i.e., I-5 in San Joaquin County) the absence of a rest area or truck weigh station may have been the impetus for an informal rest area location, and may signal the need for a formal rest area. In other cases, as along route 80, many informal rest areas have been established that are in some cases adjacent to or within a short distance of the formal rest area locations, indicating either a lack of adequate facilities, or some other source of discontent on the part of drivers.

There was a wide range in the number of collisions recorded on ramps, from minimal to very high. The higher number of collisions may have been due to higher traffic, improper geometry or obstruction of sight lines.

Similarly, some segments of freeway recorded a higher number of fatigue-related collisions (strict definition) overall; these freeway segments should be analyzed for their safety characteristics, and rest areas should be added. Route 80, particularly in the eastbound direction, recorded a high number of such collisions. Informal rest area locations experienced an inconsistent pattern of fatigue-related collisions, both higher and lower than the remaining freeway segments, indicating the need for additional rest areas. All segments of freeway analyzed for this study experienced a significant number of strict fatigue-related truck collisions. This confirms the need for additional rest area facilities, prioritizing segments that recorded a high number of collisions and a high number of two or three-collision locations.

11. DISCUSSION

This study resulted in a number of significant findings regarding the characteristics of fatigue-related collisions, based on a literature review and analysis of SWITRS and TASAS data. Findings and recommendations are below.

The presence of rest areas was found to lower fatigue-related collisions statistically significantly, particularly when comparing 10-mile segments up and downstream of rest areas. In addition, this study corroborated findings in the literature indicating that fatigue-related collisions increase significantly beyond 30 miles of rest area locations, suggesting that optimal placement of rest areas should be every 30 miles. However, considering potential influences of various other collision factors, additional rigorous studies may be required to identify the cause of this phenomenon, which may be caused by driver fatigue beyond 30 miles, different roadway design or environment factors within and beyond the 30-mile zone, or a bias in collision reports. For this purpose, before-and-after research on temporary rest areas closures would be an ideal future study. Such a study would prevent the effects of other variables on collisions and verify whether the findings from the present study are reproducible:

1. Did closures increase collision densities 30 mile downstream of rest areas?
2. Did collision densities decrease when the temporary closures ended?

A broad statewide analysis of fatigue data, which identified specific times and locations of fatigue-related collisions was used for the analysis. The study identified the demographics of the population prone to such crashes in order to target this group for education and awareness measures. Further, providing information to drivers regarding the locations of all nearby rest areas, would allow drivers to make more informed decisions when stopping.

Rest area ramps record lower collision rates compared with other ramps, and a majority of collisions on rest area ramps are IRL#4 collisions; the collisions that occur at the intersection of the ramp and the highway. Collisions that occurred during parking or with a parked vehicle were the most frequent type of collision in rest areas. These findings may be useful in the design of rest areas in order to avoid such collisions.

Informal rest area ramps were generally found to be more dangerous than other ramps, although only three of the nine informal rest area ramps recorded very high collision rates. The effect of informal rest areas on fatigue-related highway collisions was inconclusive. However, since designated rest areas appeared to reduce fatigue-related collisions, it is recommended that adequate rest areas be provided at or near these locations. Adequate rest areas, as described in the literature, provide food, water, restrooms, phones, safety and convenience. Additionally, private truck stops also offer fuel, showers and a wider range of food selections. Inadequate parking, expensive facilities, lack of security, and time-limit enforcements have often deterred the use of designated rest areas.

Under constrained resources, there could be a tradeoff between the spacing of rest areas and the extent of services provided at available rest areas. Further studies on fatigue-related collisions and rest area provision could examine a number of related issues, including, for example, whether or not time limits should be imposed (and if so, optimal time for such limits), and what improvements would have the greatest impact on enhancing parking facilities. Avoiding the tragic impact of collisions that result from driver fatigue should be a priority in future research.

APPENDIX 1: LITERATURE REVIEW

Generally, sleep is a neurobiological activity with predictable patterns. Disruption of these patterns, especially the circadian processes (24-hour rhythms that control our sleep/wake cycles), sleep fragmentation, or sleep restriction and loss can result in a diminished capacity to perform everyday tasks—such as driving—due to impairment in the following: reaction time, vigilance, attention, and information processing (NCSDR/NHTSA). In the extreme, it can also lead to falling asleep while driving. The National Highway Traffic Safety Administration makes the distinction between "fatigue" and "inattention," defining fatigue as a "disinclination to continue" a particular task; in the case of driving, it is not so much a disinclination to driving as it is a "progressive withdrawal of attention to the tasks required for safe driving." This is characterized as inattention, which is a product of fatigue and other such factors as "preoccupation or distractions inside the vehicle" (NCSDR/NHTSA).

Research on fatigue and its effects on collisions has a long history, characterized by a near-constant stream of analysis in five main categories:

1. Characteristics and Magnitude of Fatigue Related Crashes
2. Effect of Fatigue on Performance
3. Causes of Fatigue
4. Countermeasures
5. Effect of Rest Stops on Fatigue

Among these, only a limited number of studies have been undertaken to understand the effects of the distance between rest stops on fatigue collisions. One of the most interesting studies related to this topic was conducted by researchers at Michigan State University.[4] They found a correlation between the distance between rest stops and the percentage of single vehicle crashes: "the greater the distance between rest areas, the higher the percentage of single vehicle truck crashes." The research team created a "hazard model with a conditional probability format" that concluded that there was a "significant" increase in single vehicle truck crashes once the distance between rest areas was greater than thirty miles. The study did not, however, compare or separate characteristics of collisions caused by fatigue-related factors and other counterparts.

To understand the effects of rest stops on fatigue collisions, the present research entails empirical analysis of (i) unique spatial correlations between fatigue collisions and the locations of rest stops; and (ii) general characteristics of fatigue and non-fatigue collisions that arise in rest stops.

An extensive annotated bibliography follows.

[4] Taylor, W. C., N. Sung, et al. (1999). A Study of Highway Rest Area Characteristics and Fatigue Related Truck Crashes: 1-59.

A1.1 Annotated Bibliography: Characteristics and Magnitude of Fatigue Related Crashes

Blower, Daniel and Kenneth Campbell. (1998)
***Fatalities and Injuries in Truck Crashes by Time of Day*. Ann Arbor, University of Michigan: 1-16.**

KEYWORDS
Trucks
Long-Haul Trucks
Truck-Passenger Vehicle Crashes
Fatalities
Injuries
Time Of Day
Hours-Of-Service
Driver Fatigue

ABSTRACT
The Federal Highway Administration (FHWA) currently is considering proposals to change the regulations governing the hours-of-service (HOS) of commercial truck drivers. The purpose of the present report is to provide information on the distribution of crashes, injuries, and fatalities by time of day and to measure the consequences of truck crashes by time of day, both to truck occupants and to other road users. Older sources of VMT data (vehicle miles traveled) are used to illustrate the relative risk of day and night travel.

About 20% of all fatal crashes and fatalities and 10% of all injuries involving a long-haul truck (tractor pulling at least one trailer) occur between midnight and 6:00 a.m. Crashes at night tend to be more severe, with about 435 injuries per thousand crashes between midnight and 6:00 a.m., compared with 320 injuries per thousand for the remainder of the day. There are about three times as many fatalities per thousand crashes midnight-6:00 a.m.

Truck travel estimates by hour of the day are not currently available. Using exposure data classifying night as 9:00 p.m. to 6:00 a.m., truck travel during that period is associated with a relative risk about twice that of the rest of the day. Truck driver fatigue in single-vehicle fatal crashes is a significant factor. Driver fatigue and alcohol use in nontruck drivers also form a significant component of the higher risk of night travel. Almost 40% of the nontruck drivers in multiple-vehicle crashes with trucks between midnight and 3:00 a.m. had used alcohol, compared with 2.7% of the truck drivers. Fatigue was also coded more often for nontruck drivers than for truck drivers in multiple-vehicle crashes.

URL
No URL provided.

Bunn, T. L., S. Slavova, et al. (2005)
"Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries." *Accid Anal Prev* 37(5): 862-9.

KEYWORDS
Accidents, Occupational/*mortality
Accidents, Traffic/*mortality
Adult
Age Distribution
Attention
Case-Control Studies
Male
Matched-Pair Analysis
Middle Aged
Proportional Hazards Models
Retrospective Studies
Risk Factors
Seat Belts/utilization
Sleep Disorders, Circadian Rhythm/*epidemiology

ABSTRACT
A retrospective population-based case-control study was conducted to determine whether driver sleepiness/fatigue and inattention/distraction increase the likelihood that a commercial motor vehicle collision (CVC) will be fatal. Cases were identified as CVC drivers who died (fatal) and controls were drivers who survived (nonfatal) an injury collision using the Kentucky Collision Report Analysis for Safer Highways (CRASH) electronic database from 1998-2002. Cases and controls were matched on unit type and roadway type. Conditional logistic regression was performed. Driver sleepiness/fatigue, distraction/inattention, age of 51 years of age and older, and nonuse of safety belts increase the odds that a CVC will be fatal. Primary safety belt law enactment and enforcement for all states, commercial vehicle driver education addressing fatigue and distraction and other approaches including decreased hours-of-service, rest breaks and policy changes, etc. may decrease the probability that a CVC will be fatal.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15921653

Carroll, R. (1998)
***Impact of Local/Short Haul Operations on Driver Fatigue: Focus Group Summary and Analysis:* 1-4.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Carroll, R. (2001)
***Impact of Local/Short-Haul Operations on Driver Fatigue: Field Study:* 1-4.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Carroll, R. (2002)
***Impact of Sleeper Berth Usage on Driver Fatigue: Final Report:* 1-4.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Carsten, O. (1987)
***Road Class and Large Truck Involvements in Fatal Accidents*. Ann Arbor, University of Michigan: 1-35.**

KEYWORDS
Medium trucks
Heavy Trucks
Accidents
Road Type

ABSTRACT
The data that have been collected by the University of Michigan Transportation Research Institute through a follow-up on large trucks involved in fatal accidents provide the opportunity to examine the relationship between road class and fatal accident involvement. The fatal accident involvement rate per mile travelled for combination trucks is calculated from University of Michigan and Federal Highway Administration data. The rate is higher on rural non-interstates than on the other road types.

For the rest of the report, a four-way breakdown of road class is examined. This categorizes roads into urban and rural and divided and undivided. Significant differences in the distribution of accident factors are observed between road classes. This has important implications for the selection of accident countermeasures in that a countermeasure is unlikely to reduce involvements equally on all classes of road. Certain types of accident, seeminly involving fatigue, are observed to be relatively more common at dawn; however, this fatigue cannot be attributed to exhaustion after long hours of driving.

RESEARCH NOTES

URL
No URL provided.

Connor, J., R. Norton, et al. (2002)
"Driver sleepiness and risk of serious injury to car occupants: population based case control study." **BMJ324(7346): 1125.**

KEYWORDS
Accidents, Traffic
Adolescent
Aged, 80 and over
Automobile Driving
Case-Control Studies
Fatigue/complications/epidemiology
Female
Humans
Male
Middle Aged
New Zealand/epidemiology
Risk Factors
Sleep Deprivation/*complications/epidemiology
Wounds and Injuries/*etiology

ABSTRACT
OBJECTIVES: To estimate the contribution of driver sleepiness to the causes of car crash injuries. DESIGN: Population based case control study. SETTING: Auckland region of New Zealand, April 1998 to July 1999. PARTICIPANTS: 571 car drivers involved in crashes where at least one occupant was admitted to hospital or killed ("injury crash"); 588 car drivers recruited while driving on public roads (controls), representative of all time spent driving in the study region during the study period. MAIN OUTCOME MEASURES: Relative risk for injury crash associated with driver characteristics related to sleep, and the population attributable risk for driver sleepiness. RESULTS: There was a strong association between measures of acute sleepiness and the risk of an injury crash. After adjustment for major confounders significantly increased risk was associated with drivers who identified themselves as sleepy (Stanford sleepiness score 4-7 v 1-3; odds ratio 8.2, 95% confidence interval 3.4 to 19.7); with drivers who reported five hours or less of sleep in the previous 24 hours compared with more than five hours (2.7, 1.4 to 5.4); and with driving between 2 am and 5 am compared with other times of day (5.6, 1.4 to 22.7). No increase in risk was associated with measures of chronic sleepiness. The population attributable risk for driving with one or more of the acute sleepiness risk factors was 19% (15% to 25%). CONCLUSIONS: Acute sleepiness in car drivers significantly increases the risk of a crash in which a car occupant is injured or killed. Reductions in road traffic injuries may be achieved if fewer people drive when they are sleepy or have been deprived of sleep or drive between 2 am and 5 am.

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12003884

Connor, J., R. Norton, et al. (2001)
"Prevalence of driver sleepiness in a random population-based sample of car driving." ***Sleep*** **24 (6): 688-94.**

KEYWORDS
Adolescent
Adult
Automobile Driving
Disorders of Excessive Somnolence/*epidemiology
Fatigue/epidemiology
Population Surveillance
Questionnaires
Severity of Illness Index

ABSTRACT
STUDY OBJECTIVES: To obtain reliable estimates of the prevalence of driver sleepiness. DESIGN: A two-stage cluster sampling technique was employed to obtain a sample of car drivers representative of time spent driving on public roads in a geographically defined region. Data were collected by interviewer-administered questionnaire, and analyzed in accordance with the sampling design. SETTING: The Auckland region of New Zealand, between April 1998 and July 1999. PARTICIPANTS: 588 drivers of cars and other light vehicles recruited at 69 roadside survey sites. MEASUREMENTS AND RESULTS: Of 746 eligible participants, 79% were interviewed, 12% refused, 8% were untraceable, and 1% were unable to give informed consent. From this sample we estimated that 58.7% of driving was undertaken by men. The vast majority of driving (90.8%) was undertaken by drivers with Epworth Sleepiness scores in the normal range (<10), but a significant minority was undertaken by drivers with one or more characteristics likely to impair alertness. 3.1% had < or = 5 hours sleep in the previous 24 hours, and 21.9% had < or = 4 full nights sleep in the previous week. The triad of symptoms associated with sleep apnea (snoring, choking, and breathing pauses while sleeping) was present in 1.6%; and 8.1% worked a pattern of shifts likely to interfere with normal sleep. CONCLUSION: The prevalence of sleepiness amongst a random sample of New Zealand car driving was low, and less than suggested by previous studies.

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11560182

Connor, J., G. Whitlock, et al. (2001)
"The role of driver sleepiness in car crashes: a systematic review of epidemiological studies." *Accid Anal Prev* 33(1): 31-41.

KEYWORDS
Accidents, Traffic/prevention & control/*statistics & numerical data
Automobile Driving
Fatigue
Humans
Research Design
Sleep Stages

ABSTRACT
To assess the available evidence for a causal role of driver sleepiness in car crashes or car crash injury, and to quantify the effect, a systematic review of the international literature was conducted. The review included all studies with a fatigue-related exposure measure, a crash or crash injury outcome measure and a comparison group, regardless of publication status, language or date of the study. Eighteen cross-sectional studies and one case-control study fulfilled the inclusion criteria. The fatigue-related exposures investigated in these studies were sleep disorders (n = 14), shift work (n = 2), sleep deprivation/fragmentation (n = 1), and excessive daytime sleepiness (n = 2). Only one study used an injury outcome measure. Studies were limited in their ability to establish a causal relationship by their design, by biases, and in many cases, by small sample sizes. The better quality cross-sectional studies were suggestive of a positive relationship between fatigue and crash risk, but could not provide reliable estimates of the strength of the association. The case-control study provided moderately strong evidence for an association between sleep apnea and risk of driver injury, with an adjusted odds ratio of 7.2 (95% confidence interval 2.4-21.8). We conclude that the direct epidemiological evidence for a causal role of fatigue in car crashes is weak, but suggestive of an effect. To estimate the burden of injury due to fatigue-related crashes in the population, information is required from well-designed observational epidemiological studies about the prevalence of fatigue in the car driving population and the size of the risk this confers.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11189120

Dinges, D. F. and G. Maislin (1998)
***Final Report: Evaluation of Techniques for Ocular Measurement as an Index of Fatigue and as the Basis for Alertness Management.* Washington, DC, National Highway Traffic Safety Administration: 1-113.**

KEYWORDS
Drowsy Driving
Fatigue
Driver Monitoring
Driving Simulation
Vigilance
Driver Impairment
Drowsiness Detection
Technology Validation
Psychophysical Measurement

ABSTRACT
This final report establishes the scientific validity of the ocular measure "Perclose" as a generally useful and reliable nidex of lapses in visual attention, i.e. the percentage of eyelid closure over the pupil. Perclose was previously specified as a relevant measure of drowsiness in several driving simulator studies (NHTSA Final Report, DOT HS 808 640). In the present research, further validation of Perclose was established among other measures, in a controlled sleep deprivation study, using a well-known psychophysical index of lapses in visual attention, i.e. Psychomotor Vigilance Task (PVT). The present study provides the scientific and practical basis to relate real-time lapses in visual attention to over-the-road driving performance.

RESEARCH NOTES

URL
No URL provided.

Drobnich, D. (2005)
"A National Sleep Foundation's conference summary: the National Summit to Prevent Drowsy Driving and a new call to action." ***IndHealth*** **43(1): 197-200.**

KEYWORDS
Accidents, Traffic/mortality/*prevention & control/psychology
Automobile Driving/*psychology
Fatigue/physiopathology/*prevention & control
Foundations
Program Development
Public Policy
Sleep Initiation and Maintenance Disorders/*physiopathology
United States/epidemiology

ABSTRACT
On November 20-21, 2002, the National Sleep Foundation (NSF), a U.S.-based non-profit organization, and a coalition of other organizations, federal agencies and corporations convened a National Summit to Prevent Drowsy Driving at the National Academy of Sciences in Washington, DC. The Summit brought together experts in the fields of transportation, safety and health, sleep research, and communications as well as advocates to assist in the creation of a comprehensive national agenda to increase awareness about the dangers of drowsy driving. Recommendations from the Summit formed the basis of post-summit activities, including the development of a new Web site (www.drowsydriving.org) dedicated to the prevention of driver fatigue and a report, the National Action Plan to Prevent Drowsy Driving, which describes a series of action items for national, state and local initiatives in the areas of research, public policy, and educational programs.

RESEARCH NOTES

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Garbarino, S., L. Nobili, et al. (2001)
"Sleep related vehicle accidents on Italian highways." ***G Ital Med LavErgon*** **23(4): 430-4.**

KEYWORDS
Accidents, Traffic/*statistics & numerical data
Adult
Age Distribution
Age Factors
Aged
Analysis of Variance
Incidence
Italy/epidemiology
Middle Aged
Poisson Distribution
Sleep Disorders, Circadian Rhythm/*epidemiology
Time Factors

ABSTRACT
Sleepiness has been identified as a significant risk factor for vehicle accidents, and specific surveys are needed for Italy. The aim of this study was to assess incidence and characteristics of sleep-related vehicle-crashes on Italian highways. The database of the Italian National Institute of Statistics (1993-1997) was the source for the survey (50859 accidents with 1632 (3.2%) ascribed to sleep by the police). The distribution of accidents was evaluated by means of the analysis of variance considering the year, the day of the week, the age and the time of day and their interactions as main factors. The relative risk of sleep-related accidents was also evaluated with reference to the relative traffic density as estimated by the Italian Highways Society. The counts of sleep-related accidents, and even more the relative risk, revealed the presence of peaks and troughs in zones at a higher level of sleepiness and alertness respectively. Death of the driver occurred in 11.4% of sleep related accidents versus 5.6% in general accidents. The great majority of sleep-related accidents occurred to drivers under 35 (61.4%) mainly during the night with an increasing trend in the yearly number of sleep-related accidents, especially on weekends. Therefore sleepiness appears a remarkable risk factor and, in our opinion, its incidence as sole or contributory cause of accidents on Italian highways is still underestimated.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11758145

Glaze, A. L. and J. M. Ellis (2003)
***2002 Pilot Study of Distracted Drivers*, Virginia Commonwealth University: 1-60.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Hakkanen, H. and H. Summala (2000)
"Sleepiness at work among commercial truck drivers." ***Sleep*** **23(1): 49-57.**

KEYWORDS
Accidents, Traffic
Adult
Fatigue/*diagnosis/etiology
Male
Middle Aged
Motor Vehicles
Occupational Diseases/*diagnosis/etiology
Risk Factors
Self Care
Sleep Apnea, Obstructive/diagnosis
Sleep Disorders, Circadian Rhythm/*diagnosis/etiology
Work Schedule Tolerance

ABSTRACT
Two separate groups consisting of both long-haul (N=184) and short-haul (N=133) truck drivers were surveyed to examine the frequency of driver sleepiness-related problems at work during the previous three months and to assess the incidence of sleep apnea syndrome symptoms. We also aimed to identify factors likely to predict self-reported difficulties in staying alert in work driving, dozing off (sometimes referred to as microsleep) at the wheel and near misses. The responses suggest that for approximately 13% of the long-haul drivers the mean driving time per shift exceeded the EEC regulation. About 40% of the long-haul drivers and 21% of the short-haul drivers reported having problems in staying alert on at least 20% of their drives. Over 20% of the long-haul drivers also reported having dozed off at least twice while driving. Near misses due to dozing off had occurred in 17% of these drivers. Factors indicating sleep apnea syndrome occurred in only about 4% of the long-haul drivers and in only two short-haul drivers. Work and individual related factors as well as factors indicating sleep apnea syndrome contributed only slightly to predicting driver sleepiness-related problems. This suggests that driver sleepiness-related problems tend to be shared by many of the professional drivers, rather than being a "specific" and permanent problem for a smaller portion of drivers. However, difficulties in sleep patterns, such as having difficulty falling asleep, were infrequent.

RESEARCH NOTES

URL
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Haraldsson, P. O. and T. Akerstedt (2001)
"Drowsiness—greater traffic hazard than alcohol. Causes, risks and treatment."
***Lakartidningen* 98(25): 3018-23.**

KEYWORDS
Accidents, Traffic/prevention & control/psychology
Disorders of Excessive Somnolence/complications/physiopathology/psychology
Male
Middle Aged
Narcolepsy/complications/physiopathology/psychology
Risk Factors
Sleep Apnea, Obstructive/complications/physiopathology/psychology
Sleep Disorders/*complications/physiopathology/psychology
Sleep Disorders, Circadian Rhythm/complications/physiopathology/psychology
Sleep Stages/physiology

ABSTRACT
Stress and shortage of sleep may cause daytime somnolence and impaired vigilance at the wheel, especially among those suffering from sleep disturbances. According to the international consensus meeting in Stockholm in May of 2000 on "The sleepy driver and pilot--causes, risks and countermeasures", drowsy driving is an underestimated risk factor in official statistics, and as many as 15-30 percent of today's traffic accidents are related to drowsiness; thus it is an even greater risk factor than alcohol. Drowsy drivers suffer from inattention, impaired concentration and may even fall asleep at the wheel. Accidents during dozing result in three times as many fatalities as other accidents. There are a number of reasons for habitual drowsiness at the wheel aside from sleep deprivation, including rhonchopathy, shift work and jet lag, mental depression, insomnia, narcolepsy, endocrinological diseases, periodic limb movement disorder, medication, pain-disordered sleep, and heart disease. Among the most active drivers, i.e. middle aged men, obstructive sleep apnea syndrome (OSAS) has been found to be the most common reason for habitually drowsy driving. OSAS causes a 2-3 fold increased risk of traffic accidents, and it impairs simulated driving. Palatoplasty as well as nasal CPAP have been shown to improve vigilance and driving performance to an extent that the increase in risk is eliminated. Drivers suffering from habitual drowsiness and micro-sleep attacks forcing them to take repeated rests are at special risk. Even if they are as dangerous as drivers with unlawful blood alcohol levels they cannot be caught in a police checkpoint. However they often seek medial advice, and properly treated they may often return safely to traffic. If not, there could be a need to report them to the authorities so as to limit or prohibit their driving.

RESEARCH NOTES

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Hertz, R. P. (1988)
"Tractor-trailer driver fatality: the role of nonconsecutive rest in a sleeper berth."
Accid *Anal Prev* 20(6): 431-9.

KEYWORDS
Accidents, Traffic/*mortality
Circadian Rhythm
Fatigue/*complications
Regression Analysis
Risk Factors
Sleep Deprivation
Time Factors

ABSTRACT
Federal regulation allows truck drivers to use sleeper berths to accumulate eight hours of off-duty rest in two separate periods. Because sleep disruption may cause fatigue and deterioration of performance, a study was conducted to evaluate the association between sleeper-berth use in two periods and tractor-trailer driver fatality. Using Bureau of Motor Carrier Safety Reports, crashes that resulted in tractor-trailer driver fatality were compared with property damage crashes. After adjusting for confounding variables by logistic regression, tractor-trailer driver fatality was found to be significantly associated with sleeper-berth use in two shifts (odds ratio = 3.05). Statistically significant but weaker associations were found between driver fatality and rural district, night driving, gross vehicle weight of 72,000 pounds or more, single-vehicle collision, intercity trip, and employment on an occasional basis.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=3228467

Horne , J., and Reyner, Louise (2001)
"Sleep-related vehicle accidents: some guides for road safety policies."
***Transportation Research Part F: Traffic Psychology and Behaviour* 4(1): 11.**

KEYWORDS
Sleepiness
Time of day
Shiftwork
Vehicle accidents
Safety policies
Countermeasures
Sleep disorders

ABSTRACT
Sleep-related vehicle accidents (SRVAs) are a common form of highway accident, often wrongly attributed to other causes. SRVAs typically involve running off the road or into the back of another vehicle, with no braking beforehand. Because of a high impact speed these accidents are often serious. SRVAs peak around 02:00-06:00 hand 14:00-16:00 h, when daily sleepiness is naturally higher. Hence, time of day is a critical factor, as important as the duration of the drive. Most SRVAs are not due to sleep pathology. Many are work-related. Non-sleeping "rest" is no substitute for sleep. Sleep does not occur spontaneously without warning, and is preceded by feelings of increasing sleepiness of which drivers are quite aware. Driving impairment is usually worse than is realized by the sleepy driver. The best countermeasure is sleep, or even a short nap. Even more effective is the combination of a nap with caffeine.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236172%232001%23999959998%23242693%23FLA%23&_cdi=6172&_pubType=J&view=c&_auth=y&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=bdccf7a2c480a79d95cc4e5562bffae5

Horne, J. A. and L. A. Reyner (1995)
"Sleep related vehicle accidents." ***Bmj*** **310(6979): 565-7.**

KEYWORDS
Accidents, Traffic/statistics & numerical data
Adolescent
Adult
Age Factors
Automobile Driving
England/epidemiology
Female
Humans
Incidence
Male
Middle Aged
Sleep
Time Factors

ABSTRACT
OBJECTIVES: To assess the incidence, time of day, and driver morbidity associated with vehicle accidents where the most likely cause was the driver falling asleep at the wheel. DESIGN: Two surveys were undertaken, in southwest England and the midlands, by using police databases or on the spot interviews. SUBJECTS: Drivers involved in 679 sleep related vehicle accidents. RESULTS: Of all vehicle accidents to which the police were summoned, sleep related vehicle accidents comprised 16% on major roads in southwest England, and over 20% on midland motorways. During the 24 hour period there were three major peaks: at around 0200, 0600, and 1600. About half these drivers were men under 30 years; few such accidents involved women. CONCLUSIONS: Sleep related vehicle accidents are largely dependent on the time of day and account for a considerable proportion of vehicle accidents, especially those on motorways and other monotonous roads. As there are no norms for the United Kingdom on road use by age and sex for time of day with which to compare these data, we cannot determine what the hourly exposure v risk factors are for these subgroups. The findings are in close agreement with those from other countries.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=7888930

Johns, M. W. (2000)
"A Sleep Physiologist's View of the Drowsy Driver." Transportation Research Part F: Traffic Psychology and Behaviour 3(4): 241-249.

KEYWORDS
Driving
Drowsiness
Sleepiness
Vehicle accidents

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
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Klauer, S. G., T. A. Dingus, et al. (2003)
The Effects Of Fatigue On Driver Performance For Single And Team Long-Haul Truck Drivers. ***Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design.***

KEYWORDS
No keywords provided.

ABSTRACT
Driver fatigue is an important safety issue for long-haul truck drivers. To provide an efficient means of obtaining sleep, long-haul truck drivers often use tractors equipped with sleeper berth units. Depending on the type of cargo and distances traveled, long-haul truck drivers either drive in teams or alone as single drivers. Team drivers, therefore, typically sleep in a moving truck whereas single drivers sleep in a stationary truck. It has been hypothesized that sleeping in a moving truck could adversely affect the sleep quality and, therefore, the alertness level of team drivers. A naturalistic data collection system was developed and installed in two Class 8 heavy trucks. This trigger-based system consisted of vehicle sensors and cameras that allowed the experimenters to obtain the driving performance and driver alertness data for analysis of fatigue. Fatigue was measured using both objective and subjective measures that were recorded before and after sleep and while driving. Fatigue and driving performance were compared for single versus team drivers to determine which driver type acquired the greatest sleep deficit during a trip. Results suggest that single drivers were more frequently involved in critical incidents while exhibiting extreme drowsiness than were team drivers by a factor of 4 to 1. These results will be discussed in relation to the general safety of single versus team trucking operations.

RESEARCH NOTES

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No URL provided.

Knipling, R. (1995-1998)
"Driver Alertness and Fatigue: Summary of Completed Research Projects, 1995–98." ***Federal Motor Carrier Safety Administration.***

KEYWORDS
No keywords provided.

ABSTRACT
This document describes projects in the Federal Motor Carrier Safety Administration's (FMCSA) Driver Alertness and Fatigue Research and Technology (R&T) focus area that were completed during the years 1995 to 1998 under the former Office of Motor Carriers (OMC) in the Federal Highway Administration (FHWA). Information on more recently completed, current, and planned projects on driver fatigue is contained in the Driver Alertness and Fatigue R&T Focus Area Summary, which is available on the FMCSA Web site: http://www.fmcsa.dot.gov.

RESEARCH NOTES

URL
http://www.fmcsa.dot.gov/documents/tb00-006.pdf

Kwon, T. M. (1999)
***Automatic Detection of Driver Fatigue - Phase III*, University of Minnesota: 36.**

KEYWORDS
Driver Fatigue
CCD Cameras
Tracking
Micro-Sleeps

ABSTRACT
Sleep deprivation and sleep disorder continues to cause problems on the road. Reducing the number of accidents related to driver fatigue would save the society a significant amount of money and personal suffering.

Monitoring the driver's symptoms can help determine driver fatigue early enough to prevent accidents due to lack of awareness. This report describes advances towards a non-intrusive approach for real-time detection of driver fatigue. It uses a video camera that points directly toward the driver's face and monitors the driver's eye to detect micro-sleeps, or short periods of sleep of about three-to-four seconds.

RESEARCH NOTES

URL
No URL provided.

Document available from National Technical Information Services, Springfield, VA

Lal, S. K. L. and A. Craig (2001)
"A Critical Review of the Psychophysiology of Driver Fatigue." ***Biological Psychology*** **55(3): 173-194.**

KEYWORDS
Electroencephalography
Electro-occulogram
Driver fatigue
Countermeasure
Anxiety
Mood

ABSTRACT
Driver fatigue is a major cause of road accidents and has implications for road safety. This review discusses the concepts of fatigue and provides a summary on psychophysiological associations with driver fatigue. A variety of psychophysiological parameters have been used in previous research as indicators of fatigue, with electroencephalography perhaps being the most promising. Most research found changes in theta and delta activity to be strongly linked to transition to fatigue. Therefore, monitoring electroencephalography during driver fatigue may be a promising variable for use in fatigue countermeasure devices. The review also identified anxiety and mood states as factors that may possibly affect driver fatigue. Furthermore, personality and temperament may also influence fatigue. Given the above, understanding the psychology of fatigue may lead to better fatigue management. The findings from this review are discussed in the light of directions for future studies and for the development of fatigue countermeasures.

RESEARCH NOTES

URL
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Lal, S. K. L. and A. Craig (2001)
"Electroencephalography Activity Associated with Driver Fatigue: Implications for a Fatigue Countermeasure Device." ***Journal of Psychophysiology*** **15(3): 183-189.**

KEYWORDS
Fatigue
Countermeasure
Electroencephalography
Neurophysiology
Drowsiness

ABSTRACT
This paper reviews the association between electroencephalography (EEG) activity and driver fatigue. The current literature shows substantial evidence of changes in brain wave activity, such as simultaneous changes in slow-wave activity (e.g., delta and theta activity) as well as alpha activity during driver fatigue. It is apparent from the literature review that EEG is a promising neurophysiological indicator of driver fatigue and has the potential to be incorporated into the development of a fatigue countermeasure device. The findings from this review are discussed in the light of directions for future fatigue research studies.

RESEARCH NOTES

URL
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Lal, S. K. L. and A. Craig (2002)
"Driver Fatigue: Electroencephalography and Psychological Assessment." ***Psychophysiology*** **39: 313-321.**

KEYWORDS
Driver fatigue
Electroencephalography
Electro-oculogram
Countermeasure
Mood
Anxiety

ABSTRACT
Fatigue has major implications for transportation system safety; therefore, investigating the psychophysiological links to fatigue could enhance our understanding and management of fatigue in the transport industry. This study examined the psychophysiological changes that occurred during a driver simulator task in 35 randomly selected subjects. Results showed that significant electroencephalographic changes occur during fatigue. Delta and theta activity were found to increase significantly during fatigue. Heart rate was significantly lower after the driving task. Blink rate also changed during the fatigue task. Increased trait anxiety, tension–anxiety, fatigue–inertia and reduced vigor–activity were shown to be associated with neurophysiological indicators of fatigue such as increased delta and theta activity. The results are discussed in light of directions for future studies and for the development of a fatigue countermeasure device.

RESEARCH NOTES

URL
No URL provided.

Liu, G. F., S. Han, et al. (2003)
"Driver sleepiness and risk of car crashes in Shenyang, a Chinese northeastern city: population-based case-control study." ***Biomed Environ Sci*** **16(3): 219-26.**

KEYWORDS
Accidents, Traffic
Adult
Aged
Automobile Driving
Case-Control Studies
China
Fatigue
Female
Male
Middle Aged
Risk Factors
Sleep
Urban Population

ABSTRACT
OBJECTIVE: To estimate the association of driver sleepiness with the risk of car crashes. METHODS: A population-based case-control study was conducted in Shenyang, a northeastern city in China, between November 2001 and July 2002. The case group comprised 406 car drivers involved in crashes, and 438 car drivers recruited at randomly selected sites, and on the day of week, and the time of day when they were driving on highways in the study region during the study period were used as control groups. Face-to-face interviews with drivers were conducted according to a well-structured questionnaire covering the circumstances of their current trip and their background information. Stanford sleepiness scale and Epworth sleepiness scale were used to quantify acute sleepiness and chronic sleepiness respectively. RESULTS: There was a strong association between chronic sleepiness and the risk of car crash. Significantly increased risk of crash was associated with drivers who identified themselves as sleepy (Epworth sleepiness score > or = 10 vs< 10; adjusted odds ratio 2.07, 95% confidence interval 1.30 to 3.29), but no increased risk was associated with measures of acute sleepiness. CONCLUSIONS: Chronic sleepiness in car drivers significantly increases the risk of car crash. Reductions in road traffic injuries may be achieved if fewer people drive when they are sleepy.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14631827

Massie , D., Blower, Daniel, and Campbell, Kenneth (1997)
***Short haul trucks and driver fatigue*, Center for national truck statistics: 50.**

KEYWORDS
Short-Haul Trucks
Driver Fatigue
Fatal Crash Rates

ABSTRACT
This report has two main objectives. The first is to present data that may be used to create a definition of short-haul trucks in computerized data files. The second is to examine the prevalence of driver fatigue as coded in crash data files and relate it to parameters that define short-haul trucking operations.
Tabulations were made of the numbers of large trucks registered in the United States and their annual travel using data from the 1992 Truck Inventory and Use Survey. Truck crash statistics were derived from the 1991-1993 Trucks Involved in Fatal Accidents file and, to a lesser extent, 1995 SafetyNet data. These tabulations were cross-classified by gross vehicle weight rating (GV\VR) class, area of operation and vehicle type, and crash involvement rates per truck and per mile were generated.
Three possible definitions of short-haul trucks are proposed and the different definitions are compared in terms of percentage of registered trucks and miles traveled, fatal crash involvements, fatal involvement rates per truck and per mile, and prevalence of fatigue-related fatal crash involvements. The results may assist others in making decisions about hours of service regulations for the short-haul segment of the trucking industry.

RESEARCH NOTES

URL
http://books.google.com/books?id=FyzpVOOyKKAC&dq=Short+haul+trucks+and+driver+fatigue&q=Short+haul+trucks+and+driver+fatigue&pgis=1

Maycock, G. (1996)
"Sleepiness and driving: the experience of UK car drivers." ***J Sleep Res*** **5(4): 229-37.**

KEYWORDS
Accidents, Traffic
Adolescent
Adult
Age Factors
Automobile Driving
Disorders of Excessive Somnolence
Great Britain
Male
Middle Aged
Questionnaires
Sleep
Snoring

ABSTRACT
A postal questionnaire survey aimed at exploring the relationship between accidents and daytime sleepiness was sent to 9000 male drivers of which 4621 (51.3%) responded (mean age 47.7, SD 17.1). Drivers provided details of the accidents they had experienced in the last 3 y, and identified those factors, including tiredness, they thought contributed to the accident. In addition, drivers completed the Epworth scale measuring daytime sleepiness and reported whether they had felt close to falling asleep whilst driving during the past 12 mo. Analysis of the data showed that 29% of drivers had felt close to falling asleep at the wheel in the last 12 mo, the probability of which depended on Epworth score, age, occupational group, annual mileage, the proportion of time spent driving on motorways and in built-up areas, how long the driver is prepared to drive before taking a break, and whether the driver is driving a company car or not. Overall, about 7% of accident 'involvements' were associated with tiredness (representing 9-10% of accidents)-a figure which is higher on motorways than on rural roads or built-up roads and higher still in the early hours of the morning. Accident rates of company car drivers and/or those who have felt close to falling asleep at the wheel in the last year are shown to be associated with daytime sleepiness. For example, a company car driver who has felt close to falling asleep at the wheel in the last 12 mo and who scores highly on the Epworth scale has an accident liability which is 70% higher than a similar driver who scores zero on the Epworth scale. Snoring every night increases accident liability by about 30%.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9065874

McCartt, A. T., S. A. Ribner, et al. (1996)
"The scope and nature of the drowsy driving problem in New York State." ***Accid Anal Prev*** **28(4): 511-17.**

KEYWORDS
Accidents, Traffic/*statistics & numerical data
Adolescent
Adult
Aged
Automobile Driving/*statistics & numerical data
Female
Health Knowledge, Attitudes, Practice
Male
Middle Aged
New York/epidemiology
Questionnaires
Risk Factors
Sleep Stages
Time Factors
Work Schedule Tolerance

ABSTRACT
A telephone survey was conducted of a random sample of New York State licensed drivers to determine the prevalence and circumstances of drowsy driving. Based on the survey responses, 54.6% of the drivers had driven while drowsy within the past year; 22.6% had ever fallen asleep at the wheel without having a crash, 2.8% had ever crashed when they fell asleep, and 1.9% had crashed when driving while drowsy. Of the reported crashes due to driving while drowsy or falling asleep at the wheel, 82.5% involved the driver alone in the vehicle, 60.0% occurred between 11:00 p.m. and 7:00 a.m. 47.5% were drive-off-road crashes, and 40.0% occurred on a highway or expressway. Multiple regression analysis suggested that the following driver variables are predictive of an increased frequency of driving drowsy: demographic characteristics (younger drivers, more education, and men); sleep patterns (fewer hours of sleep at night and greater frequency of trouble staying awake during the day); work patterns (greater frequency of driving for job and working rotating shifts); and driving patterns (greater number of miles driven annually and fewer number of hours a person can drive before becoming drowsy).

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8870778

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"Falling asleep at the wheel: aclose look at 1,269 fatal and serious injury-producing crashes." ***Behav Sleep Med*** **1(3): 171-83.**

KEYWORDS
Accidents, Traffic/*mortality/statistics & numerical data
Adolescent
Adult
Automobile Driving
Female
Humans
Male
Sleep
Wounds and Injuries/*epidemiology

ABSTRACT
This article reviews the literature on the prevalence of sleep-related motor vehicle crashes and presents a detailed analysis of the driver and context variables associated with a sample of 1,269 sleepy-driver, fatal and injury-causing vehicle crashes that occurred over a 6-year period in Tennessee. The crash profiles and trends are discussed in terms of their implications for addressing this significant problem in highway safety. Findings suggest that younger drivers, ages 15-21, are more at-risk for sleep-related motor vehicle crashes. Also, there is some evidence for the effectiveness of rumble strips in reducing sleep-related, run-off-road, interstate crashes.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15600220

NCSDR/NHTSA
Drowsy Driving And Automobile Crashes.
NHTSA.

KEYWORDS
Sleep
Circadian Rhythms
Sleepiness
Drowsiness
Sleep Physiology
Sleep Disorders
Traffic Safety
Technology
Alerting Devices
Industrial Accidents
Shift Work

ABSTRACT
Drowsy driving is a serious problem that leads to thousands of automobile crashes each year. This report, sponsored by the National Center on Sleep Disorders Research (NCSDR) of the National Heart, Lung, and Blood Institute of the National Institutes of Health, and the National Highway Traffic Safety Administration (NHTSA), is designed to provide direction to an NCSDR/NHTSA educational campaign to combat drowsy driving. The report presents the results of a literature review and opinions of the Expert Panel on Driver Fatigue and Sleepiness regarding key issues involved in the problem. Sleep is a neurobiologic need with predictable patterns of sleepiness and wakefulness. Sleepiness results from the sleep component of the circadian cycle of sleep and wakefulness, restriction of sleep, and/or interruption or fragmentation of sleep. The loss of one night's sleep can lead to extreme short-term sleepiness, while habitually restricting sleep by 1 or 2 hours a night can lead to chronic sleepiness. Sleeping is the most effective way to reduce sleepiness. Sleepiness causes auto crashes because it impairs performance and can ultimately lead to the inability to resist falling asleep at the wheel. Critical aspects of driving impairment associated with sleepiness are reaction time, vigilance, attention, and information processing.

Subjective and objective tools are available to approximate or detect sleepiness. However, unlike the situation with alcohol-related crashes, no blood, breath, or other measurable test is currently available to quantify levels of sleepiness at the crash site. Although current understanding largely comes from inferential evidence, a typical crash related to sleepiness has the following characteristics:

- The problem occurs during late night/ early morning or midafternoon.
- The crash is likely to be serious.
- A single vehicle leaves the roadway.
- The crash occurs on a high-speed road.
- The driver does not attempt to avoid a crash.
- The driver is alone in the vehicle.

Although evidence is limited or inferential, chronic predisposing factors and acute situational factors recognized as increasing the risk of drowsy driving and related crashes include:

- Sleep loss.
- Driving patterns, including driving between midnight and 6 a.m.; driving a substantial number of miles each year and/or a substantial number of hours each day; driving in the midafternoon hours (especially for older persons); and driving for longer times without taking a break.
- Use of sedating medications, especially prescribed anxiolytic hypnotics, tricyclic antidepressants, and some antihistamines
- Untreated or unrecognized sleep disorders, especially sleep apnea syndrome (SAS) and narcolepsy.
- Consumption of alcohol, which interacts with and adds to drowsiness. These factors have cumulative effects; a combination of them substantially increases crash risk.
- Although no driver is immune, the following three population groups are at highest risk, based on evidence from crash reports and self-reports of sleep behavior and driving performance.
- Young people (ages 16 to 29), especially males. Shift workers whose sleep is disrupted by working at night or working long or irregular hours. People with untreated sleep apnea syndrome (SAS) and narcolepsy.

To prevent drowsy driving and its consequences, Americans need information on approaches that may reduce their risks. The public needs to be informed of the benefits of specific behaviors that help avoid becoming drowsy while driving. Helpful behaviors include (1) planning to get sufficient sleep, (2) not drinking even small amounts of alcohol when sleepy, and (3) limiting driving between midnight and 6 a.m. As soon as a driver becomes sleepy, the key behavioral step is to stop driving-for example, letting a passenger drive or stopping to sleep before continuing a trip. Two remedial actions can make a short-term difference in driving alertness: taking a short nap (about 15 to 20 minutes) and consuming caffeine equivalent to two cups of coffee. The effectiveness of any other steps to improve alertness when sleepy, such as opening a window or listening to the radio, has not been demonstrated.

A more informed medical community could help reduce drowsy driving by talking to patients about the need for adequate sleep, an important behavior for good health as well as drowsy-driving prevention. The detection and management of illnesses that can cause sleepiness, such as SAS and narcolepsy, are other health care-related countermeasures.
Information could be provided to the public and policymakers about the purpose and meaning of shoulder rumble strips, which alarm or awaken sleepy drivers whose vehicles are going off the road. These rumble strips placed on high-speed, controlled-access, rural roads reduce drive-off-the-road crashes by 30 to 50 percent. However, rumble strips are not a solution for sleepy drivers, who must view any wake-up alert as an indication of impairment-a signal to stop driving and get adequate sleep before driving again.

Employers, unions, and shift work employees need to be informed about effective measures they can take to reduce sleepiness resulting from shift work schedules. Countermeasures include following effective strategies for scheduling shift changes and, when shift work precludes normal nighttime sleep, planning a time and an environment to obtain sufficient restorative sleep.

URL
http://www.nhtsa.dot.gov/PEOPLE/INJURY/drowsy_driving1/drowsy.html

Nordbakke, S. and F. Sagberg (2007)
"Sleepy at the Wheel: Knowledge, Symptoms and Behaviour among Car Drivers."
***Transportation Research Part F: Traffic Psychology and Behaviour* 10(1): 1-10.**

KEYWORDS
Sleepiness
Behaviour
Road safety

ABSTRACT
Driver sleepiness has been shown to be one of the most important risk factors in road crashes. The aim of the present study was to increase the understanding of drivers' actions when feeling sleepy. A national Internet panel survey was conducted among private drivers in the autumn of 2003. Reported symptoms of sleepiness differed between drivers who had fallen asleep and those who had not, but had been afraid to do so. The results indicate that drivers in general have a good knowledge of the various factors influencing the risk of falling asleep while driving. Furthermore, most of them are well aware of the most effective measures to prevent falling asleep at the wheel, such as stopping the car and take a nap. In spite of all their knowledge, most of the drivers continue driving when recognising sleepiness while driving. A short trip, appointments, and the wish to arrive at a reasonable hour are the most frequently reported reasons for continuing driving while fatigued or sleepy.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science/article/B6VN8-4JVSWY2-1/2/6d86b526f00cbfc12bdc32a60fa1fe12

Pack, A. I., A. M. Pack, et al. (1995)
"Characteristics of crashes attributed to the driver having fallen asleep." ***Accid Anal Prev*** **27(6): 769-75.**

KEYWORDS
Accidents, Traffic/*mortality/prevention & control
Adolescent
Adult
Aged
Alcoholic Intoxication/complications/mortality/prevention & control
Circadian Rhythm
Cross-Sectional Studies
Female
Male
Middle Aged
North Carolina/epidemiology
Risk Factors
Sleep
Wounds and Injuries/mortality/prevention & control

ABSTRACT
While it has been known for some time that crashes can result from the driver falling asleep at the wheel, this issue has received less attention in traffic safety programs than the role of alcohol or speed of the vehicle. The present study was done to investigate the characteristics of crashes attributed to the driver being asleep. The study utilized the database at the Highway Safety Research Center at the University of North Carolina that is based on the uniform crash reporting system in that state. Over the years 1990-1992, inclusive, there were 4333 crashes in which the driver was judged to be asleep but not intoxicated. The crashes were primarily of the drive-off-the-road type (78% of the total) and took place at higher speeds (62% in excess of 50 mph). The fatality rate was of similar magnitude to that in alcohol-related crashes with fatalities in 1.4% of such crashes (alcohol crashes had fatalities in 2.1%). The crashes occurred primarily at two times of day--during the nighttime period of increased sleepiness (midnight to 7.00 a.m.) and during the mid-afternoon "siesta" time of increased sleepiness (3.00 p.m.). These crashes occurred predominately in young people. Fifty-five percent of these were in individuals 25 years of age or younger, with a peak age of occurrence at age 20 years. Sleepiness may play a role in crashes other than those attributed by the police to the driver being asleep. Determining the magnitude of this role is a challenge to the traffic safety community.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8749280

Putcha, D. (2001)
***Bus Accidents in the United States 1995-1999*. Washington, DC: 22.**

KEYWORDS
No keywords provided.

ABSTRACT
This document presents aggregate statistics on buses involved in traffic accidents over five years, 1995-1999. These statistics are derived from two sources: the Fatality Analysis Reporting System (FARS) file maintained by the National Highway Traffic Safety Administration (NHTSA) and the General Estimates System (GES) file, also maintained by NHTSA. All figures for involvements in fatal accidents and fatalities are taken from the FARS files. The GES files are used to extend the analysis to nonfatal accidents.

An estimated 286,000 buses were involved in traffic accidents over the five year period, 1995-1999. About 1,483 of these were fatal bus involvements. There were 1,698 fatalities and 154,000 injuries in accidents involving buses.

RESEARCH NOTES

URL
No URL provided.

Radun, I. and H. Summala (2004)
"Sleep-related fatal vehicle accidents: characteristics of decisions made by multidisciplinary investigation teams." ***Sleep*** **27(2): 224-7.**

KEYWORDS
Accidents, Traffic/*mortality/*statistics & numerical data
Adult
Aged
Automobile Driving
Decision Making
Fatigue/epidemiology
Female
Finland/epidemiology
Humans
Male
Middle Aged
Patient Care Team
Sleep Deprivation/*epidemiology
Time Factors

ABSTRACT
OBJECTIVES: To analyze factors that explain the attribution of crash causes as sleep-related by accident investigators. DESIGN: Analysis of national database of fatal road accidents studied in depth. All nonprofessional nonintoxicated car drivers responsible for a fatal accident from 1991 to 2001 were included (N = 1464). SETTING: Finland, with approximately 5.1 million inhabitants and 2.3 million motor vehicles. PARTICIPANTS: N/A. INTERVENTIONS: N/A. MEASUREMENTS: Comprehensive database recorded by multidisciplinary investigation teams, with specific emphasis on the availability of sleep-related driver variables and sleep-related causal decisions by teams. RESULTS: Injury severity, age, and marital status of the responsible car driver were related to the proportion of missing data in fatigue-related variables in the database (sleeping time, time awake, lifetime mileage). While there were differences between investigation teams and their activities, a series of logistic regression models showed that the lack of relevant variables in the database did not affect the proportion of accidents attributed to falling asleep (10% of cases) or as having fatigue-related causal factors (an additional 5% of the cases). The accident type (head-on and running-off versus other) and road conditions (dry or wet versus icy or snowy pavement) predicted the investigation teams' attribution of sleep-related causes in all models. CONCLUSIONS: Multidisciplinary teams' attribution of sleep-related causal factors were rather stable, comprising 10% to 15% of the cases investigated, independent of the availability of specific sleep-related information.

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15124714

Rajaratnam, S. M. and C. B. Jones (2004)
"Lessons about sleepiness and driving from the Selby rail disaster case: R v Gary Neil Hart." ***ChronobiolInt*** **21(6): 1073-7.**

KEYWORDS
Accidents, Traffic/legislation & jurisprudence
Automobile Driving
Humans
Male
Risk Factors
Sleep
Wakefulness

ABSTRACT
In April 2003, near the town of Selby in North Yorkshire, England, a motor vehicle went off the road to cause a train collision, killing 10 and injuring more than 70 people. The driver of the vehicle, Gary Neil Hart, had allegedly fallen asleep while driving, and was charged and subsequently convicted of causing death by dangerous driving. Evidence from an expert witness was led by the prosecution to establish that Hart had in fact fallen asleep, and that prior to falling asleep, he knew (or ought to have known) that he was at risk of falling asleep but nevertheless continued to drive. The issue of whether and to what extent individuals are aware that they are about to fall asleep has significant implications for criminal prosecutions. Generally, the definition of a criminal offense includes a mental element such as intent or knowledge. Therefore, it is imperative that issues such as whether in every individual there is forewarning of sleep and the degree to which individuals are able to self-assess their ability to continue driving under conditions of extreme sleepiness must be resolved. Sleepiness is now regarded as the largest identifiable and preventable cause of accidents in all modes of transportation. Litigation for such accidents is likely to increase, and therefore it is of great importance that further research be undertaken to examine the process of falling asleep, especially the subjective experiences immediately preceding sleep.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15646252

Rey de Castro, J., J. Gallo, et al. (2004)
"Tiredness and sleepiness in bus drivers and road accidents in Peru: a quantitative study." ***Rev PanamSaludPublica*** **16(1): 11-8.**

KEYWORDS
Accidents, Traffic/psychology/*statistics & numerical data
Adult
Age Factors
Aged
Attention
Automobile Driving/psychology/*statistics & numerical data
Awareness
Cross-Sectional Studies
Fatigue/*epidemiology
Humans
Male
Middle Aged
Peru/epidemiology
Sleep Deprivation/*epidemiology

ABSTRACT
OBJECTIVE: To evaluate the relationship that tiredness and sleepiness in bus drivers have to road accidents in Peru. Information from various countries indicates that driver sleepiness plays an important role in road accidents. However, there is only limited information on this subject in Peru. METHODS: Using a supervised, pretested survey, a cross-sectional observational and comparative study was carried out with 238 bus drivers who drive on the Northern Pan American Highway of Peru. To determine the relationship between variables the chi-square test was used, along with the Pearson correlation coefficient. The level of significance was set at $P < 0.05$. The variables analyzed were: tiredness, sleepiness, hours of driving per day, daily hours of sleep, body mass index, snoring, sleep apnea, and either having had or almost having had an accident while driving. RESULTS: Of the 238 drivers, all of them were men, 45% said they had had or nearly had had an accident while driving, 55% slept less than 6 hours per day, 31% had slept less than 6 hours in the 24 hours before answering the survey, and 80% were in the habit of driving more than 5 hours without stopping. Of the drivers, 56% of them reported being tired at least some of the time while driving; of this group, 65% of them reported being tired during the early morning. Seventy-six drivers (32%) said that while they were driving their eyes had fallen shut. In terms of where they slept, 194 of the drivers (81%) said they always slept in the lower luggage compartment of the bus while another driver was driving the bus or when the bus was parked in the bus terminal. The steps that drivers took to avoid falling asleep while driving included: wetting the face with water, eating fruit, opening the window of the driver's compartment, drinking coffee, listening to music, smoking, chewing coca leaves, and drinking alcohol mixed with coca leaves. In the opinion of 55% of the drivers, the leading cause of road accidents is tiredness. Accidents and near-accidents while driving occurred mainly between

midnight and 6 a. m. Having an accident or a near-accident was strongly associated with tiredness and with having the eyes drop shut while driving ($P < 0.0005$). CONCLUSIONS: Tiredness and sleepiness while driving were common among the bus drivers, with various possible causes: acute and chronic sleep deprivation, irregular schedule changes, and sleep disorders due to the drivers' working conditions. Our results support the hypothesis that fatigue and sleepiness among bus drivers are related to road accidents.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15333261

Sagberg, F. (1999)
"Road accidents caused by drivers falling asleep." ***Accid Anal Prev*** **31(6): 639-49.**

KEYWORDS
Accidents, Traffic/prevention & control/statistics & numerical data
Attention
Female
Logistic Models
Male
Sleep
Sleep Stages
Time Factors

ABSTRACT
About 29600 Norwegian accident-involved drivers received a questionnaire about the last accident reported to their insurance company. About 9200 drivers (31%) returned the questionnaire. The questionnaire contained questions about sleep or fatigue as contributing factors to the accident. In addition, the drivers reported whether or not they had fallen asleep some time whilst driving and what the consequences had been. Sleep or drowsiness was a contributing factor in 3.9% of all accidents, as reported by drivers who were at fault for the accident. This factor was strongly over-represented in night-time accidents (18.6%), in running-off-the-road accidents (8.3%), accidents after driving more than 150 km on one trip (8.1%), and personal injury accidents (7.3%). A logistic regression analysis showed that the following additional factors made significant and independent contributions to increasing the odds of sleep involvement in an accident: dry road, high speed limit, driving one's own car, not driving the car daily, high education, and few years of driving experience. More male than female drivers were involved in sleep-related accidents, but this seems largely to be explained by males driving relatively more than females on roads with high speed limits. A total of 10% of male drivers and 4% of females reported to have fallen asleep while driving during the last 12 months. A total of 4% of these events resulted in an accident. The most frequent consequence of falling asleep—amounting to more than 40% of the reported incidents—was crossing of the right edge-line before awaking, whereas crossing of the centreline was reported by 16%. Drivers' lack of awareness of important precursors of falling asleep—like highway hypnosis, driving without awareness, and similar phenomena—as well as a reluctance to discontinue driving despite feeling tired are pointed out as likely contributors to sleep-related accidents. More knowledge about the drivers' experiences immediately preceding such accidents may give a better background for implementing effective driver warning systems and other countermeasures.

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10487339

Steier, S., S. Vinker, et al. (2003)
"Driver drowsiness—are physicians at a special risk?" ***Harefuah*** **142(5): 338-41, 399, 398.**

KEYWORDS
Accidents, Traffic/prevention & control
Automobile Driving/*psychology
Fatigue/*etiology
Female
Male
Nurses
Occupational Diseases/*physiopathology/psychology
Physicians
Questionnaires
Risk Assessment
Work Schedule Tolerance

ABSTRACT
BACKGROUND: Sleepiness at the wheel is the main cause of approximately a fifth of road traffic accidents. The driver will often feel drowsy before the accident, therefore preventive measures can be taken in order to stay alert. AIM: To estimate sleepiness among sleep deprived drivers and to explore methods they use to stay alert. METHODS: We choose three professions at increased risk of sleepiness: physicians working night shifts, night shift nurses and hi-tech workers who work 12 hours or more a day at least twice a week. The subjects answered an anonymous questionnaire concerning past involvement in road accidents or "near misses", known risk factors for road accidents and methods used to fight sleepiness, as well as some demographic data. RESULTS: A total of 115 drivers (38 physicians, 37 nurses and 40 hi-tech workers) participated in this study. The average age was 36.0 + 7.9 years and 53% males. Thirteen percent had been involved in road accidents as drivers in the last year, 53% of them remember that the accident was due to sleepiness or fatigue. Thirty-seven percent remember at least one occasion of "near accident" due to sleepiness. Driving in the "dangerous" hours was positively associated with "near accidents" (69% vs. 29%, $p < 0.001$) and in accidents (17% vs. 11% P = NS). Physicians were involved in "near accidents" ($p < 0.005$) more often. The most frequent methods used to overcome sleepiness were: listening to the radio (86.1%), opening the window (65.2%) and turning on the air conditioning in the car (57.4%). CONCLUSION: Driving whilst sleepy is an important contributor to road accidents. It seems that sleep deprived workers and especially physicians working in shifts, are at an increased risk. This issue should receive a higher priority as part of preventive medicine among physicians themselves and their patients.

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12803055

Streff, F., Spradlin, H. (2000)
Driver Distraction, Aggression, and fatigue: A synthesis of the literature and guidelines for michigan planning. **Ann Arbor, UMTRI: 40.**

KEYWORDS
Distraction
Aggression
Fatigue
Attention
Aggressive Driving
Road
Rage, Sleepiness
Traffic Crash
Planning

ABSTRACT
This report summarizes literature on the issues of distraction, attention, aggression and fatigue as they relate to driving behavior and traffic crashes. There are three sections to this report: Distraction and Attention, Aggression, and Fatigue. Information in each section is presented in the same basic format. First, the key term for each section is defined. Second, the research findings in the area and their implications for OHSP program development are discussed. Finally, the report concludes with an annotated bibliography of relevant literature from each subject area.

RESEARCH NOTES

URL
No URL provided.

Thiffault, P. and J. Bergeron (2003). "Fatigue and individual differences in monotonous simulated driving." ***Personality And Individual Differences*** **34(1): 159-176.**

KEYWORDS
Driver Fatigue
Drowsiness
Vigilance
Individual Differences
Sensation Seeking
Extraversion
Road Accidents
Driver Evaluation
Task-Induced Fatigue
Driver Fatigue
Drowsiness Accidents
Traffic Signs
Performance
Vigilance
Countermeasures
Extroversion
Sleepiness
Attention

ABSTRACT
This study aims at evaluating personality predictors of driver fatigue. Individual differences in subject's performance are well documented in vigilance studies. Since monotonous highway driving can be seen as a vigilance task, it is possible that these differences materialize in this context and explain a portion of fatigue-related driving errors and accidents. Fifty-six male subjects drove for two 40 min periods on a straight highway. Road environment was repetitive and monotonous in one condition (road A), whilst visual elements aiming to disrupt monotony were presented in the other one (road 13). Multiple regression analyses showed that sensation seeking, and more specifically the Experience Seeking (ES) dimension, are predictive of the standard deviation of steering wheel movements, a performance measure used to assess driver fatigue. ES explains 12.3% of the observed variance on road A and 8% on road B. An interaction effect was also obtained between extraversion and sensation seeking on road A, where sensation seeking explained 26% of the observed variance, but only for the more extraverted subjects. Results also indicate that subjects who report falling asleep at the wheel in the past tend to be high sensation seekers. Implications in terms of driver evaluation and management are discussed (C) 2002 Elsevier Science Ltd. All rights reserved.

URL
No URL provided.

Department for Transport.Driver Sleepiness (No.21)
***London, Department for Transport*: 1-12.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
http://www.dft.gov.uk/pdf/pgr/roadsafety/research/rsrr/theme3/driversleepinessno21

Weinger, M. a. S. A.-I. (2002)
Sleep Deprivation and Clinical Performance, *American Medical Association*. 287: 3.

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from www.jama.com

A1.2 Annotated Bibliography: Effect of Fatigue on Performance

Baas, P. H., Charlton, Samuel G., and Bastin, Gary T. (2000)
"Survey of New Zealand truck driver fatigue and fitness for duty." ***Transportation Research*****: 185-193.**

KEYWORDS
Fatigue
Performance Tasks
Activity Survey
Hours Of Service
Safety Culture
Social Influences

ABSTRACT
This paper presents recent research into compliance with current driving hours regulations, the effectiveness of using driving hours to predict fatigue, and alternative compliance and enforcement options. The paper describes results of a major survey of truck driver fatigue in New Zealand, a review of international compliance and enforcement procedures, and research focusing on the social forces and influences that affect truck drivers. The survey of truck drivers was based on interviews and performance tests collected from 600 truck drivers at depots, wharves, markets, and other locations throughout the North Island of New Zealand. The interviews included: questions on driver demographic and work/rest patterns, drivers' attitudes towards fatigue, propensity towards daytime sleepiness, and a self-assessment of the driver's momentary level of fatigue. In addition, a simulator-based performance test of driving was undertaken. The performance test included a combination of a standard driving task, a dual-axis sub-critical tracking task (maintaining speed and steering in a controlled but unstable environment, a virtual roadway affected by the appearance of random wind gusts requiring steering correction), and a tertiary or side-task requiring driver monitoring and periodic responses. The initial results from the first 100 drivers have found a sizable number of drivers exceeding the allowable driving hours, high levels of fatigue and sleepiness, and interesting differences between line-haul and local delivery drivers. A related research project into the social processes and relationships that affect truck drivers has resulted in a good understanding of the social conditions that influence cultural change and the actions of truck drivers and fleet managers. In this paper we will have particular regard to these processes in the construction of ideas concerning safety. This includes an understanding of the role of major stakeholders, such as freight forwarders and the enforcement agencies with respect to drivers and their conditions, actions and understanding of the road transport industry. This knowledge coupled with the survey results and an understanding of compliance and enforcement alternatives will be used to explore potential fatigue management options. © 2001 Elsevier Science Ltd. All rights reserved.

URL
http://ntlsearch.bts.gov/tris/record/tris/00810580.html

Baulk, S. D., L. A. Reyner, et al. (2001)
"Driver sleepiness--evaluation of reaction time measurement as a secondary task."
***Sleep* 24(6): 695-8.**

KEYWORDS
Acoustic Stimulation
Adult
Analysis of Variance
Automobile Driving
Disorders of Excessive Somnolence/*diagnosis
Electroencephalography
Female
Humans
Male
Reaction Time

ABSTRACT
The application of reaction time (RT) as a secondary task to determine sleepiness in drivers is of increasing interest, but is a problematic area. We assessed the extent to which RT reflected this sleepiness, and/or otherwise affected driving behaviour in sleep restricted, moderately sleepy people. They drove a real-car interactive simulator for two, two hour afternoon monotonous drives, with and without RT (counterbalanced). Simple auditory RT was used, with a semi-random inter-stimulus interval averaging 21/2 minutes. Lane wandering (driving "incidents"), subjective and EEG measures of sleepiness were obtained. For both conditions all three indices changed significantly during the course of the afternoon circadian "dip". However, this was not reflected in RT, which remained relatively stable. Nevertheless, RT provided more "stimulation" for the sleepy driver, and significantly reduced subjective sleepiness, with a trend for fewer incidents and a more alert EEG. Possible reasons for the disparity in sensitivity between RT and the other measures are discussed. Under this experimental protocol, RT did not provide a useful guide to driver sleepiness; it was merely a mechanism for increasing task load and reducing monotony. The drivers' own insight into their sleepiness had more validity as a tool for assessing sleepiness.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11560183

Desmond, P. A. and G. Matthews (1997)
"Implications of task-induced fatigue effects for in-vehicle countermeasures to driver fatigue." ***Accident Analysis & Prevention*** **29(4): 515.**

KEYWORDS
Transportation
Motor Vehicles
Human Factors
Accidents
Simulation
Fatigue
Safety Engineering

ABSTRACT
Two driving simulator studies are reported which investigate the variation of fatigue effects with task demands and provide recommendations for system design to counteract driver fatigue. Two opposing explanations of the interactive effects of task demands and fatigue were examined. One explanation is that fatigue drains attentional resources, so that detrimental effects of fatigue on performance are accentuated when task demands increase. The alternative explanation is that fatigue disrupts matching of effort to task demands, such that the fatigued driver fails to regulate effort effectively when the task appears easy. In both studies, drivers performed both a fatiguing drive, in the first part of which they were required to perform a secondary detection task, and a control drive with no additional secondary task. In the last part of both drives, drivers were required to detect movement in pedestrian stimuli presented on both sides of the road. Vehicle control and steering movements were logged throughout both drives. The results are consistent with dynamic models of stress and sustained performance which suggest that fatigue may impair adaptation to conditions of underload, but are inconsistent with the attentional resource explanation. These task-specific fatigue effects have important implications for in-vehicle countermeasures to driver fatigue. Current approaches to the implementation of such devices fail to reflect the task-specific nature of fatigue effects. Fatigue-monitoring devices may only be valid in certain driving environments or contexts. Hence, it may be necessary to integrate performance-based feedback monitoring information with route and traffic density information from navigation systems.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V5S-3SWY7V7-F&_user=10&_coverDate=07%2F31%2F1997&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=fb21ce6632c7158d2765803c196161f4

Fairclough, S. H. and R. Graham (1999)
"Impairment of driving performance caused by sleep deprivation or alcohol: a comparative study." ***Hum Factors*** **41(1): 118-28.**

KEYWORDS
Adult
Alcoholic Intoxication/*physiopathology
Automobile Driving
Humans
Male
Middle Aged
Multivariate Analysis
Psychomotor Performance
Sleep Deprivation/*physiology

ABSTRACT
A study was conducted to assess the relative impact of partial sleep deprivation (restriction to 4 h sleep before testing) and full sleep deprivation (no sleep on the night before testing) on 2 h of simulated driving, compared with an alcohol treatment (mean blood alcohol content = 0.07%). Data were collected from the 64 male participants on the primary driving task, psychophysiology (0.1 Hz heart rate variability), and subjective self-assessment. The results revealed that the full sleep deprivation and alcohol group exhibited a safety-critical decline in lane-keeping performance. The partial sleep deprivation group exhibited only noncritical alterations in primary task performance. Both sleep-deprived groups were characterized by subjective discomfort and an awareness of reduced performance capability. These subjective symptoms were not perceived by the alcohol group. The findings are discussed with reference to the development of systems for the online diagnosis of driver fatigue. Potential applications of this research include the formulation of performance criteria to be encompassed within a driver impairment monitoring system.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10354808

Philip, P., J. Taillard, et al. (2003)
"Effect of fatigue on performance measured by a driving simulator in automobile drivers." ***J PsychosomRes*** **55(3): 197-200.**

KEYWORDS
Adolescent
Adult
Age Factors
Automobile Driving/*psychology
Fatigue
Female
Humans
Male
Middle Aged
Risk Factors
Task Performance and Analysis

ABSTRACT
OBJECTIVE: To identify risk factors of performance decrement in automobile drivers. METHODS: 114 drivers (age <30 years, n=57; age > or =30 years, n=57) who stopped at a rest stop area on a freeway were recruited for the study. They filled out a questionnaire on their journey, sleep/wake patterns and performed a 30-min test on a driving simulator. The test evaluates, by computerized analysis, the lateral deviation of a virtual car from an appropriate trajectory on a virtual road. A sex/age matched control group was recruited in the community. Control subjects were studied at the same time of day as the index case driver. Controls had normal sleep wake schedule, absence of long driving and performed the same driving test. RESULTS: Drivers performed significantly worse than controls on the driving test. Age and duration of driving were the main factors associated with decreased performance. CONCLUSION: Our driving simulator can identify fatigue generated by driving but results must be considered in relation with age of subjects.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12932791

Philip, P., J. Taillard, et al. (1999)
"Simple reaction time, duration of driving and sleep deprivation in young versus old automobile drivers." ***J Sleep Res 8*** **(1): 9-14.**

KEYWORDS
Adult
Age Factors
Aging/physiology
Automobile Driving
Female
Humans
Male
Middle Aged
Questionnaires
Reaction Time
Sleep Deprivation
Time Factors

ABSTRACT
Car accidents are one of the major causes of death in modern society and sleepiness is identified as one major risk factor. The purposes of the present study were: (1) to relate the sleep loss and driving time to a performance indicator and (2) to identify risk factors of performance decrement. We investigated 294 drivers (age < 30 years, n = 100; age > or = 30 years, n = 194) who drove into a rest stop area. All were asked to fill out a questionnaire about the drive and previous sleep/wake pattern, and to carry out a 10 min, simple reaction time (RT) test. The level of performance is identified by the 10% slowest RTs. Multiple regression analysis, with the mean of the 10% Slowest RTs as the dependent variable, showed that age, duration of drive, and duration (shortness) of previous breaks were the main predictors. Our study suggests that public awareness may need to be raised with respect excessive length of driving, especially in young drivers.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10188131

Riley, M. W., Terry L. Stentz, and IbraheemTarawneh (1997)
Safety Impact Issues of Job-Associated Sleep. **Lincoln, University of Nebraska-Lincoln: 127.**

KEYWORDS
Truck Safety
Truck Driver Fatigue
Ergonomics
Human Factors

ABSTRACT
This research investigated the safety impact issues of job-associated sleep in truck drivers. The research focused on the anonymous survey of professional truck drivers. Information was gathered regarding perception of driving performance and its relationship to sleep on the road. In addition to the survey, detailed information was gathered on a typical sleeper berth used by 65% of the respondents.

All recommendations address issues that were identified by less than 85% of the respondents in the questionnaire. Thus, the potential impact of these recommendations may be low due to the small response sample of professional drivers. First, drivers should be medically screened and treated if necessary for sleep disorders. Second, special training and education is needed to help drivers improve their strategies to overcome fatigue and obtain higher and/or greater quantity of sleep. Third, the presence of sleep deprivation in drivers, as a result of many contributing factors, indicates a need for a comprehensive design model for work-rest cycle planning. Fourth, the physical discomforts reported by drivers need additional investigation to determine the sources of exposure in order to facilitate exposure elimination or reduction.

RESEARCH NOTES

URL
No URL provided.

A1.3 Annotated Bibliography: Causes of Fatigue

Arnold, P. K. and L. R. Hartley (2001)
"Policies and Practices of Transport Companies That Promote or Hinder the Management of Driver Fatigue." T*ransportation Research Part F: Traffic Psychology and Behaviour* 4(1): 1-17.

KEYWORDS
Driver
Fatigue
Management
Policy
Organisations
Safety

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science/article/B6VN8-42SPXDV-1/2/9255b960eeabcdb3b27590bbe943f101

Arrowhead Space & Telecommunications, I. (1999)
***Bus Driver Fatigue and Stress Issues Study: Final Report*: 1-54.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Black, Barbara and D. Fell. (1997)
"Driver Fatigue in the City" ***Accld. Anal. and Prev*** **29(4): 463-469.**

KEYWORDS
Driver Fatigue,
City Trips
Night-Time Driving

ABSTRACT
The current survey investigates the features of driver fatigue incidents (accidents, near accidents and unintentional drifting-out-of-lane events) which occurred in cities. The results show similar patterns to previous surveys, with incident trips tending to be short, and prior sleep loss and late night driving featuring as factors. Work trips feature very strongly among city fatigue incident trips and work is also a common reason for sleep loss before a fatigue incident. Consistent with the high representation of work trips, there are peaks in incident occurrence at commuter travel times. Shift workers are prominent amongst fatigue incident-involved drivers. Social trips also feature amongst fatigue incident trips countermeasures.

RESEARCH NOTES

URL
http://www.ingentaconnect.com/content/els/00014575/1997/00000029/00000004/art00025

Braver, E. R., C. W. Preusser, et al. (1992)
"Long hours and fatigue: a survey of tractor-trailer drivers." ***J Public Health Policy*** **13(3): 341-66.**

KEYWORDS
Accidents, Traffic
Automobile Driving
Commerce
Fatigue
Humans
Interviews
Risk Factors
Safety
Salaries and Fringe Benefits
Socioeconomic Factors
Time Factors

ABSTRACT
Fatigue and long driving hours have been implicated as risk factors in truck crashes. Under federal regulations, commercial drivers are permitted to drive no more than 10 hours before having an 8-hour break and cannot work more than 70 hours over an 8-day period. Several studies have suggested that violations of these rules are common. A survey of long haul tractor-trailer drivers was conducted to estimate what proportion of drivers report that they regularly violate the hours-of-service rules and to identify the drivers most likely to commit hours-of-service violations. During December 1990 through April 1991, a total of 1,249 drivers were interviewed at truck safety inspection stations, truck stops, and agricultural inspection stations in Connecticut, Florida, Oklahoma, and Oregon. In each state, interviews were conducted during varying periods of the day over the course of seven days at inspection stations. Overall, 89 percent of eligible drivers asked for interviews participated in the survey. According to self-reports, almost three-fourths of the respondents violate hours-of-service rules. About two-thirds of the drivers reported that they routinely drive or work more than the weekly maximum. A primary impetus for violating rules appears to be economic factors, including tight delivery schedules and low payment rates. Many other driver, job, and vehicle characteristics were significantly associated with being an hours-of-service violator. The high prevalence of hours-of-service violations among tractor-trailer drivers is a problem in need of urgent attention. Potential measures to reduce the prevalence of rules violations include more enforcement directed toward carriers, wider use of electronic recorders, and increasing the number of rest areas.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1401052

Brill , J. C., Hancock , P. A., and Gilson , Richard D. (2003)
Driver Fatigue: Is Something Missing? ***Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*****. Park City, Utah: 5.**

KEYWORDS
Drowsiness
Fatigue
Sleep Debt
Circadian Rhythm
Shift Work
Motion

ABSTRACT
Drowsiness and fatigue are serious problems in all transportation systems. One persistent issue is the lack of an agreed definition of these respective energetic states. Here we review the theoretical approaches (cognitive versus physiological) framing the driver fatigue problem. Known contributing factors to drowsiness include sleep debt, circadian rhythm, and shift work. However, we also suggest that certain inherent physiological reactions engaged in responses to motion itself represent a previously unrecognized but significant source of fatigue. We confirm the impact of this factor through comparisons of studies that either have or have not included prolonged motion.

RESEARCH NOTES

URL
No URL provided.

Brown, I. D. (1994)
"Driver fatigue." ***Human Factors*** **36(2): 298-314.**

KEYWORDS
Accidents, Traffic/prevention & control
Automobile Driving
Circadian Rhythm/physiology
Fatigue/*etiology
Humans
Occupational Diseases/*etiology
Sleep/physiology
Stress, Psychological/*etiology
Work Schedule Tolerance

ABSTRACT
Psychological fatigue is defined as a subjectively experienced disinclination to continue performing the task at hand. It generally impairs human efficiency when individuals continue working after they have become aware of their fatigue. It does not depend on energy expenditure and cannot be measured simply in terms of performance impairment. The interacting causal contributions to fatigue are the length of continuous work spells and daily duty periods, time available for rest and continuous sleep, and the arrangement of duty, rest, and sleep periods within each 24-h cycle. Empirical evidence for the separate and combined effects of these factors on fatigue, performance decrement, and accident risk are briefly reviewed, and the implications of these findings for driving and road safety are considered, with particular reference to the professional driver. This study shows that fatigue is insufficiently recognized and reported as a cause of road accidents and that its effects stem largely from prolonged and irregular working hours, rather than simply from time spent at the wheel.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8070794

Campbell, Kenneth L. and Michael E. Belzer. (2000)
Hours of Service Regulatory Evaluation Analytical Support - Task 1: Baseline Risk Estimates and Carrier Experience. **Ann Arbor, University of Michigan: 1-171.**

KEYWORDS
Truck Driver Fatigue
Safety
Hours-Of-Service
Driver Pay
Driver Schedule

ABSTRACT
The objective of this project is to provide baseline information to assess the safety and economic impact of the proposed hours of service (HOS) options. The analysis is organized around driver/operation groups developed by Federal Motor Carrier Safety Administration (FMCSA) for the hours of service (HOS) options. This report provides preliminary information for a Notice of Proposed Rulemaking. Baseline estimates of the prevalence and risk of fatigue accidents are presented. Estimates of the number of vehicles, vehicle miles of travel and fatigue accidents are developed for populations affected by hours of service regulations. The incidence of fatigue accidents is combined with the population data to estimate the overall risk of fatigue accidents. These risk estimates are the necessary starting point for subsequent estimates of the safety impact of each HOS option.

A preliminary assessment of the impact on drivers and motor carriers is also presented, including baseline information on driver wages, hours and working conditions. This information shows that drivers do not comply with current regulations. Estimates are presented of the cost of compliance with the current law, as well as social opportunity cost of the proposed policy changes. Qualitative estimates of the industry impact on daily and weekly schedule and daily and weekly maximum hours are presented.

RESEARCH NOTES

URL
No URL provided.

Federal Motor Carrier Safety Administration & ICF Consulting, I. (2005)
Regulatory Impact Analysis and Small Business Analysis for Hours of Service Options.
Washington, DC, Federal Motor Carrier Safety Administration: 41-62.

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
http://www.fmcsa.dot.gov/rules-regulations/topics/hos/regulatory-impact.htm

Fell, D. L. and B. Black (1997)
"Driver fatigue in the city." ***Accid Anal Prev*** **29(4): 463-9.**

KEYWORDS
Accidents, Occupational/psychology/statistics & numerical data
Accidents, Traffic/psychology/*statistics & numerical data
Adolescent
Adult
Attention
Cross-Sectional Studies
Fatigue/*epidemiology/psychology
Female
Humans
Incidence
Male
Middle Aged
New South Wales/epidemiology
Risk Factors
Sleep Deprivation
Urban Population/*statistics & numerical data
Work Schedule Tolerance

ABSTRACT
The current survey investigates the features of driver fatigue incidents (accidents, near accidents and unintentional drifting-out-of-lane events) which occurred in cities. The results show similar patterns to previous surveys, with incident trips tending to be short, and prior sleep loss and late night driving featuring as factors. Work trips feature very strongly among city fatigue incident trips and work is also a common reason for sleep loss before a fatigue incident. Consistent with the high representation of work trips, there are peaks in incident occurrence at commuter travel times. Shift workers are prominent amongst fatigue incident-involved drivers. Social trips also feature amongst fatigue incident trips but are likely to be more difficult to address with countermeasures.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9248504

Freund, D. (1999)
Commercial Truck Driver Fatigue, Alertness, and Countermeasures Survey, Federal Highway Administration, Office Of Motor Carriers.

KEYWORDS
Alertness
Fatigue (Physiological Condition)
Trucking Safety
Commercial Drivers
Truck Drivers

ABSTRACT
Driver fatigue and loss-of-alertness have long been considered important issues in commercial motor vehicle (CMV) crashes resulting in fatality and injury. The Department of Transportation has devoted considerable resources to addressing the issue of CMV driver fatigue, including sponsorship of major field research studies. In 1988, the Federal Highway Administration held a Symposium on Truck and Bus Driver Fatigue. The recommendations of the Symposium resulted in the decision to conduct a comprehensive Driver Fatigue and Alertness Study (DFAS). This study included an extensive literature review that highlighted a need for additional data about drivers whose particular job characteristics might lead to irregular schedules, night driving, and daytime sleeping.

A survey was designed and conducted, to extend prior work discussed in the Driver Fatigue and Alertness Study literature review, by collecting additional data about commercial motor vehicle (CMV) drivers and their job characteristics. It also sought to determine the prevalence of factors that may contribute to fatigue in CMV drivers and to identify and assess the methods used by drivers to alleviate fatigue or its symptoms. This tech brief summarizes the methods and results of that survey. 4 p.

RESEARCH NOTES

URL
http://ntl.bts.gov/lib/10000/10100/10108/tb99-006.pdf

Hakkanen, H. and H. Summala (2001)
"Fatal Traffic Accidents among Trailer Truck Drivers and Accident Causes as Viewed by Other Truck Drivers." ***Accident Analysis & Prevention*** **33(2): 187-196.**

KEYWORDS
In-Depth Accident Analysis
Driver Fatigue
Chronic Illness
Fatal Road Accidents
Truck Drivers
Technological Countermeasure

ABSTRACT
Causality factors, the responsibility of the driver and driver fatigue-related factors were studied in fatal two-vehicle accidents where a trailer truck driver was involved during the period of 1991-1997 (n=337). In addition, 251 long-haul truck drivers were surveyed in order to study their views regarding contributing factors in accidents involving trucks and the development of possible countermeasure against driver fatigue. Trailer truck drivers were principally responsible for 16% of all the accidents. Younger driver age and driving during evening hours were significant predictors of being principally responsible. In addition, the probability of being principally responsible for the accident increased by a factor of over three if the driver had a chronic illness. Prolonged driving preceding the accident, accident history or traffic offence history did not have a significant effect. Only 2% of the drivers were estimated to have fallen asleep while driving just prior to the accident, and altogether 4% of the drivers had been tired prior to the accident. Of the drivers 13% had however, been driving over 10 h preceding the accident (which has been criminally punishably in Finland since 1995 under the EC regulation) but no individual factors had a significant effect in predicting prolonged driving. The surveyed views regarding causes of truck accidents correspond well with the accident analysis. Accidents were viewed as being most often caused by other road users and driver fatigue was viewed to be no more than the fifth (out of eight) common cause of accidents. The probability of viewing fatigue as a more common cause increased significantly if the driver had experienced fatigue-related problems while driving. However, nearly half of the surveyed truck drivers expressed a negative view towards developing a technological countermeasure against driver fatigue. The negative view was not related to personal experiences of fatigue-related problems while driving.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science/article/B6V5S-42810G9-6/2/99d0313c959c3ed657fdeae484814248

Hanley, P. (2001)
***Bus Driver Fatigue and Stress Issues Study.* Washington, DC, Office of Research and Technology: 1-4.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Oron-Gilad, T., and Hancock, Peter A. (2005)
Road Environment and Driver Fatigue. ***Proceedings of the Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design.*** **Orlando, MIT2 Laboratory: 7.**

KEYWORDS
No keywords provided.

ABSTRACT
We distinguish between fatigue caused by the demands of the driving task itself (see Hancock & Desmond, 2001) from the standard traditional approach that links fatigue predominately to the lack of sleep. Fatigue can be caused by two sources: (1) the driver's initial state before starting the drive, or (2) the characteristics of the drive and the road environment; both sources can have a cumulative effect. It is not clear what principles are involved in making one road environment more prone to inducing driver fatigue than another. For the purpose of the current presentation we provide empirical data on road environment and driver fatigue summarized from a series of three experiments that the first author has conducted at Ben-Gurion University (see Oron-Gilad, 2003; Oron-Gilad, et al., 2001). Those are examined in relation to the Hancock and Warm (1989)
model of adaptability. The most significant and consistent findings of the three experiment is in the way that fatigue is reflected in driving performance across different road environments. These findings suggest that drivers are flexible in the way they handle fatigue over the course of time. They can adopt different strategies to compensate for their performance decrement, by focusing efforts on critical elements of each different type of roadway. Understanding of this dependency of fatigue symptoms on road conditions is of especial relevance to designers of technological fatigue countermeasures as well as those of future roadway systems.

RESEARCH NOTES

URL
No URL provided.

Sabbagh-Ehrlich, S., L. Friedman, et al. (2005)
"Working conditions and fatigue in professional truck drivers at Israeli ports."
***InjPrev* 11(2): 110-4.**

KEYWORDS
Accident Prevention/methods
Accidents, Occupational/*psychology
Accidents, Traffic/psychology
Adult
Aged
Automobile Driving/*psychology
Employment
Female
Health Status
Humans
Israel
Male
Mental Fatigue/*psychology
Middle Aged
Motor Vehicles
Rest
Risk Factors
Safety
Sleep
Sleep Deprivation/psychology
Stress, Psychological/psychology
Time Factors
Work Schedule Tolerance/psychology
Workload/*psychology

ABSTRACT
BACKGROUND: Trucks represent 6% of all vehicles, but truck crashes account for 20% of road deaths in Israel, even though travel distances are usually short (<200 km) and overnight travel is uncommon. OBJECTIVE: To determine occupational and individual predictors of fatigue, falling asleep at the wheel, and involvement in crashes with injuries and deaths in truck drivers. SETTING AND METHODS: We carried out field interviews of 160 port truck drivers regarding driver characteristics, workplace and driving conditions, employer-employee relations, medical conditions, sleep quality and fatigue, falling asleep at the wheel, and involvement in road crashes. RESULTS: One day before interview, 38.1% of the drivers had worked more than the 12-hour legal limit. More than 30% reported falling asleep at the wheel recently, and 13% had prior involvement in a sleep related crash. Sixty-seven (41.9%) drivers said that their employer forced them to work beyond the legal 12 hour daily limit. Involvement in a crash with casualties was associated with poor sleep quality (adjusted OR = 2.9; p = 0.042) and frequent difficulty finding parking when tired (OR = 3.7; p = 0.049). Self-assessment of fatigue underestimated fatigue from the Pittsburgh Sleep Quality Questionnaire. However fatigue

occurred in many drivers without sleep problems and many crashes occurred without fatigue. CONCLUSIONS: Prevention requires measures to reduce work stresses, screening drivers, speed control, and modal shifts. The work risks and adverse outcomes of truck drivers in large countries with long overnight journeys occur in a small country with small distances, relatively short work journeys, and little overnight travel.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15805441

Stutts, J. C., J. W. Wilkins, et al. (2003)
"Driver risk factors for sleep-related crashes." ***Accid Anal Prev*** **35(3): 321-31.**

KEYWORDS
Accidents, Traffic/*statistics & numerical data
Adult
Automobile Driving/*statistics & numerical data
Case-Control Studies
Fatigue
Female
Humans
Male
Motor Vehicles
North Carolina
Risk Factors
Sleep Deprivation
Sleep Stages
Work Schedule Tolerance

ABSTRACT
A population-based case-control study was carried out to examine driver risk factors for sleep-related motor vehicle crashes. Cases included 312 drivers involved in recent North Carolina crashes and identified on police reports as asleep at the time of the crash and 155 drivers identified as fatigued. Controls were 529 drivers also involved in recent crashes but not identified as asleep or fatigued, and 407 drivers not involved in recent crashes. All drivers were contacted for brief telephone interviews. Results showed that drivers in sleep-related crashes were more likely to work multiple jobs, night shifts, or other unusual work schedules. They averaged fewer hours sleep per night, reported poorer quality sleep, were less likely to feel they got enough sleep, were sleepier during the day, drove more often late at night, and had more prior instances of drowsy driving. Compared to drivers in non-sleep-related crashes, they had been driving for longer times, been awake more hours, slept fewer hours the night before, and were more likely to have used soporific medications. Knowledge of specific risk factors for sleep-related crashes is an important first step in reducing the thousands of deaths and injuries each year in the US attributed to drowsy driving.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12643949

Summala, H. and T. Mikkola (1994)
"Fatal accidents among car and truck drivers: effects of fatigue, age, and alcohol consumption." ***Hum Factors*** **36(2): 315-26.**

KEYWORDS
Accidents, Traffic/*statistics & numerical data
Adolescent
Adult
Age Factors
Aged
Alcohol Drinking/*adverse effects
Automobile Driving/*statistics & numerical data
Fatigue/*complications
Finland
Humans
Middle Aged
Sleep Deprivation
Time Factors
Work Schedule Tolerance

ABSTRACT
Fatigue increases the risk of an accident if the driver, on recognizing symptoms of fatigue, does not stop driving. We studied whether a tendency to continue the current activity and complete the task especially affects younger drivers, who are more susceptible to motivational pressures at the wheel in general. The data consisted of Finnish in-depth studies on 586 single-vehicle and 1357 multiple-vehicle accidents in which at least one vehicle occupant died. When excluding alcohol-related cases, the results showed that, first, trailer-truck drivers who either fell asleep or were tired to a degree that contributed to the accident were younger than those involved in the other fatalities. For car drivers, the proportion of fatigue-related cases was approximately constant in each age group, but a variation was seen when studied according to the time of day of the accident, mainly resulting from two distinct peaks. The first was in young drivers 18 to 20 years old between midnight and 6:00 a.m. The other occurred in drivers 56 years and older during the late afternoon hours. These data also indicate that in terms of fatal accidents, fatigue and alcohol seem to be less of a problem for truckers than for car drivers.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8070795

Taylor, A. H. and L. Dorn (2006)
"Stress, fatigue, health, and risk of road traffic accidents among professional drivers: the contribution of physical inactivity." ***Annu Rev Public Health*** **27: 371-91.**

KEYWORDS
Accidents, Occupational/*prevention & control/psychology
Accidents, Traffic/*prevention & control/psychology
Automobile Driving/*psychology
Exercise/*physiology/*psychology
Fatigue/*prevention & control
Health Status
Humans
Risk Factors
Stress, Psychological/*prevention & control

ABSTRACT
Strategies to achieve ambitious targets for reducing road accidents (34) have largely focused on engineering and technological advancements, the modification of occupational demands, and, to a lesser extent, human factors. These factors include stress and psychological states; sleep, fatigue, and alertness; and health status. Physical activity appears to influence all these human factors but has not previously been systematically considered as a direct or indirect risk factor for driver accidents. This chapter provides an overview, within an evidence-based framework, of the impact each of these human factors has on driver performance and risk of at-work road traffic accidents and then examines how physical (in)activity may moderate and mediate these relationships. Finally, we consider practical implications for work site interventions. The review aims to offer an evidence base for the deployment of resources to promote physical activity, manage stress, facilitate sleep, reduce fatigue, and enhance alertness to improve physical and psychological health among professional drivers.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16533122

Wylie, C. D., T. Shultz, et al. (1996)
***Commercial Motor vehicle Driver fatigue and alertness study: technical summary, Federal Highway Administration*. U.S. Department of Transportation: 70.**

KEYWORDS
Truck Driver
Fatigue
Alertness
CMV drivers
Vigilance
Shift work
Driver

ABSTRACT
This is the Technical Summary of the research report Commercial Motor Vehicle Driver Fatigue and Alertness Study by Wylie et al., dated October 1996, concerning the largest and most comprehensive over-the-road study on this subject ever conducted in North America.
The data collection involved eighty drivers in the U.S. and Canada who were monitored over a period of sixteen weeks. A number of work-related factors thought to influence the development of fatigue, loss of alertness and degraded performance in CMV drivers was studied within an operational setting of real-life, revenue-generating trips. These included: the amount of time spent driving during a work period; the number of consecutive days of driving; the time of day when driving took place; and schedule regularity.
In Section 1 of the Technical Summary, the reader is provided with some extracts from the technical literature on the involvement of fatigue in crashes, a historical summary of the U.S. Department of Transportation's focus on commercial motor vehicle driver fatigue and the background to the study. The study's overall objectives and the approach used in their attainment are also provided. Section 2 presents the conclusions drawn from the literature review conducted in preparation for the study and considered in the formulation of the study's own conclusions and recommendations. Section 3 presents the study methodology and data collections methods, while Section 4 presents the study's results, conclusions and recommendations.
For the amount of sleep and the four to five days of driving observed for each driver in this study, it was found that the strongest and most consistent factor influencing driver fatigue and alertness was time-of-day; drowsiness, as observed in video recordings of the driver's face, was markedly greater during night driving than during daytime driving. The number of hours of driving (time-on-task) and cumulative number of days were not strong or consistent predictors of observed fatigue. Numerous other findings are provided relating to scientific methodologies and fatigue countermeasure concepts.

URL
http://www.tc.gc.ca/TDC/publication/pdf/12800/12876e.pdf

A1.4 Annotated Bibliography: Countermeasures

Brown, I. D. (1997)
"Prospects for technological countermeasures against driver fatigue." ***Accid Anal Prev*** **29(4): 525-31.**

KEYWORDS
Accidents, Occupational/*prevention & control/psychology
Accidents, Traffic/*prevention & control/psychology
Arousal
Fatigue/*prevention & control/psychology
Humans
Occupational Diseases/*prevention & control/psychology
Protective Devices
Risk Factors
Sleep Deprivation
Transportation
Work Schedule Tolerance
Workload/psychology

ABSTRACT
There are three reasons for giving serious consideration to technological countermeasures against driver fatigue: 1, fatigue is a persistent occupational hazard for professional drivers; 2, some professional drivers are under considerable pressure to reach their scheduled destination, in spite of feeling drowsy; 3, fatigue adversely affects an individual's ability to assess their own fitness to continue driving. However, there are two reasons for exercising caution in implementing technological countermeasures: 1, their reliability under real traffic conditions is largely unproven; 2, they could be used by unscrupulous drivers to support the continuation of journeys that should have been terminated because of human impairment. This paper draws on the findings of research into the origins, symptoms and development of human fatigue, and on recent research into driver-support systems, to assess the prospects for implementations of technological countermeasures against driver fatigue in the foreseeable future.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9248511

De Valck, E. and R. Cluydts (2001)
"Slow-release caffeine as a countermeasure to driver sleepiness induced by partial sleep deprivation." ***J Sleep Res*** **10(3): 203-9.**

KEYWORDS
Adult
Affect/drug effects
Automobile Driving
Caffeine/administration & dosage/*pharmacology
Central Nervous System Stimulants/administration & dosage/*pharmacology
Delayed-Action Preparations/administration & dosage
Disorders of Excessive Somnolence/*etiology/*prevention & control
Female
Humans
Male
Severity of Illness Index
Sleep Deprivation/*complications/diagnosis
Wakefulness/drug effects

ABSTRACT
The effect of partial sleep deprivation (PSD) on driving abilities, as measured with a driving simulator, and the value of slow-release caffeine as a countermeasure to the expected performance decrements, were studied. Twelve subjects, between 20 and 25 years of age, underwent four experimental conditions, 4.5 or 7.5 h time in bed (TIB) with 300 mg slow-release caffeine or placebo, according to a Latin square design. Driving performance was measured twice by a 45-min driving task on a simulator. Subjective sleepiness/alertness and mood were assessed four times, by means of the Stanford Sleepiness Scale (SSS) and Profile of Mood States (POMS). After 4.5 h as compared with 7.5 h TIB lane drifting and speed deviation were higher, but only the effect on the first variable reached significance. In the placebo condition at 13.00 h, accident liability increased after PSD. Subjective sleepiness was higher in the 4.5 h TIB group. Caffeine intake gave rise to a decrease in lane drifting and after PSD it led to a smaller speed deviation and accident liability. The findings suggest that a lack of sleep can lead to a significant driving performance impairment, with drivers having problems to maintain an appropriate road position and a posted speed and more drivers getting involved in an accident. Secondly, the results indicate that caffeine - more specifically slow-release caffeine - can serve as a valuable countermeasure to these performance decrements, in the absence of any important side-effects, especially when its application is of an acute nature and when there is no opportunity to take a nap.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11696073

Dingus, T. A., H. L. Hardee, et al. (1987)
"Development of models for on-board detection of driver impairment." ***Accid Anal Prev*** **19(4): 271-83.**

KEYWORDS
Alcoholic Intoxication/*psychology
Automobile Driving
Computer Simulation
Female
Humans
Male
Models, Psychological
Sleep Stages

ABSTRACT
Two of the leading causes of automobile accidents are driver impairment due to alcohol and drowsiness. Apparently, a relatively large percentage of these accidents occur because drivers are unaware of the degree to which they are impaired. The purpose of this research was to develop models, utilizing changes in driver behavior, which could detect driver impairment due to alcohol, drowsiness, or the combination of alcohol and drowsiness, and which could be practically implemented in an automobile. A computer-controlled automobile simulator was used to simulate a nighttime highway driving scenario for six drivers who participated in each of four conditions: a control condition, an alcohol condition, a sleep-deprived condition, and a combined alcohol and sleep-deprived condition. The results indicated that a useful on-board drowsiness detection device is possible and practical for highway driving. The results also showed that on-board alcohol impairment detection may be possible at levels below the legal driving limit in most states (BAC 0.1%).

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=3651201

Feyer, A. M., A. Williamson, et al. (1997)
"Balancing work and rest to combat driver fatigue: An investigation of two-up driving in Australia." ***Accident Analysis & Prevention*** **29(4): 541.**

KEYWORDS
Transportation
Motor Vehicles
Accidents
Human Factors
Australia
Fatigue

ABSTRACT
This study is the fourth in a series examining driver fatigue in the Australian long distance road transport industry. Thirty-seven long haul truck drivers were measured on a routine 4500 km round trip. Two types of driving operations were compared, single driving, involving a solo driver, and two-up driving, where a pair of drivers operate a truck continuously and alternate between work and rest. Two-up drivers reported higher levels of fatigue than single drivers overall and tended to show poorer levels of performance. However, this result appeared to reflect differential fatigue at the start of the trip. Both two-up and single drivers showed marked increases in fatigue across the first half of the trip, followed by a substantial recovery of alertness and performance provided that drivers had stationary overnight rest at mid trip or had shorter trips. Fatigue continued to increase on the second half of the trip for drivers who did longer trips without the benefit of a substantial night rest or who did not have access to on-board rest, that is single drivers. The use of overnight rest, in combination with two-up driving, appeared to be the most successful strategy for managing fatigue across the trip.

RESEARCH NOTES

URL
http://www.ingentaconnect.com/content/els/00014575/1997/00000029/00000004/art00034

Gander, P. H., N. S. Marshall, et al. (2005)
"An evaluation of driver training as a fatigue countermeasure." ***Transportation Research Part F: Traffic Psychology and Behavior*** **(1): 47.**

KEYWORDS
Driver fatigue
Training
Effectiveness
Traffic
Psychology

ABSTRACT
Fatigue management education for drivers is often advocated but evaluations of its effectiveness are seldom published. As part of a comprehensive fatigue management approach, driver education programmes were developed and implemented for light vehicle drivers working for a major oil company, and heavy vehicle drivers working for its distribution contractors and other companies in New Zealand. Three different assessments of the effectiveness of training were undertaken. An anonymous quiz was administered to 275 heavy vehicle drivers before and after a 2-h live fatigue management training session, to assess immediate knowledge transfer. There was a significant improvement in the median score from 9/16 to 14/16. A follow-up survey was mailed to all tanker drivers working for the petroleum distribution contractors 1-26 months after training (74% response rate). Most tanker drivers (82%) answered correctly on at least 12/14 true/false questions about fatigue and countermeasures. Seventy--five percent thought that fatigue management training was at least moderately useful, 47% had changed their strategies at home, and 49% had changed their strategies at work. A follow--up survey was also distributed at least one month after initial training to 350 light vehicle drivers (54% response rate). The majority (70%) answered correctly on at least 11/13 true/false questions about fatigue and countermeasures. Ninety-one percent thought that fatigue management training was at least moderately useful, 50% had changed strategies at home, and 43% had changed strategies at work. These findings suggest that immediate knowledge gains at the time of training were largely retained, a significant proportion of drivers had implemented at least some of the strategies suggested, and the majority perceived at least some benefit from fatigue management training. We conclude that fatigue management education is useful for developing a fatigue management culture within an organization.

RESEARCH NOTES

URL
No URL provided.

Garbarino, S., B. Mascialino, et al. (2004)
"Professional shift-work drivers who adopt prophylactic naps can reduce the risk of car accidents during night work." *Sleep* 27(7): 1295-302.

KEYWORDS
Accidents, Occupational/*prevention & control/statistics & numerical data
Accidents, Traffic/*prevention & control/statistics & numerical data
Adult
Arousal
Circadian Rhythm
Cross-Sectional Studies
Female
Humans
Italy
Male
Police
Proportional Hazards Models
Prospective Studies
Retrospective Studies
Sleep
Sleep Deprivation/complications/epidemiology
Sleep Disorders, Circadian Rhythm/epidemiology/*prevention & control
Wakefulness

ABSTRACT
STUDY OBJECTIVES: Night work can be dangerous because both circadian sleep propensity (process C) and sleep pressure due to the prolonged wakefulness (process S) contribute to the reduction of vigilance levels. As naps are a countermeasure to sleepiness, this study evaluates the role they play in preventing sleep-related accidents in Italian shift-working police drivers. DESIGN/SETTING/PARTICIPANTS: The study concerns highway car accidents that occurred to Italian shift-working police drivers; it was performed in 2 steps: a retrospective analysis of the overall number of accidents that occurred during the years 1993--1997 (n, 1195), followed by a validation analysis of a smaller cohort of accidents prospectively collected during 2003 (n, 84). INTERVENTIONS: N/A. MEASUREMENTS AND RESULTS: RETROSPECTIVE ANALYSIS: The influence of process S, process C, driver characteristics, and context conditions on accident risk, estimated by means of Cox hazard regression, revealed that nighttime accident risk was mainly influenced by process S levels. Consequently, an experimental mathematical model linking the hourly observed number of accidents to process S levels was designed. Its generalization to the theoretical case of drivers omitting naps showed an increase of about 38% of accidents. PROSPECTIVE ANALYSIS: In order to validate our results, we compared retrospective and prospective sleep patterns: no statistical difference was found. Again, the hourly number of accidents increased with homeostatic sleep pressure; the theoretical efficacy of napping was quantified in 48% accidents decrease. CONCLUSIONS: Our data seem to confirm that napping before working a night shift is an effective countermeasure to alertness and

performance deterioration associated with night work. Moreover, this self-initiated behavior could have a prophylactic efficacy in reducing the number of car accidents.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15586782

Hakkanen, H., H. Summala, et al. (1999)
"Blink duration as an indicator of driver sleepiness in professional bus drivers."
***Sleep* 22(6): 798-802.**

KEYWORDS
Adult
Automobile Driving
Blinking/*physiology
Disorders of Excessive Somnolence/etiology/*psychology
Motor Vehicles
Positive-Pressure Respiration/methods
Questionnaires
Random Allocation
Severity of Illness Index
Sleep Apnea Syndromes/complications/diagnosis/therapy
Time Factors

ABSTRACT
This study focused on eyeblink duration as a measure of sleepiness in on-road driving and on the driving performance of professional bus drivers with polysomnographically confirmed mild obstructive Sleep Apnea Syndrome (OSAS). Ten bus drivers with OSAS and their matched controls participated in the study. The Maintenance of Wakefulness Test (MWT) and a monotonous on-road driving task were completed. Eyeblink duration and frequency and speed control were measured while driving. Lane-keeping was evaluated by the supervisor in the car. Subsequent to these tasks, drivers with OSAS received continuous positive airway pressure treatment (nasal CPAP). After nine weeks of treatment, the tasks were repeated. Prior to treatment the average blink duration in the driving task was significantly longer and sleep latency in the MWT was significantly shorter for bus drivers with OSAS than for controls (mean blink duration 82.3 ms; 51.9 ms and mean sleep latency 23.2 min; 35.4 min), indicating increased daytime sleepiness. Subsequent to treatment both measures in drivers with OSAS decreased to the level of the controls. Treatment effects in MWT and blink duration in on-road driving also correlated significantly. No significant differences between the groups appeared in average blink frequency or driving performance in terms of maintenance of speed. No significant lane drifting appeared either. These results support earlier findings on blink duration as an indicator of increased sleepiness and have important implications for those involved in the transport technological industry. The findings also suggest that nasal CPAP treatment is effective in reducing excessive daytime sleepiness.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10505826

Hanks, W. A., R. M. Merrill, et al. (1999)
"An examination of common coping strategies used to combat driver fatigue." ***J Am CollHealth*** **48(3): 135-7.**

KEYWORDS
Focus Groups
Case-Control Studies
Students/*psychology
Automobile Driving/*psychology
Fatigue/*prevention & control
Research Support, Non-U.S. Gov't
Universities
Self Care/*psychology
Adaptation, Psychological
Humans

ABSTRACT
Driver fatigue is recognized as an important highway safety risk. Many organizations have published recommendations for coping with driver fatigue. The authors explored the effectiveness of 10 common coping strategies, using a case-controlled design to examine the use of coping strategies among a random sample of college students (N = 301). The students were questioned about their use of coping strategies for driver fatigue and their record of having experienced a dozing-related incident. Odds ratios were calculated and 4 strategies--taking a walk, drinking caffeinated beverages, stopping for a nap, and chewing ice--were found to predict an incident. Three other strategies, snacking, rolling the window down, and talking with a passenger, were found to be protective.

RESEARCH NOTES

URL
http://findarticles.com/p/articles/mi_hb3259/is_199911/ai_n7959582

Hickey Jr., J. J. (1997)
Shoulder Rumble Strip Effectiveness: Drift-Off-Road Accident Reductions on the Pennsylvania Turnpike. **Washington DC, National Research Council. 1573: 105-109.**

KEYWORDS
No keywords provided.

ABSTRACT
To help decrease the number of accidents caused by drowsy drivers, engineers for the Pennsylvania Turnpike developed and installed an innovative type of shoulder rumble strip called the Sonic Nap Alert Pattern (SNAP). A distinct warning sound and vibration are produced when drowsy or inattentive drivers' vehicles drift so their tires cross this pattern of recessed grooves along the shoulder of the roadway. Various lengths and depths of grooves were tested to select a design with enough sound and vibration to be perceptible in a truck cab and yet not too severe for cars or motorcycles. Design features, testing and initial results were presented at the TRB Annual Meeting in January 1994. After installation of SNAP, drift-off-road accidents per month decreased by 70 percent. This study reviews those initial results, adds traffic exposure to compare accident rates per vehicle-distance-traveled, adjusts for a decline in all accidents during the years considered, and revises the initially reported accident reduction to 65 percent. Follow-on results are developed for reportable accidents from 1990-1995, singling out those that could be directly affected by SNAP. About 12 percent of all accidents were considered fully susceptible to SNAP treatment. A reduction of 60 percent in treatable accidents, or a decline in rate by 2.3 accidents per 100 million vehicle miles (1.43 per 100 million vehicle kilometers) was documented for 53 segments totaling 348 mi (560 km) of roadway.

RESEARCH NOTES

URL
No URL provided.

Horne, J. and L. Reyner (1999)
"Vehicle accidents related to sleep: a review." ***Occup Environ Med*** **56(5): 289-94.**

KEYWORDS
Accidents, Occupational/*prevention & control
Accidents, Traffic/*prevention & control
Automobile Driving
Awareness
Humans
Sleep Deprivation
Work Schedule Tolerance

ABSTRACT
Falling asleep while driving accounts for a considerable proportion of vehicle accidents under monotonous driving conditions. Many of these accidents are related to work--for example, drivers of lorries, goods vehicles, and company cars. Time of day (circadian) effects are profound, with sleepiness being particularly evident during night shift work, and driving home afterwards. Circadian factors are as important in determining driver sleepiness as is the duration of the drive, but only duration of the drive is built into legislation protecting professional drivers. Older drivers are also vulnerable to sleepiness in the mid-afternoon. Possible pathological causes of driver sleepiness are discussed, but there is little evidence that this factor contributes greatly to the accident statistics. Sleep does not occur spontaneously without warning. Drivers falling asleep are unlikely to recollect having done so, but will be aware of the precursory state of increasing sleepiness; probably reaching a state of fighting off sleep before an accident. Self awareness of sleepiness is a better method for alerting the driver than automatic sleepiness detectors in the vehicle. None of these have been proved to be reliable and most have shortcomings. Putative counter measures to sleepiness, adopted during continued driving (cold air, use of car radio) are only effective for a short time. The only safe counter measure to driver sleepiness, particularly when the driver reaches the stage of fighting sleep, is to stop driving, and--for example, take a 30 minute break encompassing a short (< 15 minute) nap or coffee (about 150 mg caffeine), which are very effective particularly if taken together. Exercise is of little use. CONCLUSIONS: More education of employers and employees is needed about planning journeys, the dangers of driving while sleepy, and driving at vulnerable times of the day.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10472301

Horne, J. A. and L. A. Reyner (1995). "Driver sleepiness." ***J Sleep Res*** **4(S2): 23-29.**

KEYWORDS
No keywords provided.

ABSTRACT
Falling asleep at the wheel accounts for a sizeable number of vehicle accidents under monotonous driving conditions. The risk of driver death and serious injury is high. Circadian factors are profound and seem to be of equal (if not more) importance to the duration of the drive. Unfortunately, only the latter tends to be built into legislation. Young adults are the most likely to have these accidents, especially in the early morning, whereas older adults may be more vulnerable in the early afternoon. Drivers falling asleep are unlikely to recollect having done so, but they are aware of the precursory state of feeling sleepy, as normal sleep does not occur spontaneously without warning. Self-awareness of sleepiness is a better method for alerting the driver than in-car automatic devices. Car simulator studies show high inter-correlations between driving performance, EEG measures of drowsiness and self-assessments of sleepiness. Putative countermeasures to sleepiness during continued driving (for example cold air, playing car radio) have to be substantiated. The only safe countermeasure is to stop driving. At this point, a nap and/or coffee (caffeine) can be effective. Exercise is of little use. More driver education is needed about the dangers of driving whilst sleepy.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10607207

Horne, J. A. and L. A. Reyner (1996)
"Counteracting driver sleepiness: effects of napping, caffeine, and placebo."
***Psychophysiology* 33(3): 306-9.**

KEYWORDS
Adult
Automobile Driving
Blinking/drug effects/physiology
Caffeine/*pharmacology
Central Nervous System Stimulants/*pharmacology
Double-Blind Method
Electroencephalography/drug effects
Female
Humans
Male
Sleep/drug effects/*physiology

ABSTRACT
Sleepy drivers should "take a break," but the efficacy of feasible additional countermeasures that can be used during the break is unknown. We examined a shorter than 15 min nap, 150 mg of caffeine in coffee, and a coffee placebo, each given randomly across test sessions to 10 sleepy subjects during a 30-min rest period between two 1-hr monotonous early afternoon drives in a car simulator. Caffeine and nap significantly reduced driving impairments, subjective sleepiness, and electroencephalographic (EEG) activity indicating drowsiness. Blink rate was unaffected. Sleep during naps varied, whereas caffeine produced more consistent effects. Subjects acknowledged sleepiness when the EEG indicated drowsiness, and driving impairments were preceded by self-knowledge of sleepiness. Taking just a break proved ineffective.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8936399

Ingre, M., T. Akerstedt, et al. (2006)
"Subjective sleepiness, simulated driving performance and blink duration: examining individual differences." ***J Sleep Res*** **15(1): 47-53.**

KEYWORDS
Adult
Automobile Driving/*statistics & numerical data
Blinking/*physiology
Disorders of Excessive Somnolence/*epidemiology
Fatigue/epidemiology
Female
Humans
Male
Time Factors
User-Computer Interface

ABSTRACT
The present study aimed to provide subject-specific estimates of the relation between subjective sleepiness measured with the Karolinska Sleepiness Scale (KSS) and blink duration (BLINKD) and lane drifting calculated as the standard deviation of the lateral position (SDLAT) in a high-fidelity moving base driving simulator. Five male and five female shift workers were recruited to participate in a 2-h drive (08:00-10:00 hours) after a normal night sleep and after working a night shift. Subjective sleepiness was rated on the KSS in 5-min intervals during the drive, electro-occulogram (EOG) was measured continuously to calculate BLINKD, and SDLAT was collected from the simulator. A mixed model anova showed a significant ($P < 0.001$) effect of the KSS for both dependent variables. A test for a quadratic trend suggests a curvilinear effect with a steeper increase at high KSS levels for both SDLAT ($P < 0.001$) and BLINKD ($P = 0.003$). Large individual differences were observed for the intercept ($P < 0.001$), suggesting that subjects differed in their overall driving performance and blink duration independent of sleepiness levels. The results have implications for any application that needs prediction at the subject level (e.g. driver fatigue warning systems) as well as for research design and the interpretation of group average data.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16490002

Lal, S. K. L., A. Craig, et al. (2003)
"Development of an Algorithm for an Eeg-Based Driver Fatigue Countermeasure."
***Journal of Safety Research* 34(3): 321-328.**

KEYWORDS
Fatigue
Drivers
Electroencephalography
Countermeasures
Road safety

ABSTRACT
Problem: Fatigue affects a driver's ability to proceed safely. Driver-related fatigue and/or sleepiness are a significant cause of traffic accidents, which makes this an area of great socioeconomic concern. Monitoring physiological signals while driving provides the possibility of detecting and warning of fatigue. The aim of this paper is to describe an EEG-based fatigue countermeasure algorithm and to report its reliability. Method: Changes in all major EEG bands during fatigue were used to develop the algorithm for detecting different levels of fatigue. Results: The software was shown to be capable of detecting fatigue accurately in 10 subjects tested. The percentage of time the subjects were detected to be in a fatigue state was significantly different than the alert phase ($P<.01$). Discussion: This is the first countermeasure software described that has shown to detect fatigue based on EEG changes in all frequency bands. Field research is required to evaluate the fatigue software in order to produce a robust and reliable fatigue countermeasure system. Impact on Industry: The development of the fatigue countermeasure algorithm forms the basis of a future fatigue countermeasure device. Implementation of electronic devices for fatigue detection is crucial for reducing fatigue-related road accidents and their associated costs.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science/article/B6V6F-49F84P0-5/2/46c503a16639216dbe625c8eb3f08dd4

Lee, J., Thomas A. Dingus, Michael Mollenhauer, Timothy Brown, and and V. L. Neale (1997)
D*evelopment of Human Factors Guidelines for Advanced Traveler Information Systems (Atis) and Commercial Vehicle Operations (Cvo): Cvo Driver Fatigue and Complex in-Vehicle Systems.* Blacksburg, VA, Virginia Polytechnic Institute and State University: 79.

KEYWORDS
Advanced Traveler Information System
ATIS
Commercial Vehicle Operation
CVO
Fatigue
Mental Workload

ABSTRACT
As one of a series of studies aimed at gathering data to develop human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO), the present study utilized a driving simulator to study CVO drivers and (1) the effects of driver fatigue and (2) the effects of mental workload on objective and subjective indices of driver performance and opinion. Fatigue was induced through sleep deprivation and through a 90- minute simulator drive. Mental workload was manipulated through driving task load and ATIS complexity. Although the results indicated degraded driving performance under the sleep-deprived condition, performance on ATIS-related tasks was not affected by sleep deprivation. The implication of this and other results are detailed.

RESEARCH NOTES

URL
No URL provided.

Lucidi, F., P. M. Russo, et al. (2006)
"Sleep-related car crashes: risk perception and decision-making processes in young drivers." ***Accid Anal Prev*** **38(2): 302-9.**

KEYWORDS
Accidents, Traffic
Adolescent
Adult
Attitude
Automobile Driving/statistics & numerical data
Chi-Square Distribution
*Decision Making
Female
Humans
Male
Questionnaires
Risk-Taking
Sex Factors
Sleep Deprivation

ABSTRACT
The aim of the present study is to analyse factors affecting worries, coping strategies and decisions of young drivers regarding the risk of sleep-related car crashes. Furthermore, the study also analyses whether framing the same information about sleepiness in two different linguistic forms influences: (1) the evaluation of the level of risk associated to a specific level of drowsiness (Attribute Framing problem); (2) the willingness to enact strategies to "prevent" sleepiness before night-time driving (Goal Framing problem); (3) the choice between two different ways, both of equal expected efficacy, of lowering drowsiness (Risky decision-making Framing problem). Six hundred and ninety-five young drivers [(57.6% females, 42.4% males); mean age 20.85 years (S.D.=1.2)] answered questions on drive risk perception and sleepiness, on nocturnal driving experience and on the strategies to deal with driver sleepiness, responding to one of the two different versions of the framed problems. A sub-sample of 130 participants completed the framed problems in both versions. The results show that experiences of sleep attacks and nocturnal driving frequency in the past 6 months affect both risk perception and the preventive strategies adopted. Furthermore, the manipulation on two out of the three problems (attribute and risky decision-making frames) significantly affected the respondents' evaluation.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16288959

Lyznicki, J. M., T. C. Doege, et al. (1998)
"Sleepiness, driving, and motor vehicle crashes. Council on Scientific Affairs, American Medical Association." ***Jama*** **279(23): 1908-13.**

KEYWORDS
Accidents, Traffic/prevention & control/*statistics & numerical data
American Medical Association
Automobile Driving
Awareness
Humans
Physician's Role
Risk Factors
Safety
Sleep
United States

ABSTRACT
OBJECTIVE: To assess the contribution of driver sleepiness to highway crashes and review recent recommendations to change federal hours-of-service regulations for commercial motor vehicle drivers. DATA SOURCES: Information was derived from a search of the MEDLINE, Transportation Research Information Service (TRIS), and Bibliographic Electronic Databases of Sleep (BEDS) databases from 1975 through 1997 and from manual review of the reference lists in relevant journal articles, government publications, conference proceedings, and textbooks. DATA SYNTHESIS: Driver sleepiness is a causative factor in 1% to 3% of all US motor vehicle crashes. Surveys of the prevalence of sleepy behavior in drivers suggest that sleepiness may be a more common cause of highway crashes than is reflected in these estimates. About 96% of sleep-related crashes involve passenger vehicle drivers and 3% involve drivers of large trucks. Risk factors include youth, shift work, alcohol and other drug use, over-the-counter and prescription medications, and sleep disorders. CONCLUSIONS: Increased awareness of the relationship between sleepiness and motor vehicle crashes will promote the health and safety of drivers and highway users. Physicians can contribute by encouraging good sleep habits, recognizing and treating sleep-related problems, and counseling patients about the risks of driving while sleepy. To protect public health and safety, the American Medical Association recommends continued research on devices and technologies to detect the signs of sleepiness and prevent the deterioration of driver alertness and performance. Educational programs about the risks of falling asleep while driving are needed for physicians, the public, and commercial truck drivers.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9634264

MacLean, A. W., David R. T. Davies and Kris Thiele (2003)
The Hazards and Prevention of Driving While Sleepy. ***Sleep Medicine Reviews.*** **Ontario. 7: 507-521.**

KEYWORDS
Driving,
Sleepiness,
Detection,
Countermeasures,
Education

ABSTRACT
In the present paper the literature bearing on the association between sleepiness and driving is reviewed and the current state of prevention is discussed. Sleepiness may be a factor in about 20% of motor vehicle accidents and studies carried out in controlled environments suggest that the most common changes in driving performance attributable to sleepiness include increased variability of speed and lateral lane position. Higher-order functions including judgment and risk taking may also deteriorate. Moreover, prolonging wakefulness even by a few hours may produce deterioration in driving performance comparable to that seen in drivers with blood alcohol concentrations at levels deemed dangerous by legislation. The majority of prevention efforts to date have focused on short-term solutions that only mask underlying sleepiness and it is suggested that more emphasis be directed toward primary prevention efforts such as educating drivers about the importance of getting sufficient sleep and avoiding circadian performance troughs. Finally, the important role that health professionals can play in the identification, treatment, and education of sleepy drivers is highlighted.

RESEARCH NOTES

URL
No URL provided.

Masaki Yamaguchi a, MitsuoDeguchi a, Junichi Wakasugi a, and N. T. b. Shin Onoa, Tomoyuki Higashi c, Yasufumi Mizuno c. (2005)
"Hand-Held Monitor of Sympathetic Nervous System Using Salivary Amylase Activity and Its Validation by Driver Fatigue Assessment."

KEYWORDS
No keywords provided.

ABSTRACT
In order to realize a hand-held monitor of the sympathetic nervous system, we fabricated a completely automated analytical system for salivary amylase activity using a dry-chemistry system. This was made possible by the fabrication of a disposable test-strip equipped with built-in collecting and reagent papers and an automatic saliva transfer device. In order to cancel out the effects of variations in environmental temperature and pH of saliva, temperature- and pH-adjusted equations were experimentally determined, and each theoretical value was input into the memory of the hand-held monitor. Within a range of salivary amylase activity between 10 and 140 kU/l, the calibration curve for the hand-held monitor showed a coefficient with R2 = 0.97. Accordingly, it was demonstrated that the hand-held monitor enabled a user to automatically measure the salivary amylase activity with high accuracy with only 30l sample of saliva within a minute from collection to completion of the measurement. In order to make individual variations of salivary amylase activity negligible during driver fatigue assessment, a normalized equation was proposed. The normalized salivary amylase activity correlated with the mental and physical fatigue states. Thus, this study demonstrated that an excellent hand-held monitor with an algorithm for normalization of individuals' differences in salivary amylase activity, which could be easily and quickly used for evaluating the activity of the sympathetic nervous system at any time. Furthermore, it is suggested that the salivary amylase activity might be used as a better index for psychological research.

RESEARCH NOTES

URL
No URL provided.

Morrow, P. C., and Michael R. Crumb (2004)
"Antecedents of fatigue, close calls, and crashes among commercial motor-vehicle drivers" *Journal of Safety Research* 35: 59-69.

KEYWORDS
Driver Fatigue
Close Calls
Crashes
Safety Management Practices
Trucking Industry

ABSTRACT
Problem: Minimizing driver fatigue among commercial motor-vehicle (CMV) drivers is a major safety issue in the United States. This study examines the effects of potentially fatigue-inducing factors inherent in truck driving work and company safety management in explaining: (a) drivers driving while fatigued, (b) the frequency of close calls due to fatigue, and (c) actual crashes among CMV drivers. Method: Data for this study are derived from a survey of CMV drivers in 116 trucking firms, with all data being driver-reported. The relative roles of fatigue-inducing factors and safety management practices in explaining variation in fatigue, close calls, and crashes are reported, along with the roles of fatigue in affecting close calls and crashes via hierarchical regression. Results: Findings indicated that fatigue-inducing factors inherent in driving work and safety practices accounted for appreciable variation in driving fatigued (R 2 = .42) and close calls (R2 = .35), but not crash involvement. Driving while fatigued also accounted for incremental increases in the amount of variation in close calls, after consideration of inherent factors and safety practices. Impact on industry: Findings indicate that safety practices (e.g., establishment of a strong safety culture, dispatcher scheduling practices, company assistance with fatiguing behaviors such as loading and unloading) have considerable potential to offset fatigue-inducing factors associated with truck driving work.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14992847

Oron-Gilad, T. and D. Shinar (2000)
"Driver fatigue among military truck drivers." ***Transportation Research*** **3F(4): Res. F: Tr.**

KEYWORDS
Occupational Safety
Motor Vehicles
Military
Trucks
Fatigue
Israel

ABSTRACT
The Israeli Defense Force (IDF) Transport Center is the largest and the most diverse transportation organization in Israel: three times as large as the largest commercial fleet in Israel, and military bases are spread all over the country. It also has the ability to regulate the drivers better: enforcing diet, hours of sleep, and working hours. The drivers are either permanently employed civilians, career service personnel, or mandatory service personnel. This employment status correlates with age, experience, carrier type, and several job characteristics (for example mandatory service drivers typically do not drive at night). The study consisted of a survey of 314 male drivers (30% of the entire base driver population). Despite the different environment, the military drivers display many characteristics and coping-behaviors characteristic of civilian drivers. Our results cast a doubt on the efficacy of enforcing night sleep and prohibiting night drives as an alternative to regulating hours of service. Our findings also reveal that it is insufficient to provide drivers with the time to sleep. One has to ensure that they also get a good quality of sleep. Implications for reducing fatigue in this environment are suggested. We identified the mandatory service drivers (young, less experienced drivers, lower military ranks) as a group of drivers that falls asleep more often and to a greater extent. They are particularly sensitive to sleep deficits and influenced by external events such as aggravation and boredom. It is important to provide drivers with more in-vehicle, accessible countermeasures to counter fatigue since they often do not stop, particularly in short-haul conditions. Since the radio has a high level of usage and acceptance among drivers, it could be exploited as an interactive communications system, as an educational medium, and as an image-enhancing device.

RESEARCH NOTES

URL
http://ntlsearch.bts.gov/tris/record/tris/00810581.html

Reyner, L. A. and J. A. Horne (1998)
"Evaluation "in-car" countermeasures to sleepiness: cold air and radio." ***Sleep*** **21(1): 46-50.**

KEYWORDS
Accidents, Traffic/*prevention & control
Adult
Automobile Driving
Cold
Disorders of Excessive Somnolence/*prevention & control
Electroencephalography
Female
Humans
Male
Radio

ABSTRACT
The efficacy of putative "in-car" countermeasures to driver sleepiness is unknown. Sixteen young adult drivers within the normal range for the Epworth Sleepiness Scale (ESS), had their sleep restricted to 5 hours the night before, and drove an interactive car simulator in the afternoon for 2.5 hours, under monotonous conditions. After 30 minutes of driving they were exposed to: (1) cold air to the face (AIR) from the vehicle's air conditioning vents, (2) listening to the vehicle's radio/tape (RADIO) according to subjects' choice, or (3) NIL treatment. The active treatments typified those experienced under real driving conditions. Drifting over lane markings were "incidents." EEGs were recorded and spectrally analyzed in the alpha and theta range. Subjects responded to the Karolinska Sleepiness Scale (KSS) every 200 seconds. Overall, RADIO and AIR had no significant effects on incidents, although there was a trend for RADIO to reduce incidents, particularly during the first 30 minutes, when AIR also had some effect. KSS scores were significantly lower for RADIO for most of the drive, whereas AIR had only transient and non-significant effects. The EEG showed no significant effects of the active treatments. Compared with other countermeasures such as caffeine and a brief nap, which we have previously shown to be more effective (using the same equipment and protocols), AIR and RADIO are at best only temporary expedients to reduce driver sleepiness, perhaps enabling drivers to find a suitable place to stop, take a break and avail themselves of caffeine and a nap.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9485532

Reyner, L. A. and J. A. Horne (2000)
"Early morning driver sleepiness: effectiveness of 200 mg caffeine."
***Psychophysiology* 37(2): 251-6.**

KEYWORDS
Adult
Automobile Driving
Caffeine/*pharmacology
Central Nervous System Stimulants/*pharmacology
Electroencephalography/drug effects
Female
Humans
Male
Psychomotor Performance/drug effects
Sleep Stages/*drug effects

ABSTRACT
Sleep-related vehicle accidents are prevalent early morning, especially in younger drivers. In two independent studies following a night of either restricted or nil sleep, young experienced drivers drove for 2 hr (0600-0800 h) continuously in an immobile car on an interactive, computer-generated, dull, and monotonous roadway. This exercise followed ingestion (at 0530 h) of 200 mg caffeine (= 2-3 cups coffee) versus placebo, counterbalanced, double blind. Driving incidents (lane drifting), subjective sleepiness, and 4-11 Hz electroencephalogram (EEG) activity were logged. In Study 1 (sleeping 0000-0500 h), caffeine significantly reduced incidents and subjective sleepiness throughout the 2-hr drive, and EEG power for the second 30-min period. In Study 2 (no sleep), sleepiness affected all measures profoundly, and driving was terminated after 1 hr. Nevertheless, caffeine reduced incidents significantly for the first 30 min and subjective sleepiness for the hour. This caffeine dose, feasibly taken via coffee, effectively reduces early morning driver sleepiness for about 30 min following nil sleep, and for around 2 hr after sleep restriction.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10731775

Reyner, L. A. and J. A. Horne (2002)
"Efficacy of a 'functional energy drink' in counteracting driver sleepiness."
PhysiolBehav
7 5(3): 331-5.

KEYWORDS
Adult
Automobile Driving/*psychology
Caffeine/pharmacology
Central Nervous System Stimulants/*pharmacology
Electroencephalography/drug effects
Female
Glucuronates/pharmacology
Humans
Male
Sleep Stages/*drug effects
Taurine/pharmacology

ABSTRACT
Driver sleepiness is a major cause of serious road crashes. Coffee is often used as an effective countermeasure to driver sleepiness. However, the caffeine levels in coffee are variable, whereas certain proprietary "functional energy drinks" (FEDs) contain known levels of caffeine (and other ingredients). We investigated the effectiveness of a well-known FED in reducing sleepiness in drivers. Twelve healthy young adults drove an instrumented car simulator between 14:00 and 17:00 h. Their sleepiness was enhanced by sleep restriction to 5 h the night before. Following a pretreatment 30-min drive and at the beginning of a 30-min break, participants were given double-blind 250-ml FED (containing sucrose, glucose, 80-mg caffeine, taurine, glucuronolactone and vitamins) vs. a control drink with the same volume and same taste but without caffeine, taurine and glucuronolactone. Two hours of continuous driving ensued. Lane drifting, subjective sleepiness and the electroencephalogram (EEG) were monitored throughout. Compared with the control, the FED significantly reduced sleep-related driving incidents and subjective sleepiness for the first 90 min of the drive. There was a trend for the EEG to reflect less sleepiness during this period. It was concluded that the FED is beneficial in reducing sleepiness and sleep-related driving incidents under conditions of afternoon monotonous driving following sleep restriction the night before.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11897259

Sung, E. J., B. C. Min, et al. (2005)
"Effects of oxygen concentrations on driver fatigue during simulated driving."
***Applied Ergonomics* 36(1): 25-31.**

KEYWORDS
Driver Fatigue
Oxygen
Reaction Time
Falling Asleep
Accidents
Sleepiness

ABSTRACT
Driver fatigue has been the cause of traffic accidents. Despite this, the amount of time that drivers spend within cars has been increasing due to complex city life, traffic congestion, and particular occupational requirements. Consequently, fatigue and stress cannot be avoided. In present study, in order to find out the possibility for reducing fatigue while driving due to the supply of oxygen, driver fatigue resulting from the passage of time when different oxygen concentrations are supplied has been examined through subjective evaluations and reaction times using driving simulator for 10 male subjects. The results revealed the subjective fatigue feeling was highest in the low rate (18%) oxygen condition, while in the high rate (30%), it decreased to a certain extent. The feeling of sleepiness also showed the tendency to decrease somewhat in the case of the driving time having passed over I h in the high-rate conditions. Also, the reaction time for braking after being instructed to suddenly stop following more than 2 h of driving was reduced in the high-rate oxygen conditions compared to the low-rate oxygen condition. From the above results, it was shown that while driving a car, if the oxygen rate is lowered, fatigue is felt severely, and that in the case of supplying a high-rate of oxygen, the feeling of fatigue is lowered to some extent and the reaction time is shortened. It was suggested that the driver's fatigue can be reduced according to the supply of oxygen.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=PubMed&list_uids=15627418&dopt=Abstract

Thiffault, P. and J. Bergeron (2003)
"Monotony of road environment and driver fatigue: a simulator study." ***Accident Analysis And Prevention*** **35(3): 381-391.**

KEYWORDS
Fatigue
Drowsiness
Vigilance
Monotony
Road Accidents
Prevention
Accidents
Countermeasures
Sleepiness
Attention
Symptoms
Crashes
Asleep

ABSTRACT
Studies have shown that drowsiness and hypovigilance frequently occur during highway driving and that they may have serious implications in terms of accident causation. This paper focuses on the task induced factors that are involved in the development of these phenomena. A driving simulator study was conducted in order to evaluate the impact of the monotony of roadside visual stimulation using a steering wheel movement (SWM) analysis procedure. Fifty-six male subjects each drove during two different 40-min periods. In one case, roadside visual stimuli were essentially repetitive and monotonous, while in the other one, the environment contained disparate visual elements aiming to disrupt monotony without changing road geometry. Subject's driving performance was compared across these conditions in order to determine whether disruptions of monotony can have a positive effect and help alleviate driver fatigue. Results reveal an early time-on-task effect on driving performance for both driving periods and more frequent large SWM when driving in the more monotonous road environment, which implies greater fatigue and vigilance decrements. Implications in terms of environmental countermeasures for driver fatigue are discussed.

RESEARCH NOTES

URL
No keywords provided.

Veeraraghavan, H. and N. P. Papanikolopoulos (2001)
Detecting Driver Fatigue through the Use of Advanced Face Monitoring Techniques. Minneapolis, University of Minnesota: 31.

KEYWORDS
No keywords provided.

ABSTRACT
Driver fatigue is an important factor in many vehicular accidents. Reducing the number of fatigue-related accidents would save society a significant amount financially, in addition to reducing personal suffering. The researchers developed a driver fatigue monitoring system that uses a camera (or cameras) to detect indications of driver fatigue. The mechanism detects and tracks the eyes of the driver based on human skin color properties, along with templates that monitor how long the eyes are open or closed. Tests of the approach were run on 20 human subjects in a simulated environment (the driving simulator at the Human Factors Research Laboratory) in order to find its potential and its limitations. This report describes the findings from these experiments.

RESEARCH NOTES

URL
No URL provided.

Wierwille, W. W. and L. A. Ellsworth (1994)
"Evaluation of driver drowsiness by trained raters." ***Accid Anal Prev*** **26(5): 571-81.**

KEYWORDS
Adaptation, Psychological
Automobile Driving
Evaluation Studies
Facial Expression
Female
Humans
Male
Observer Variation
Reproducibility of Results
Sleep Stages/*physiology
Videotape Recording

ABSTRACT
Drowsiness of vehicle operators is a major hazard in transportation systems, and methods need to be developed for practical evaluation of drowsiness level. One suggested approach is observer rating. Accordingly, an experiment was carried out using trained observer-raters to evaluate the levels of drowsiness of drivers, the drivers' faces were recorded on videotape. Videotaped segments of drivers at various stages of drowsiness were presented in two sessions separated by a time interval of one week. The experiment was directed at determining test-retest reliability, interrater reliability, intrarater reliability, and consistency. Results indicate that such ratings are reliable and consistent. A subsequent experiment shows that ratings covary with other known indicators of drowsiness.

RESEARCH NOTES

URL
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=7999202

Wierwille, W. W., M. G. Lewin, et al. (1996)
Final Reports: Research on Vehicle-Based Driver Status/Performance Monitoring, Part I. **Blacksburg, VA, Vehicle Analysis & Simulation Laboratory, Department of Industrial & Systems Engineering, Virginia Polytechnic Institute & State University: 60.**

KEYWORDS
No keywords provided.

ABSTRACT
A driver drowsiness detection/alarm/countermeasures system was specified, tested and evaluated, resulting in the development of revised algorithms for the detection of driver drowsiness. Previous algorithms were examined in a test and evaluation study, and were found to be ineffective in detecting drowsiness. These previous algorithms had been developed and validated under simulator conditions that did not emphasize the demand for maintaining the vehicle in the lane as would be expected in normal driving. Revised algorithms were then developed under conditions that encouraged more natural lane-keeping behavior by drivers in the simulator. In these revised algorithms, correlations between dependent drowsiness measures and independent performance-related measures were lower than expected. However, classification accuracy improved when a criterion of "drowsiness or performance" was used, with performance assessed directly from a lane-related measure.

RESEARCH NOTES

URL
No URL provided.

Yamaguchi, M., M. Deguchi, et al. (2006)
"Hand-Held Monitor of Sympathetic Nervous System Using Salivary Amylase Activity and Its Validation by Driver Fatigue Assessment." ***Biosensors and Bioelectronics*** **21(7): 1007-1014.**

KEYWORDS
Dry-chemistry
Enzyme activity
Amylase
Saliva
Sympathetic nervous system
Fatigue

ABSTRACT
In order to realize a hand-held monitor of the sympathetic nervous system, we fabricated a completely automated analytical system for salivary amylase activity using a dry-chemistry system. This was made possible by the fabrication of a disposable test-strip equipped with built-in collecting and reagent papers and an automatic saliva transfer device. In order to cancel out the effects of variations in environmental temperature and pH of saliva, temperature- and pH-adjusted equations were experimentally determined, and each theoretical value was input into the memory of the hand-held monitor. Within a range of salivary amylase activity between 10 and 140 kU/l, the calibration curve for the hand-held monitor showed a coefficient with R2 = 0.97. Accordingly, it was demonstrated that the hand-held monitor enabled a user to automatically measure the salivary amylase activity with high accuracy with only 30 [mu]l sample of saliva within a minute from collection to completion of the measurement. In order to make individual variations of salivary amylase activity negligible during driver fatigue assessment, a normalized equation was proposed. The normalized salivary amylase activity correlated with the mental and physical fatigue states. Thus, this study demonstrated that an excellent hand-held monitor with an algorithm for normalization of individuals' differences in salivary amylase activity, which could be easily and quickly used for evaluating the activity of the sympathetic nervous system at any time. Furthermore, it is suggested that the salivary amylase activity might be used as a better index for psychological research.

RESEARCH NOTES

URL
http://www.sciencedirect.com/science/article/B6TFC-4G7NF5W-1/2/0561f013b546f1dca88d376c0d982086

A1.5 Annotated Bibliography: Effect of Rest Stop Availability on Fatigue

American Trucking Associations (2000)
Iowa Needs More Truck Parking. *Transport Topics*, American Trucking Associations. No. 3371 (Mar. 6, 2000): P. 8: Ill.

KEYWORDS
Iowa
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: University Study Asks for State Involvement.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

American Trucking Associations, Apogee Research, Incorporated, et al. (1996) ***Commercial Driver Rest & Parking Requirements: Making Space for Safety. Appendix B - National Database on Interstate Rest Area Facilities and Use*****, Federal Highway Administration: v.p.**

KEYWORDS
Commercial drivers
Data collection
Databases
Inventories
Inventory
Parking
Parking capacity
Parking demand
Parking regulations
Parking restrictions
Private property
Private truck stops
Rest areas
Roadside rest areas
Truck drivers
Truck facilities

ABSTRACT
A critical first step in this study on public rest areas and private truck stops for commercial truck drivers was to collect information on rest areas on the Interstate highways in the contiguous United States. This information forms the first national database on public rest areas on Interstate highways that serve both passenger and commercial vehicles. The database was used for a variety of purposes, including: the location and identification of public rest areas across the country; development of a capacity utilization model to examine the utilization of public rest area truck parking spaces; and development of a nationwide demand model to determine truck driver parking requirements at public rest areas. The results of the completed database are contained in this appendix. %3 FHWA-MC-96-0010 %2 DTFH61-92-C-00092 %W Transportation Research Board %M 00735968

RESEARCH NOTES

URL
No URL provided.

American Trucking Associations, Apogee Research, Incorporated, et al. (1996)
Commercial Driver Rest & Parking Requirements: Making Space for Safety. Appendix C - How to Determine Commercial Drivers' Requirements for Parking at Rest Areas, **Federal Highway Administration: 31 p.**

KEYWORDS
Commercial drivers
Data analysis
Data collection
Forms (Paper)
Guides to information
Inventories
Inventory
Mathematical analysis
Mathematical models
Parking
Parking demand
Private property
Private truck stops
Research methods
Rest areas
Roadside rest areas
Surveys (Data collection)
Truck drivers
Truck facilities

ABSTRACT
The purpose of this guide is to help state and Federal Highway Administration transportation officials develop a successful "safe rest area" program that meets the needs of commercial drivers and the traveling public. The process requires that a need or demand be identified, that the extent of that need be determined and that solutions be developed through an orderly planning process. This guide will answer most, if not all, of the questions likely to arise, including: What is the manual for and how can I use it? What steps need to be completed for each task in the process? How do I implement the steps described? What do I do with the results? A good "safe rest area" program requires sound approaches to planning, location and design, and is fully integrated with the state's transportation program. This guide's introduction describes why this issue arose, how to implement such a program and how to use this guide. Subsequent sections provide instructions on how to implement the process, from inventorying resting facilities to administering the survey, applying the model and analyzing and reporting the results. A rest-area survey form is appended.

RESEARCH NOTES

URL
http://www.fhwa.dot.gov/reports/append3.htm

American Trucking Associations, Apogee Research, Incorporated, et al. (1996)
***Commercial Driver Rest & Parking Requirements: Making Space for Safety. Final Report*, Federal Highway Administration: 159 p.**

KEYWORDS
Commercial drivers
Data collection
Field observation
Field studies
Guides
Guides to information
Inventories
Inventory
Mathematical models
Parking
Parking capacity
Parking demand
Parking regulations
Parking restrictions
Policy
Private property
Private truck stops
Recommendations
Research
Research methods
Rest areas
Roadside rest areas
Surveys
Surveys (Data collection)
Truck drivers
Truck facilities

ABSTRACT
A study was conducted of the availability and need for truck parking at public rest areas and private truck stops along the Interstate highway system. The goal of the study was to assess the supply, utilization, parking statutes and practices, and demand related to rest area parking at the state and national levels and, based on the findings of that analysis, to identify policies and programs to meet commercial truck drivers' rest needs. An extensive database of truck parking activities at rest areas located along Interstates across the entire country was developed. This study relied on three general methods of data collection, resulting in five sources: an inventory of parking capacity and restrictions at public rest areas nationwide; direct observation of the actual usage of truck parking at rest areas along a medium-density trucking corridor; and three surveys —an in-person survey of truck drivers, a nationwide mail survey of motor carriers, and a mail survey of truck stop operators. The data were collected between October 1993 and January 1994. Two quantitative models were developed to analyze the data collected. The first was an

econometrically-derived Capacity Utilization Model, designed to identify those factors affecting rest area utilization by trucks. The second, a Demand Model, was a mathematical model designed to estimate the total demand for truck parking spaces at public rest areas nationwide. The results of the quantitative analyses were then used to develop policy recommendations for the Federal Highway Administration and a guidebook designed to inform state DOT executives of this research process and how it can be applied at the state level. This volume contains the study's executive summary, final report, and Appendix A - Empirical Results. Appendices B and C are published in separate volumes.

RESEARCH NOTES

URL
http://www.tfhrc.gov/safety/pubs/commercial.pdf

American Trucking Associations, Apogee Research, Incorporated, et al. (1996)
***Commercial Driver Rest Area Requirements: No Room at the Inn:* 40 p.**

KEYWORDS
Commercial Drivers
Driver Fatigue
Drivers
Fatigue (Physiological Condition)
Governments
Highway Safety
Parking Facilities
Parking Place
Private
Private Enterprise
Public
Public Safety
Requirements
Rest Areas
Roadside Rest Areas
Safety
Specifications
Truck Drivers
Truck Driving
Truck Facilities
Truck Stops

ABSTRACT
The steady growth in trucking nationwide appears to have increased the demand for rest areas along the Nations' highways. In part, this is reflected by evidence that, increasingly, truck drivers seeking rest are parking illegally along highway shoulders and entrance and exit ramps, rather than at either public rest areas or private truck stops. With a growing public and industry concern about commercial driver fatigue, and the need to assure public safety along the highways, this research has sought to address this perceived need for additional parking space through direct observation, interviews, statistical evaluations, and demographic data collection. This research documented some important distinctions between public rest areas and private rest stops. Truck drivers tend to use the public areas for short rests, and the private rest stops for overnight stops. This study finds a current shortfall of 28,400 truck parking spaces in rest areas nationwide. The cost to meet this demand totals between $489 to $629 million.

RESEARCH NOTES

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No URL provided.

Bellis, W. R. (1958)
Shoulder Use. *Highway Research Board Bulletin*, Highway Research Board: 51-53.

KEYWORDS
Automobiles
Data Collection
Data Recording
Emergency Parking Bays
Emergency Vehicles
Parking Facilities
Rest Areas
Road Shoulders
Roadside Rest Areas
Shoulder Usage
State Highways
Stopped Time Delay
Stopping
Trucks
Vehicle Miles
Vehicle Miles Of Travel

ABSTRACT
A study was conducted to determine the frequency of use of shoulders for leisure stops and for emergency stops along state highways. Data recorded included: type of vehicle, state of registration, time of stopping, time of resuming trip, lateral distance from edge of pavement, number of occupants, purpose of stop, direction of travel, distance from other vehicles on shoulder, and location of stop longitudinally. Data collected showed that: (1) emergency passenger car stops occur once for every 13,450 passenger car miles, (2) emergency truck stops occur once for every 5200 truck miles, (3) emergency stops occur once for every 11,800 vehicle miles with 20% trucks, (4) leisure passenger car stops occur once for every 980 passenger car miles, (5) leisure truck stops occur once for every 154 truck miles, (6) leisure stops occur once for every 480 vehicle miles with traffic 20% trucks, (7) passenger cars make leisure stops 13.7 times as frequently as they make emergency stops, (8) trucks make leisure stops 33.8 times as frequently as they make emergency stops, and (9) with 20% trucks there are 24.6 times as many leisure stops as emergency stops.

URL
No URL provided.

Berthelsen, G. (2002)
A Master Plan for Safety Roadside Rests. ***California Department of Transportation Journal*****, California Department of Transportation. 2: p. 42-47.**

KEYWORDS
California
California Highway Patrol
Highway Safety
Planning
Public Private Partnerships
Roadside Rest Areas
Truck Drivers

ABSTRACT
California's state highways are served by 88 roadside rest areas, first developed in 1962 and now stretched to capacity. Parking is tight and they are used heavily at peak travel times, with most of the structures forced to continue operating well beyond their original 20-year design lives, resulting in costly and difficult maintenance decisions. The California Department of Transportation (Caltrans) has developed a master plan to guide their renovation and upgrading and for adding new ones where feasible. The plan recommends 80 new ones and lays out the prime goals of a typical rest area. They are : traffic safety by allowing drivers to pull over and rest in a safe spot; amenities for commercial drivers of interstate rigs who often don't have access to private rest stops anymore; security and access to facilities by all users including those with disabilities; opportunities to create partnerships with local private businesses and other agencies to maximize the impact of investments; and esthetically pleasing, consistent architectural designs that at the same time reflect regional character. One new element is trying to incorporate drop-in facilities for highway patrol officers to provide more security and extend the scope of the patrol.

RESEARCH NOTES

URL
California Department of Transportation

Available from UC Berkeley Transportation Library through interlibrary loan or document delivery

Order Document: http://www.lib.berkeley.edu/ITSL/services.html

Bontz, R. (1988)
No Room to Rest: Tired Truckers Need More Places to Park Their Rigs. *Overdrive*, Randall Publishing Company, Incorporated. 28: p. 24-25.

KEYWORDS
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Braver, E. R., C. W. Preusser, et al. (1992)
***Who Violates Work Hour Rules? A Survey of Tractor-Trailer Drivers*, Insurance Institute for Highway Safety: 25 p.**

KEYWORDS
Countermeasures
Economic factors
Electronic recorders
Hours of labor
Interviewing
Law enforcement
Recording instruments
Regulations
Rest areas
Roadside rest areas
Salaries
Salary wage practices
Surveys
Truck drivers
Working hours

ABSTRACT
Fatigue and long driving hours have been implicated as risk factors in truck crashes. Under federal regulations, commercial drivers are permitted to drive no more than 10 hours before having an 8-hour break and cannot work more than 70 hours over an 8-day period. Several studies have suggested that violations of these rules are common. A survey of long haul tractor-trailer drivers was conducted to estimate what proportion of drivers report that they regularly violate the hours-of-service rules and to identify the drivers most likely to commit hours-of-service violations. During December 1990 through April 1991, a total of 1,249 drivers were interviewed at truck safety inspection stations, truck stops, and agricultural inspection stations in Connecticut, Florida, Oklahoma, and Oregon. In each state, interviews were conducted during varying periods of the day over the course of seven days at inspection stations. Overall, 89% of eligible drivers asked for interviews participated in the survey. According to self-reports, almost three-fourths of the respondents violate hours-of-service rules. About two-thirds of the drivers reported that they routinely drive or work more than the weekly maximum. A primary impetus for violating rules appears to be economic factors, including tight delivery schedules and low payment rates. Many other driver, job, and vehicle characteristics were significantly associated with being an hours-of-service violator. The high prevalence of hours-of-service violations among tractor-trailer drivers is a problem in need of urgent attention. Potential measures to reduce the prevalence of rules violations include more enforcement directed toward carriers, wider use of electronic recorders, and increasing the number of rest areas.

URL
No URL provided.

Chatterjee, A. and F. J. Wegmann (2000)
Overnight Truck Parking Along Tennessee's Interstate Highways and Rest Areas.
***Transportation Research Record*, Transportation Research Board: p. 64-68.**

KEYWORDS
Highway safety
Interchanges
Interstate highways
Interviewing
Night
Parking
Parking facilities
Private truck stops
Road shoulders
Roadside rest areas
Stated preferences
States
Strategic planning
Surveys
Tennessee
Truck drivers

ABSTRACT
Truck parking spaces in the public rest areas and pull-out areas along Tennessee's Interstate highways are filling up at night, and large trucks are parking along the shoulders of ramps to these areas. Trucks are also parking along regular interchange ramps and in some cases along through lanes. This is a potentially hazardous situation for travelers. A detailed survey was performed at public rest areas in Tennessee at night, covering all 7 days of the week, to learn about the occupancy characteristics of trucks. Availability of space in private truck stops near interchanges also was examined. This research presents the findings of these surveys in quantitative terms. Several truck drivers were interviewed and all neighboring states were contacted to learn more about why some drivers prefer to park along highways and what strategies are being used by other states to alleviate this problem. Findings related to these issues are presented in this research. This paper appears in Transportation Research Record No. 1734, Highway and Traffic Safety: Engineering, Evaluation, and Enforcement; Trucking and Motorcycles.

RESEARCH NOTES

URL
No URL provided.

Chatterjee, A., F. J. Wegmann, et al. (2001)
Truck Parking and Safety in Rest Areas in Tennessee. ***ITE 2001 Annual Meeting and Exhibit*****, Institute of Transportation Engineers: 13p.**

KEYWORDS
Interstate highways
Managerial personnel
Parking
Parking facilities
Private truck stops
Ramps (Interchanges)
Road shoulders
Roadside rest areas
Surveys
Tennessee
Traffic lanes
Traffic safety
Truck drivers
Truck facilities
Trucking safety
Trucks

ABSTRACT
Truck parking spaces in the public rest areas and pull-out areas along Tennessee's Interstate highways are filling up at night and large trucks are parking along the shoulders of ramps of these areas. Trucks are parking along regular interchange ramps and in some cases along through lanes. This is a potentially hazardous situation for travelers. A detailed survey was performed at public rest areas in Tennessee at night covering all seven days of the week to learn about the occupancy characteristics of trucks. Availability of space in private truck stops near interchanges also was examined. This paper presents the findings of these surveys in quantitative terms. The need for truck parking spaces was estimated along with an assessment of the shortfall. Several truck drivers were interviewed to learn more about why some drivers prefer to park along highways. A few managers of private truck stops were interviewed to learn about their views. Findings related to these issues are presented in the paper.

RESEARCH NOTES

URL
No URL provided.

Chen, K. J., K. K. Pecheux, et al. (2002)
***Commercial Vehicle Driver Survey: Assessment of Parking Needs and Preferences*, Science Applications International Corporation. Federal Highway Administration: 39 p.**

KEYWORDS
Commercial drivers
Layout
Needs assessment
Parking demand
Parking facilities
Roadside rest areas
Stated preferences
Surveys
Transportation Equity Act for the 21st Century
Truck drivers
Truck stops

ABSTRACT
This research assessed truck driver parking needs and preferences in accordance with Section 4027 of the Transportation Equity Act for the 21st Century. A survey was conducted to determine how truck drivers plan for and address their parking needs; how truck drivers select when, where, and at which facilities they park; and what truck drivers think of the adequacy of current parking facilities. This report summarizes the background, methodology, and outcome of the driver survey. Surveys were distributed to a national sample of more than 2,000 truck drivers through site visits and mailings to truck stops. The sample included male and female drivers; independent owner/operators; and drivers for small-, mid-, and large-sized carriers. The majority of respondents identified themselves as long-haul drivers. Nearly all drivers reported that they, not their company colleagues, decide where they will park. Most drivers make this decision as they are driving. When drivers park their trucks, most expect to satisfy only their basic needs. Drivers prefer parking facilities that provide food, fuel, restrooms, phones, and showers. They also consider safety and convenience important. Drivers generally prefer private truck stops to public rest areas. However, for quick naps drivers showed a preference for rest areas over truck stops. Many respondents indicated they have trouble finding available parking at rest areas and truck stops. In fact, drivers asserted that building more truck stop and rest area spaces would be the best way to improve the parking situation. Survey respondents indicated that the parking facilities they encounter generally have characteristics that make those facilities usable. But, drivers did recommend that time limits be eliminated and that parking lot layouts be improved to accommodate large trucks. FHWA-RD-01-160, Final Report DTFH61-98-C-00059 Transportation Research Board 00930547

URL
http://www.tfhrc.gov/safety/pubs/01160/index.htm

Clark, R. (1979)
Fatigue Makes for Dangerous Driving. *ROBOT*, South African Road Safety Council Snelco-Pro Public Relations Consultants: p. 29-30.

KEYWORDS
Alertness
Comfort
Driver fatigue
Drivers
Fatigue (Physiological condition)
Mental stress
Rest stops
Roadside rest areas
Stress (Psychology)
Travel time
Trip length

ABSTRACT
Ways are examined to combat fatigue and boredom while driving, thereby making travel safer, since fatigue results in dangerous driving. Steady speeds on highways can be more wearying than varied speeds required on local roads; heavy traffic can result in stress. In avoiding fatigue, it helps if the driver sits comfortably. An incorrect posture can restrict oxygen intake. Adequate but not excessive food and enough sleep can maximize muscular efficiency and driving safety. To maintain body warmth and to stimulate circulation, 10-minute stops every hour are recommended for trips. Companionship is the best solution for boredom, with regular checks on vehicle instruments being a good way of marking time. Tips for avoiding car sickness are identified, as well as circumstances in which an individual should not drive. A checklist to facilitate safe driving emphasizes physical characteristics of the individual, features of the car, drugs and their interaction with driving, and the trip itinerary.

RESEARCH NOTES

URL
No URL provided.

Cox, K. (2004)
Natso Pleased Congress Dropped Commercialization of Rest Areas. *Transport Topics*, American Trucking Associations: P. 3+: ILL.

KEYWORDS
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Cox, K. (2004)
Truck Stops Aim at Parking Information. *Transport Topics*, American Trucking Associations: P. 28: ILL.

KEYWORDS
Parking facilities
Parking garages
Parking lots
Parking spaces.
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Crum, M. R., P. C. Morrow, et al. (2002)
***Motor Carrier Scheduling Practices and Their Influence on Driver Fatigue*, Iowa State University, Ames / The Daecher Consulting Group, Incorporated / Federal Motor Carrier Safety Administration: 230 p.**

KEYWORDS
Bus drivers
Commercial vehicles
Company safety practices
Driving environments
Fatigue (Physiological condition)
Loading and unloading
Motor carriers
Night shifts
Regression analysis
Risk analysis
Roadside rest areas
Safety education
Scheduling
Surveys
Time duration
Truck drivers

ABSTRACT
The primary objective of this report is to develop a better understanding of how the scheduling practices of motor carrier firms affect driver fatigue. The basis of this empirical research is a commercial driver fatigue model that includes driving environment (i.e., regularity of time, trip control, and quality of rest), economic pressures exerted on drivers (from customers, carriers, and the drivers themselves) and company safety practices as key factors in explaining driver fatigue. The model utilizes two measures of fatigue: frequency of close calls due to fatigue and driver perceptions of fatigue as a problem. Crash involvement is used to evaluate general safety performance. Three separate studies were conducted. First, the influence of driving environments alone on fatigue among over-the-road truck drivers was tested through a survey of 502 drivers at five geographically dispersed truck stops. A typology of driving environments was developed and the percent of drivers in each category was determined. It was found that a large number of drivers are in the "high fatigue risk" categories. Regression analysis identified starting the work week tired and longer than expected loading and unloading time as significantly related to both measures of fatigue. Regularity of time, regularity of route, and hours of uninterrupted sleep were each statistically significant factors for one fatigue measure. Next, the complete model was tested on a random sample of 279 drivers at 116 trucking companies and 122 drivers at 66 motor coach companies, which was then stratified on the basis of safety performance (i.e., SAFESTAT ratings). Data for these two studies were generated from surveys of drivers, safety directors, dispatchers, and top management at the sample firms. In the truck company study, starting the workweek tired was the single most significant factor related to fatigue. Other significant fatigue-

influencing factors were difficulty in finding a place to rest and shippers' and receivers' scheduling requirements (including loading and unloading). Company safety practices that mitigated driver fatigue were carrier assistance with loading and unloading, carrier efforts to minimize nighttime driving, and driver voluntary attendance at corporate safety and training meetings. In the motor coach company study, the most significant factors related to driver fatigue were starting the work week tired, driving tired to make a good income, and pressure on drivers to accept trips. Two safety measures - driver' perceptions of their company's safe driving culture and policies, or attempts to minimize nighttime driving - mitigated some of the factors that adversely affect driver fatigue. Date on documentation page: Dec. 2002; date on cover: Oct. 2002.

RESEARCH NOTES

URL
http://www.fmcsa.dot.gov/safetyprogs/research/briefs/Final_Report_text_and_appendixes__090502.pdf

Dobbie, K. (2002)
Fatigue-Related Crashes: An Analysis of Fatigue-Related Crashes on Australian Roads Using an Operational Definition of Fatigue. **A. T. S. Bureau, Commonwealth Department of Transport and Regional Services: 1-30.**

KEYWORDS
Driver fatigue
Fatal crashes
Operational definition
Surrogate measure
Articulated trucks

ABSTRACT
In recent years fatigue has been considered a primary contributory factor in road crashes. However, precise identification of fatigue-related crashes is hindered by the absence of a universally accepted definition of fatigue. Furthermore, it is difficult to quantify the level of driver fatigue due to difficulties in objectively measuring the degree of fatigue involved in a crash. To overcome these obstacles the Australian Transport Safety Bureau (ATSB) has proposed an operational definition of a fatigue-related crash. The definition is based on a set of well-researched selection criteria and uses crash characteristics routinely collected by different traffic authorities. This definition should be useful in monitoring fatigue-related crashes and gauging trends over time or between regions. Using the ATSB operational definition, the proportion of fatal crashes involving driver fatigue increased initially in the early 1990s, (14.9 per cent in1990 to 18.0 per cent in 1994), and then decreased in the late 1990s (16.6 per cent in 1998). The study suggests that the operational definition provides a practical and useful index of the relative incidence of fatigue-related crashes.

RESEARCH NOTES

URL
http://www.atsb.gov.au/publications/2002/pdf/Fatigue_related_sum.pdf

Federal Highway Administration. (1996)
"Commercial Driver Rest & Parking Requirements: Making Space for Safety. Final Report - Executive Summary." **Federal Highway Administration: 38 p.**

KEYWORDS
Commercial drivers
Costs
Dangerous parking locations
Data collection
Demand
Driver fatigue
Drivers
Fatigue (Physiological condition)
Highway safety
Long term parking
Mathematical models
Overnight parking
Parking
Parking capacity
Parking demand
Parking duration
Private property
Private truck stops
Rest areas
Roadside rest areas
Short term parking
Shortages
Supply
Supply and demand
Surveys
Surveys (Data collection)
Time duration
Truck drivers
Truck facilities

ABSTRACT
This publication is an executive summary of a research study on public rest areas and private truck stops for commercial drivers. The research team first assessed the current status of public rest area parking for trucks nationwide and developed analytical models to estimate the demand for truck parking spaces. This comprehensive assessment of public rest areas projected a current shortfall of 28,400 truck parking spaces in public rest areas nationwide. An important component of the assessment was the information obtained from the driver survey. More than 90% of commercial drivers sampled perceived that there is a shortage of truck parking facilities, particularly for long-term or overnight parking. For short-term parking, a majority of the sampled drivers expressed a preference for public rest areas. Two-thirds of them indicated a preference for private

truck stops for overnight or long-term rest needs. The assessment of supply and demand for long-term truck parking at private truck stops followed a process similar to that for the public rest area study. This assessment determined that about one-third of truck stop operators, based on a weighted sample, plan to expand their parking facilities over the next 3 years. This would increase total projected capacity from 185,000 truck parking spaces to more than 213,000. This suggests that some of the current shortfall at public rest areas might be satisfied in the future by private expansion efforts. However, this additional analysis found no conclusive evidence that private truck stops and public rest areas are direct substitutes for each other. Rather, they are complementary. Projected costs to meet future truck parking demands total between $489 and $629 million. The problem of inadequate truck parking can only be met by creative strategies to help facilitate future rest area spending decisions over the next 10 years. Failure to solve the truck parking shortage could pose significant risks to the traveling public by forcing tired drivers to continue driving, or park on inherently dangerous locations such as ramps and shoulders.

RESEARCH NOTES

URL
No URL provided.

Federal Highway Administration. (2002)
Fhwa Releases Report on Commercial Truck Parking Demand and Supply. ***Urban Transportation Monitor*****, LawleyPublications. V.16, NO. 14 (July 26, 2002): 7.**

KEYWORDS
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: Report links availability of parking spaces and truck driver fatigue.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Federal Highway Administration. (1999)
***"Rest Area Forum: Summary of Proceedings."* 1-54.**

KEYWORDS
No keywords provided.

ABSTRACT
This report summarizes the proceedings of the June 29-30, 1999 Rest Area Forum in Atlanta, Georgia. More than 70 representatives of stakeholder groups assembled at the Forum to discuss rest parking facilities for commercial vehicle drivers along our National Highway System. Forum participants identified key issues concerning the availability and safety of parking and generated recommendations for addressing each issue. Although differences remain among stakeholders, the Forum succeeded in promoting greater understanding and meaningful follow-up action.

RESEARCH NOTES

URL
http://www.tfhrc.gov/safety/00034.pdf

Federal Motor Carrier Safety Administration. (1998)
Commercial Driver Rest & Parking Requirements: Making Space for Safety. *Tech Brief*, Federal Motor Carrier Safety Administration: 4 p.

KEYWORDS
Alertness
Commercial drivers
Data collection
Demand
Demographics
Fatigue (Physiological condition)
Highways
Interviewing
Modeling
Night
Parking facilities
Roadside rest areas
Statistical sampling
Truck drivers
Truck facilities
Trucking safety

ABSTRACT
This tech brief presents an FHWA study that addressed the adequacy of both public and private parking facilities nationwide. The steady growth in trucking nationwide appears to have increased the demand for rest areas along the nation's highways. Commercial drivers need a safe place to park, especially at night, to maintain their alertness. A growing concern about commercial driver fatigue has created a need to assure public safety along the highways. The primary goal of this study was to consider parking statues and enforcement, and to determine the supply, utilization, and demand for truck parking at both rest areas (public facilities) and truck stops (privately-owned facilities). Research sought to address a perceived need for additional parking space through direct observation, interviews, statistical sampling and evaluations, modeling, and demographic data collection.

RESEARCH NOTES

URL
http://www.fmcsa.dot.gov/pdfs/tb98-002.pdf

Fleger, S. A., R. P. Haas, et al. (2002)
***Study of Adequacy of Commercial Truck Parking Facilities - Technical Report*,**
Science Applications International Corporation / Federal Highway Administration: 68 p.

KEYWORDS
Commercial vehicles
Guidelines
Improvements
Inventory
National Highway System
Needs assessment
Parking demand
Parking facilities
Roadside rest areas
Surveys
Truck drivers
Truck facilities
Trucks
Turnouts

ABSTRACT
This report documents the findings of a study to investigate the adequacy of commercial truck parking facilities serving the National Highway System (NHS). The study involved: 1) a national assessment of the extent and geographic distribution of parking shortages, 2) research to clarify drivers' parking-related needs and decision-making, and 3) development of a technical guidance document to be used by partnerships of public- and private-sector stakeholders in 49 States (excluding Hawaii) for inventorying current facilities serving the NHS, analyzing current and projected shortages in commercial truck parking at public rest areas and commercial truck stops and travel plazas, and developing plans for action at the appropriate jurisdictional levels. The process involved: 1) the development of an inventory of public and commercial truck spaces serving the NHS, 2) development, calibration, and application of a truck parking demand model, 3) a national survey of truck drivers to determine how drivers plan for and address their parking needs, how truck drivers select when, where, and at which facilities they park, and what truck drivers think of the adequacy of current parking facilities, 4) an estimate of parking demand using a modeling approach, 5) identification of parking deficiencies at the State and corridor level by comparing supply and demand, and 6) identification of improvements that were recommended by State partnerships to mitigate any existing or future problems identified.

RESEARCH NOTES

URL
http://www.tfhrc.gov/safety/pubs/01158/01158.pdf
http://www.tfhrc.gov/safety/pubs/01158/index.htm

Garber, N. J. and H. Wang (2004)
***Estimation of the Demand for Commercial Truck Parking on Interstate Highways in Virginia*, Virginia Transportation Research Council / Virginia Department of Transportation / Federal Highway Administration: 48 p.**

KEYWORDS
Commercial truck parking
Data collection
Interstate highways
Parking demand
Parking duration
Parking supply
Private truck stops
Roadside rest areas
Traffic volume
Truck traffic
Trucks
Virginia

ABSTRACT
The steady growth of commercial truck travel has led to an increasing demand for truck parking spaces at public rest areas and private truck stops on interstate highways in Virginia. This study developed a methodology to determine the supply and demand for commercial truck parking along these corridors. "Supply" was defined as the number of parking spaces available for commercial truck parking, and "demand" was defined as the sum of the parking accumulation and illegal parking at a given time. Phase I of this study developed a methodology to determine the supply and demand for commercial truck parking using I-81 in Virginia as a case study. This Phase II study expanded the study to other interstate highways in Virginia, checked the applicability of the parking demand model developed in Phase I, and developed new models when necessary. Extensive data on the characteristics of commercial truck parking and the characteristics of each truck stop and rest area were collected. In addition, truck drivers and truck stop owners/operators were surveyed. The data collected were used to develop models to describe the relationship between parking accumulation and independent variables such as traffic volume on the highway, truck percentage, parking duration, and the distance from a highway to a truck stop. After the applicability of the models was tested, they were used to estimate commercial truck parking demand in 2010 and 2020. Deficiencies of parking spaces with respect to estimated demand were then determined for each truck stop and the entire Virginia interstate highway system. The results indicate that the demand for commercial truck parking at individual truck stops on I-95 exceeds the supply by 10% to 22% and that there is no commercial parking shortfall at truck stops along I-64, I-77, and I-85. However, there are shortfalls at rest areas on I-66, I-77, I-85, and I-95, varying from about 6% on I-85 to about 32% on I-95. If no new parking spaces are provided and a 5% increase in truck travel is assumed, the demand/supply ratio in 2010 for large truck parking on all interstate highways in Virginia will exceed 1.00. This deficiency could be as high as 40% on I-95.

RESEARCH NOTES

URL
http://www.virginiadot.org/vtrc/main/online_reports/pdf/04-r10.pdf

Gårder, Per E. and Nicolas Bosonetto. (2002)
***Quantifying Roadside Rest Area Usage.* Orono, University of Maine: 113.**

KEYWORDS
Rest Area
Interstate
New England
Preferences
Motorists

ABSTRACT
This report outlines issues relevant to the design and operation of Interstate rest areas. The study concentrates on the New England Region and is sponsored by the NETC. Usage trends and motorists' preferences were collected through a survey program conducted at eleven sites and with residents of all the New England states. Motorists in general see rest areas as a necessity, and favor keeping them, but many have issues with public safety and cleanliness. The results also show that restrooms are the primary demand but that road condition and tourism information services are rated as highly desirable by some rest area users. This report suggests a kiosk system to provide this information to travelers using a GIS interface. Other recommendations include region-wide comprehensive parking development and management, as well as improvements in waste water systems. Rest area improvements are essential to the New England tourism and freight sectors of the economy.

RESEARCH NOTES

URL
No URL provided.

Gilroy, R. (1988)
Little Rest for Weary Drivers in Ohio. *Transport Topics*, American Trucking Associations: p. 1+.

KEYWORDS
Ohio
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Graham, S. (1998)
Sorry, No Vacancy. *Traffic Safety (Chicago)*, National Safety Council. 98: p. 16-19.

KEYWORDS
Fatigue (Physical condition)
Fatigue (Physiological condition)
Financing
Government funding
Parking demand
Parking facilities
Shortages
Sleep deprivation
Truck drivers
Truck facilities
Trucking safety

ABSTRACT
Truck drivers throughout the country are finding parking spots hard to come by when they need to sleep. A 1996 study for the Federal Highway Administration (FHWA) found a nationwide shortage of 28,400 truck parking spots in public rest areas, while some 85% of private truck stops polled report their facilities are "full" or "overflowing" at night. Truckers who cannot find parking spaces are forced to park illegally on shoulders or ramps, or to keep going and risk falling asleep behind the wheel. While no definitive figures are available on the number of truck crashes involving drowsy drivers, fatigue was voted the top concern at the FHWA's 1995 Truck and Bus Safety Summit. A 1996 FHWA study concluded that the nation needs another 28,400 truck parking spaces in public rest areas that would cost $489-629 million. Recent legislation allows states to use 100% federal funding to improve rest areas where the secretary of transportation deems a shortage of public and private facilities. To stimulate private investment as well, the National Association of Truck Stop Operators believes Congress should authorize incentives, such as low-interest loans or tax credits. A sidebar outlines how Iowa and Kentucky have tried to ease their truck-parking shortages.

RESEARCH NOTES

URL
No URL provided.

Gunatillake, T. and P. Daly (2003)
Public Perception of Rest Areas in Victoria. Proceedings of the 21st ARRB and 11th REAAA Conference. Transport. *Our Highway to a Sustainable Future*, ARRB Transport Research, Limited: 14 p.

KEYWORDS
Australia
Drivers
Highways
Planning
Public participation
Rest periods
Roadside rest areas
Route choice
Service stations
Stopping
Trip distribution
Trip purpose
Truck routes

ABSTRACT
This paper describes how driver fatigue is a major contributing factor in rural crashes. The onset of fatigue associated with long distance driving is an issue that road authorities have sought to address in a number of ways including the provision of roadside stopping areas. In Victoria, VicRoads maintains a network of service centers, rest areas, wayside stops and truck parking bays across the highway system in order to encourage motorists to stop and take regular breaks on long trips. Local Government also sustains rest area facilities along the major local routes and within townships. Drivers are encouraged to use these government provided facilities or to take breaks at commercial facilities, service clubs or attractions along the way. The current project seeks to explore motorists' views on rest areas through a market research approach. The key objectives of this paper are to: (1) identify the extent to which motorists utilize these rest areas, the facilities they find most useful and those which they find lacking; (2) determine whether patronage of these facilities is influenced by demographic factors, life stage and by residence (metropolitan or rural); (3) determine whether the requirements of motorists and patronage vary with trip purpose, trip length and the time of day; (4) gauge driver perceptions about the quality and placement of rest areas in Victoria, with a breakdown by rest area types (i.e. service centers, rest areas, wayside stops and truck stops); and (4) determine the role, if any, that rest areas play in trip planning and route selection. Full conference proceedings available on CD-ROM.

RESEARCH NOTES

URL
No URL provided.

Heine, M. A. X. (1999)
The Quest for Rest.Overdrive, Randall Publishing Company, Incorporated. V. 39 P. 34-40: Ill.

KEYWORDS
Fatigue.
Parking facilities
Parking garages
Parking lots
Parking spaces.
Roadside rest areas
Truck drivers
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: With truckers competing for too few parking places, long hauls feel longer and safety fuses burn shorter: will the industry wake up in time?

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Johnson, J. (2000)
NTSB Says Parking Shortage Problem Could Grow Worse with Hours Reform.
***Transport Topics*, American Trucking Associations: P. 5+: Ill.**

KEYWORDS
Roadside rest areas
Truck drivers
Truck facilities
Truck stops
Work rules

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Johnson, J. (2000)
NTSB: Truckers Need Free Parking Guide: Print, Electronic Versions. *Transport Topics*, American Trucking Associations: P. 3+: ILL.

KEYWORDS
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Johnson, J. (2003)
Maine Finds That It Lacks Adequate Truck Parking. *Transport Topics*, American Trucking Associations: P. 5.

KEYWORDS
Maine
Parking facilities
Parking garages
Parking lots
Parking spaces
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: Draft Study Identifies 570 Spaces at State's Public and Private Stops, Weigh Stations.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Keefer, L. E. (1963)
Trucks at Rest. *Highway Research Record*, Transportation Research Board / Highway Research Board: P. 29-38.

KEYWORDS
Improvements
Loading and unloading
Loading time
Origin & amp
Destination Studies
Origin and destination
Parking demand
Parking duration
Production
Stopped vehicles
Stopping
Taxicabs
Time and motion studies
Travel patterns
Travel time
Truck facilities
Truck terminals
Trucks
Truckstops

ABSTRACT
Preliminary findings on the length and frequency of truck stops, resulting from the Pittsburgh area transportation studies 1958 truck-taxi survey are reported. The duration of stops is given by truck type /size/, trip purpose, owners business, destination land use, destination ring /location in study area/, and time of day. The typical truck was found to be in motion less than 2 1/2 hours - 10 percent of the day. The average truck stop during the day took about twice as long as the average truck trip. This suggests that although highway improvements will materially aid the trucking industry, careful attention must also be given to developing modern and efficient loading and unloading facilities, and to parking, maintenance, management, vehicle design and other at-rest facilities. Shortening-up of truck stops and improved truck productivity could have important implications such as reduced demand for truck terminals and parking facilities. The tables also show data for taxis.

RESEARCH NOTES

URL
Transportation Research Board Business Office
Order Document: http://nationalacademies.org/trb/publications/tris/out_of_print.html

Kelley, S. (2003)
No Rest for the Weary. *Overdrive*, Randall Publishing Company, Incorporated. V. 43: P. 20-24: Ill.

KEYWORDS
Parking facilities
Parking garages
Parking lots
Parking spaces.
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: Finding a parking space for every trucker remains an elusive and complex goal as parking shortages persist, studies conflict, rest area commercialization looms and hours reform mandates longer rests.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

King, G. F. (1989)
Evaluation of Safety Roadside Rest Areas. **Washington, D.C., Transportation Research Board National Research Council.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
No URL provided.

Koklanaris, M. (2000)
A Safe Place to Rest. *Public Roads*, Federal Highway Administration.63: p. 15-18.

KEYWORDS
Drowsiness
Fatigue (Physiological condition)
Federal Motor Carrier Safety Administration
Hazards
Highway safety
New York (State)
Parking facilities
Rest periods
Roadside rest areas
Sleep deprivation
Traffic safety
Truck drivers
Truck facilities
U.S. Dept. of Transportation
U.S. Federal Highway Administration

ABSTRACT
Even the most skillful truck driver becomes a highway hazard if deprived of sleep, but finding an appropriate place to stop and take a much-needed rest is a challenge for many truckers. In a 1999 survey, more than 36% of truck drivers said that finding a rest area is which to park is a problem every night. More than 80% said that at least once a week they continue to drive past the point of feeling safe and alert because they cannot find a place to stop and rest. In a 1997 survey of 593 long-distance truck drivers randomly selected at private truck stops and public rest areas in New York, 25% said that at least once during the last year they had fallen asleep while driving, and 17% said it occurred on more than one occasion. The frequency of not finding a parking space at a rest area--80% of the drivers reported that they were always or often unable to find a parking space at a public rest area at night--was associated with drivers who fell asleep at the wheel in the past year and a tendency to violate regulations. When asked what, if anything, discouraged their use of public rest areas in New York, 51% cited inadequate parking. Other common responses were enforcement of the 2-hour parking limit (28%), prostitution/solicitation (16%), lack of security (15%), and poor or expensive food (14%). The Department of Transportation's Federal Motor Carrier Safety Administration and the Federal Highway Administration are working on a solution. A report to Congress on the status of rest parking for truckers, along with recommendations for addressing shortages, is due in June 2001. A sidebar outlines the seven top concerns identified during a 1999 Rest Area Forum in Atlanta, Georgia, and some of the recommendations offered.

RESEARCH NOTES

URL
http://www.tfhrc.gov/pubrds/marapr00/truckers.htm

Laurio, A. (2001)
States Outline Efforts to Provide More Facilities for Truck Parking. *Transport Topics*, American Trucking Associations: P. 3+: Ill.

KEYWORDS
Parking facilities
Parking garages
Parking lots
Parking spaces.
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Lockridge, D. (1999)
No Rest Areas for the Weary. ***Heavy Duty Trucking*****, Newport Communications (Irving). V. 78: P. 62-70: Ill.**

KEYWORDS
Parking facilities
Parking garages
Parking lots
Parking spaces.
Roadside rest areas
Truck facilities
Truck stops

ABSTRACT
No abstract provided.

Subtitle: Changing hours of service is futile if parking issues are not addressed.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

National Transportation Safety Board. (2000)
***Highway Special Investigation Report: Truck Parking Areas*: 1-31.**

KEYWORDS
No keywords provided.

ABSTRACT
In April 1999, the National Transportation Safety Board began a Truck/Bus Safety Initiative and
to date has held four public hearings to obtain information from a variety of sources about the relevant safety issues regarding trucks and buses and on how to address them. Participating in these hearings were representatives from the truck and bus industries, vehicle and equipment manufacturers, labor unions, safety advocacy groups, and various State and Federal agencies.
The major issue addressed in this Safety Board special investigation report is the lack of safe available commercial vehicle parking on or near interstates for truck drivers who want or need to use it. Associated with this issue, this report also discusses the lack of information about parking available to truck drivers and the State-enforced parking time limits. As a result of its investigation, the Safety Board issued recommendations to the Federal Highway Administration; the Federal Motor Carrier Safety Administration; the Governors of Alabama, Delaware, Florida, Georgia, Illinois, Kentucky, Louisiana, Minnesota, Nebraska, New Jersey, Pennsylvania, South Carolina, South Dakota, Tennessee, Virginia, and Washington; the American Trucking Associations, Inc.; the Owner-Operator Independent Drivers Association; the National Private Truck Council; the National Association of Truck Stop Operators; and the National Industrial Transportation League.

RESEARCH NOTES

URL
http://www.ntsb.gov/publictn/2000/SIR0001.pdf

Reddy, T. (2005)
FMCSA Seeks Proposals to Help Truck Drivers Find Parking. *Transport Topics*, American Trucking Associations: p. 39 + Ill.

KEYWORDS
Parking Spaces
Roadside Rest Areas
Truck Stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Reddy, T. (2005)
***Minnesota's Rest Stops Closed*, American Trucking Associations: p. 3+: Ill.**

KEYWORDS
Minnesota
Roadside Rest Areas

ABSTRACT
No abstract provided.

Subtitle: State operations affected by partisan budget battle.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Schulz, J. D. (1996)
ATA Calls for More Public Rest Areas to Alleviate Truck Driver Fatigue. *Traffic World*, Commonwealth Business Media. V. 246: P. 17-18: Ill.

KEYWORDS
Parking Facilities
Parking Garages
Parking Lots
Parking Spaces.
Roadside Rest Areas
Truck Facilities
Truck Stops

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Spillenger, P. (2000)
The Truck Stop — Where? *Land Line Magazine.* V. 25: P. 22-23+: Ill.

KEYWORDS
Roadside Rest Areas
Truck Facilities
Truck Stops

ABSTRACT
No abstract provided.

Subtitle: In an industry united in favor of more big rig parking spaces, only the truckstop operators say no to more rest are parking. Why is that?

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Strah, T. M. (1996)
Drivers Need More Room to Rest. *Transport Topics*, American Trucking Associations: P. 1+: Ill.

KEYWORDS
Parking Facilities
Parking Garages
Parking Lots
Parking Spaces.
Roadside Rest Areas
Truck Facilities
Truck Stops

ABSTRACT
No abstract provided.

Subtitle: Study finds truck space shortage at public rest areas.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Taylor, W. C., N. Sung, et al. (1999)
***A Study of Highway Rest Area Characteristics and Fatigue Related Truck Crashes*: 1-59.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
I.T.S. Library, University of California, Berkeley

Taylor, W. C., N. Sung, et al. (1999)
***A Study of Highway Rest Area Characteristics and Fatigue Related Truck Crashes* – Executive Summary: 1-9.**

KEYWORDS
No keywords provided.

ABSTRACT
No abstract provided.

RESEARCH NOTES

URL
I.T.S. Library, University of California, Berkeley

Tyler, J. M. and C. B. DeVere (1974)
Motorists' Attitudes and Behavior Concerning California's Roadside Rest Areas.
***Transportation Research Record*, Transportation Research Board: p. 29-35.**

KEYWORDS
Behavior
Demographic Studies
Demographics
Driver Behavior
Drivers
Highway User Characteristics
Parks
Public Opinion
Questionnaires
Rest Areas
Rest Stops
Restaurants
Roadside Rest Areas
Travel Patterns
Travelers

ABSTRACT
This paper reports the results of a research program conducted to assist in evaluating the highway travel and stopping patterns of California drivers. The findings of the study deal, in large part, with long-trip motorists, defined as those who have taken at least 1 trip of 100 miles or more away from home in the previous year. Eighty-six percent of all California motorists have taken at least 1 such trip. The demographic profile of the California long-trip motorist closely parallels the profile of California highway users in general. The median stopping closely parallels the profile of California highway users in general. The median stopping interval for long-trip motorists is every 73 miles and 75 minutes; the mean stopping interval is 81 miles and 85 minutes. The roadside rest area user tends to stop more often than the average long-trip motorist. The median stopping interval for all rest area users is every 58 miles and 68 minutes, and the mean is every 61 miles and 73 minutes. Sixty-four percent of all California highway users have stopped at a roadside rest area at 1 time or another; long-trip motorists are more likely to stop at such an area than short-trip motorists. Roadside rest area users have taken considerably more long driving trips (14) than the average California motorist (7) within the past 12 months. Other findings of the study concern motorists' attitudes and opinions concerning roadside rest areas, reasons for using them, comparison of the rest areas with the "ideal" stopping opportunity, and related issues.

RESEARCH NOTES

URL
Transportation Research Board
Order Document: http://nationalacademies.org/trb/publications/tris/out_of_print.html

Tzamalouka, G., M. Papadakaki, et al. (2005)
Freight Transport and Non-Driving Work Duties as Predictors of Falling Asleep at the Wheel in Urban Areas of Crete. ***Journal of Safety Research*****, Elsevier. 36: p. 75-84.**

KEYWORDS
Accident Prone Drivers
Accident Proneness
Crete (Greece)
Demographics
Drowsiness
Fatigue (Physiological Condition)
Freight Handling
Fruits And Vegetables
Hours Of Labor
Livestock
Risk Analysis
Risk Factors
Sleep Deprivation
Smoking
Truck Drivers

ABSTRACT
The risk for being involved in road crashes caused by sleepiness or falling asleep at the wheel is increased for professional drivers whose job makes great demands on their time. This article reports on a study on the impact of drowsy driving and non-driving duties (such as loading and unloading deliveries) on the falling asleep responses and road crash involvement of professional drivers in Crete (Greece). The sample of 317 drivers was studied through personal interviews. The interview questionnaire included four sections: demographic information, including lifestyle patterns such as number of cigarettes smoked per day and quantity of alcohol consumed; details of the longest distance trip recently made by the professional driver (including the type of freight carried, the hours of sleep obtained before departure, rest stops); the drivers' perceptions of sleepiness and fatigue; and the participants' driving and non-driving work schedules, including the amount of sleep obtained during the week prior to the interview. Results showed that the most significant predictors of falling asleep at the wheel were transportation of fruits/vegetables and livestock, non-driving hours of work, insufficient hours of sleep, and smoking. In addition, a higher frequency of falling-asleep incidents in the previous 12 months and a lower rate of the drivers' church attendance appeared to slightly increase the crash risk. The authors conclude that their findings raise questions about the professional drivers' work duties and highlight the need for adequate rest to reduce fatigue.

URL
No URL provided.

Wegmann, F. J. and A. Chatterjee (2002)
Truck Parking in Southeastern States: Issues and on-Going Efforts. ***International Truck and Bus Safety Research and Policy Symposium*****, University of Tennessee, Knoxville / National Safety Council: p. 145-150.**

KEYWORDS
Highway Safety
Interstate Highways
Night
Parking
Parking Facilities
Private Truck Stops
Roadside Rest Areas
Southeastern Unites States
Tennessee
Traffic Safety
Truck Facilities
Trucks

ABSTRACT
Tennessee is acknowledged as "bridge state" for through truck traffic. Based on the 1993 commodity flow survey with adjustments made by the Oak Ridge National Laboratory (ORNL), Tennessee ranks 5th nationally in terms of ton-miles of truck shipments. A major concern in Tennessee and some of the other southeastern states involves the provision of adequate public and private parking spaces, especially at nighttime, for large trucks along Interstate highways. Frequently trucks are found parked at locations that can be considered potentially hazardous. It is estimated that in the ten southeastern states there are 8,033 truck parking spaces in public rest areas, and approximately 46,000 to 74,000 parking spaces in private truck stops located along Interstate highways. The estimated demand for truck parking spaces in these 10 states in 63,700, which exceeds the rest area spaces by a factor of eight, and also exceeds the combined supply of rest area and the lower estimate of truck stop spaces. This article discusses activities in Tennessee and the other southeastern states undertaken to solve the truck parking problem.

RESEARCH NOTES

URL
No URL provided.

Whitten, D. L. (2000)
Truck Stop Operators Launch 'Park Safe' Effort, Counter Critics. *Transport Topics*, American Trucking Associations: P. 2+: ILL.

KEYWORDS
Parking Facilities
Parking Garages
Parking Lots
Parking Spaces.
Roadside Rest Areas
Truck Facilities
Truck Stops

ABSTRACT
No abstract provided.

Sidebar: NATSO members have interest in hours rules.

RESEARCH NOTES

URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

Whitten, D. L. (2002)
FHWA Says Parking Ample. *Transport Topics,* American Trucking Associations: P. 1+: Ill.

KEYWORDS
Roadside Rest Areas
Truck Facilities
Truck Stops

ABSTRACT
No abstract provided.

Subtitle: Truckers see space shortages around cities.

RESEARCH NOTES

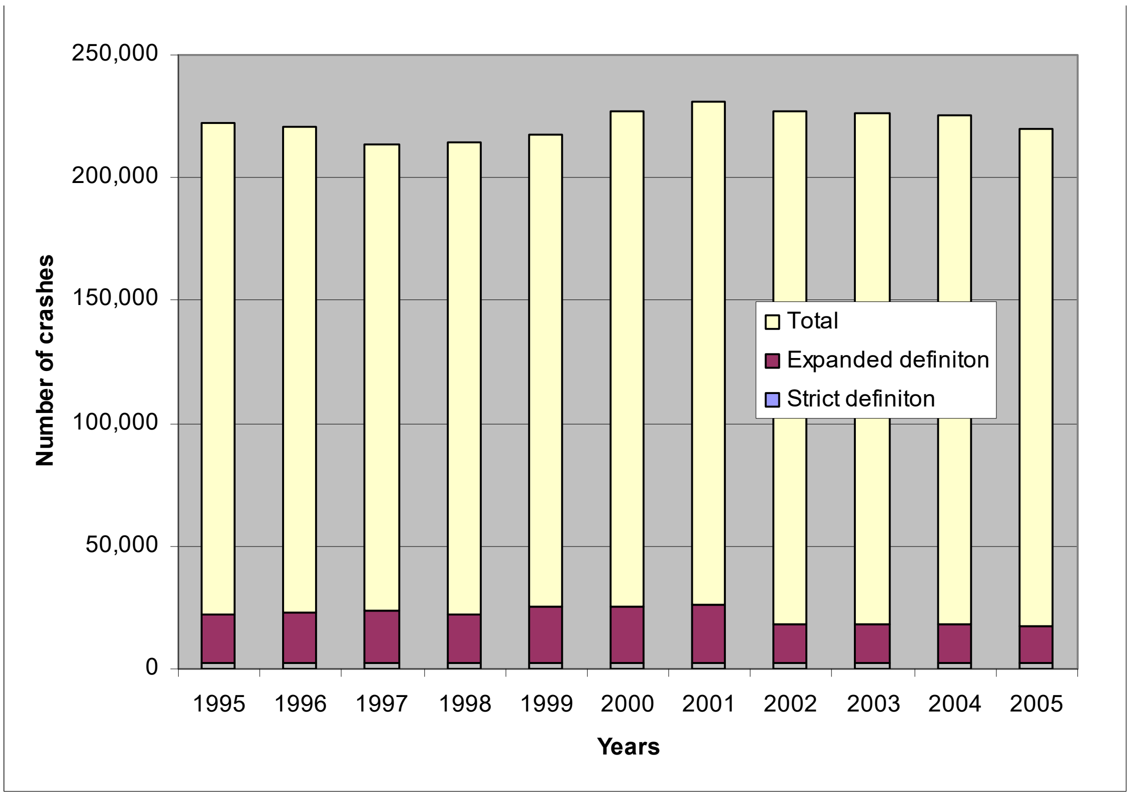
URL
Available from Northwestern University Transportation Library through interlibrary loan or document delivery

Order Document: http://www.library.northwestern.edu/transportation/services.html

APPENDIX 2: STATE-WIDE FATIGUE-COLLISION TABLES

Trends in Collisions Statistics

Trends in collision statistics are summarized in the figure below. The total number of collisions decreased in 1997 and then increased until 2001. After 2001, there was another progressive reduction. From 1995 until 2001, fatigue-related collisions contributed a higher percentage to overall collisions. Since 2002, the proportion of fatigue-related collisions has declined, by 0.1 to 0.2 percent by the strict definition and by 2.0 to 4.0 percent by the expanded definition.



The following tables present the detailed characteristics of the statewide collision data.

A2.1 Crash Severity, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Percent of Total Fatigue Related Collisions
	No		Yes				
	N	%	N	%	N	%	%
Crash Severity							
Fatal	37,664	98.1	745	1.9	38,409	100	2.66%
Major Injury	115,645	97.9	2,518	2.1	118,163	100	8.99%
Minor Injury	2,022,457	98.8	24,760	1.2	2,047,217	100	88.36%
Total	2,175,766	98.7	28,023	1.3	2,203,789	100	100.00%

Table A2.2 Crash Severity, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Percent of Total Fatigue Related Collisions
	No		Yes				
	N	%	N	%	N	%	%
Crash Severity							
Fatal	34,437	89.7	3,972	10.3	38,409	100	1.87%
Major Injury	106,375	90	11,788	10	118,163	100	5.54%
Minor Injury	1,850,097	90.4	197,120	9.6	2,047,217	100	92.60%
Total	1,990,909	90.3	212,880	9.7	2,203,789	100	100.00%

Table A2.3 Year, Fatigue Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Year						
1995	197,501	98.6	2,704	1.4	200,205	100
1996	194,781	98.7	2,579	1.3	197,360	100
1997	186,469	98.6	2,735	1.4	189,204	100
1998	189,672	98.7	2,410	1.3	192,082	100
1999	189,235	98.6	2,639	1.4	191,874	100
2000	199,104	98.7	2,575	1.3	201,679	100
2001	202,433	98.8	2,562	1.2	204,995	100
2002	206,456	98.8	2,417	1.2	208,873	100
2003	205,413	98.8	2,487	1.2	207,900	100
2004	204,739	98.9	2,348	1.1	207,087	100
2005	199,963	98.7	2,567	1.3	202,530	100
Total	2,175,766	98.7	28,023	1.3	2,203,789	100

Table A2.4 Year, Fatigue Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Year						
1995	180,486	90.2	19,719	9.8	200,205	100
1996	176,620	89.5	20,740	10.5	197,360	100
1997	167,879	88.7	21,325	11.3	189,204	100
1998	172,529	89.8	19,553	10.2	192,082	100
1999	169,179	88.2	22,695	11.8	191,874	100
2000	178,898	88.7	22,781	11.3	201,679	100
2001	181,427	88.5	23,568	11.5	204,995	100
2002	193,050	92.4	15,823	7.6	208,873	100
2003	192,152	92.4	15,748	7.6	207,900	100
2004	191,213	92.3	15,874	7.7	207,087	100
2005	187,476	92.6	15,054	7.4	202,530	100
Total	1,990,909	90.3	212,880	9.7	2,203,789	100

Table A2.5 Month, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Month						
Jan	171,716	99	1,784	1	173,500	100
Feb	164,516	98.9	1,780	1.1	166,296	100
Mar	182,123	98.9	2,092	1.1	184,215	100
Apr	176,841	98.7	2,335	1.3	179,176	100
May	183,522	98.5	2,708	1.5	186,230	100
Jun	179,535	98.5	2,801	1.5	182,336	100
Jul	180,874	98.4	2,892	1.6	183,766	100
Aug	187,150	98.5	2,837	1.5	189,987	100
Sep	185,757	98.7	2,450	1.3	188,207	100
Oct	196,578	98.9	2,211	1.1	198,789	100
Nov	181,910	98.8	2,149	1.2	184,059	100
Dec	185,244	98.9	1,984	1.1	187,228	100
Total	2,175,766	98.7	28,023	1.3	2,203,789	100

Table A2.6 Month, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Month						
Jan	160,738	92.6	12,762	7.4	173,500	100
Feb	154,232	92.7	12,064	7.3	166,296	100
Mar	167,740	91.1	16,475	8.9	184,215	100
Apr	162,287	90.6	16,889	9.4	179,176	100
May	166,721	89.5	19,509	10.5	186,230	100
Jun	162,370	89	19,966	11	182,336	100
Jul	163,203	88.8	20,563	11.2	183,766	100
Aug	168,535	88.7	21,452	11.3	189,987	100
Sep	167,758	89.1	20,449	10.9	188,207	100
Oct	178,666	89.9	20,123	10.1	198,789	100
Nov	167,495	91	16,564	9	184,059	100
Dec	171,164	91.4	16,064	8.6	187,228	100
Total	1,990,909	90.3	212,880	9.7	2,203,789	100

Table A2.7 Day of Week, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Day of Week						
Monday	307,637	98.7	3,916	1.3	311,553	100
Tuesday	315,440	98.9	3,510	1.1	318,950	100
Wednesday	315,487	99	3,312	1	318,799	100
Thursday	314,195	98.9	3,579	1.1	317,774	100
Friday	357,994	99	3,750	1	361,744	100
Saturday	305,964	98.4	4,856	1.6	310,820	100
Sunday	259,049	98.1	5,100	1.9	264,149	100
Total	2,175,766	98.7	28,023	1.3	2,203,789	100

Table A2.8 Day of Week, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Day of Week						
Monday	281,489	90.4	30,064	9.6	311,553	100
Tuesday	289,734	90.8	29,216	9.2	318,950	100
Wednesday	290,141	91	28,658	9	318,799	100
Thursday	288,771	90.9	29,003	9.1	317,774	100
Friday	327,891	90.6	33,853	9.4	361,744	100
Saturday	278,645	89.6	32,175	10.4	310,820	100
Sunday	234,238	88.7	29,911	11.3	264,149	100
Total	1,990,909	90.3	212,880	9.7	2,203,789	100

Table A2.9 Hour of Day, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Hour						
Midnight-12:59 AM	37,363	96.9	1,190	3.1	38,553	100
1:00-1:59 AM	32,461	96	1,351	4	33,812	100
2:00-2:59 AM	30,888	95	1,630	5	32,518	100
3:00-3:59 AM	17,672	91.2	1,707	8.8	19,379	100
4:00-4:59 AM	15,419	90.1	1,685	9.9	17,104	100
5:00-5:59 AM	25,537	93	1,911	7	27,448	100
6:00-6:59 AM	50,882	95.8	2,222	4.2	53,104	100
7:00-7:59 AM	110,687	98.2	2,017	1.8	112,704	100
8:00-8:59 AM	108,798	98.8	1,371	1.2	110,169	100
9:00-9:59 AM	86,684	99.1	820	0.9	87,504	100
10:00-10:59 AM	93,843	99.3	688	0.7	94,531	100
11:00-11:59 AM	112,024	99.4	701	0.6	112,725	100
Noon-12:59 PM	133,391	99.4	860	0.6	134,251	100
1:00-1:59 PM	132,626	99.2	1,047	0.8	133,673	100
2:00-2:59 PM	151,594	99.1	1,338	0.9	152,932	100
3:00-3:59 PM	176,252	99.2	1,474	0.8	177,726	100
4:00-4:59 PM	168,131	99.2	1,367	0.8	169,498	100
5:00-5:59 PM	184,420	99.4	1,051	0.6	185,471	100
6:00-6:59 PM	147,612	99.5	685	0.5	148,297	100
7:00-7:59 PM	103,097	99.6	400	0.4	103,497	100
8:00-8:59 PM	78,616	99.6	347	0.4	78,963	100
9:00-9:59 PM	71,691	99.3	475	0.7	72,166	100
10:00-10:59 PM	59,470	98.8	724	1.2	60,194	100
11:00-11:59 PM	46,608	98	962	2	47,570	100
Total	2,175,766	98.7	28,023	1.3	2,203,789	100

Table A2.10 Hour of Day, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Hour						
Midnight-12:59 AM	37,363	96.9	1,190	3.1	38,553	100
1:00-1:59 AM	32,461	96	1,351	4	33,812	100
2:00-2:59 AM	17,498	53.8	15,020	46.2	32,518	100
3:00-3:59 AM	9,741	50.3	9,638	49.7	19,379	100
4:00-4:59 AM	9,010	52.7	8,094	47.3	17,104	100
5:00-5:59 AM	16,061	58.5	11,387	41.5	27,448	100
6:00-6:59 AM	49,710	93.6	3,394	6.4	53,104	100
7:00-7:59 AM	110,687	98.2	2,017	1.8	112,704	100
8:00-8:59 AM	108,798	98.8	1,371	1.2	110,169	100
9:00-9:59 AM	86,684	99.1	820	0.9	87,504	100
10:00-10:59 AM	93,843	99.3	688	0.7	94,531	100
11:00-11:59 AM	112,024	99.4	701	0.6	112,725	100
Noon-12:59 PM	133,391	99.4	860	0.6	134,251	100
1:00-1:59 PM	132,626	99.2	1,047	0.8	133,673	100
2:00-2:59 PM	87,120	57	65,812	43	152,932	100
3:00-3:59 PM	100,920	56.8	76,806	43.2	177,726	100
4:00-4:59 PM	161,458	95.3	8,040	4.7	169,498	100
5:00-5:59 PM	184,420	99.4	1,051	0.6	185,471	100
6:00-6:59 PM	147,612	99.5	685	0.5	148,297	100
7:00-7:59 PM	103,097	99.6	400	0.4	103,497	100
8:00-8:59 PM	78,616	99.6	347	0.4	78,963	100
9:00-9:59 PM	71,691	99.3	475	0.7	72,166	100
10:00-10:59 PM	59,470	98.8	724	1.2	60,194	100
11:00-11:59 PM	46,608	98	962	2	47,570	100
Total	1,990,909	90.3	212,880	9.7	2,203,789	100

Table A2.11 Primary Collisions Factor, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Primary Collision Factor						
Unknown	98,788	99.5	486	0.5	99,274	100
Driving or Bicycling Under the Influence of Alcohol or Drug	179,908	99.5	902	0.5	180,810	100
Impeding Traffic	1,643	99.8	3	0.2	1,646	100
Unsafe Speed	599,066	99.4	3,546	0.6	602,612	100
Following Too Closely	63,570	99.8	113	0.2	63,683	100
Wrong Side of Road	74,854	97.9	1,641	2.1	76,495	100
Improper Passing	15,239	99.9	21	0.1	15,260	100
Unsafe Lane Change	82,475	99	825	1	83,300	100
Improper Turning	225,550	97.1	6,821	2.9	232,371	100
Automobile Right of Way	394,906	100	130	0	395,036	100
Pedestrian Right of Way	42,232	100	11	0	42,243	100
Pedestrian Violation	60,920	100	20	0	60,940	100
Traffic Signals and Signs	197,050	99.8	391	0.2	197,441	100
Hazardous Parking	1,412	99.7	4	0.3	1,416	100
Lights	937	100	0	0	937	100
Brakes	1,678	99.9	1	0.1	1,679	100
Other Equipment	2,072	100	1	0	2,073	100
Other Hazardous Violation	31,812	99.6	113	0.4	31,925	100
Other Than Driver (or Pedestrian)	38,236	99.8	89	0.2	38,325	100
Unsafe Starting or Backing	40,376	99.9	38	0.1	40,414	100
Other Improper Driving	19,688	99	208	1	19,896	100
Pedestrian or Other Under the Influence of Alcohol or Drug	3,354	99.9	2	0.1	3,356	100
Fell Asleep	0	0	12,657	100	12,657	100
Total	2,175,766	98.7	28,023	1.3	2,203,789	100

Table A2.12 Primary Collisions Factor, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total	
	No		Yes			
	N	%	N	%	N	%
Primary Collision Factor						
Unknown	97,185	97.9	2,089	2.1	99,274	100
Driving or Bicycling Under the Influence of Alcohol or Drug	162,043	89.6	18,767	10.4	180,810	100
Impeding Traffic	1,514	92	132	8	1,646	100
Unsafe Speed	541,450	89.9	61,162	10.1	602,612	100
Following Too Closely	56,969	89.5	6,714	10.5	63,683	100
Wrong Side of Road	69,658	91.1	6,837	8.9	76,495	100
Improper Passing	14,034	92	1,226	8	15,260	100
Unsafe Lane Change	75,102	90.2	8,198	9.8	83,300	100
Improper Turning	200,225	86.2	32,146	13.8	232,371	100
Automobile Right of Way	356,121	90.1	38,915	9.9	395,036	100
Pedestrian Right of Way	42,211	99.9	32	0.1	42,243	100
Pedestrian Violation	60,905	99.9	35	0.1	60,940	100
Traffic Signals and Signs	180,989	91.7	16,452	8.3	197,441	100
Hazardous Parking	1,355	95.7	61	4.3	1,416	100
Lights	929	99.1	8	0.9	937	100
Brakes	1,556	92.7	123	7.3	1,679	100
Other Equipment	1,924	92.8	149	7.2	2,073	100
Other Hazardous Violation	30,292	94.9	1,633	5.1	31,925	100
Other Than Driver (or Pedestrian)	38,210	99.7	115	0.3	38,325	100
Unsafe Starting or Backing	36,661	90.7	3,753	9.3	40,414	100
Other Improper Driving	18,222	91.6	1,674	8.4	19,896	100
Pedestrian or Other Under the Influence of Alcohol or Drug	3,354	99.9	2	0.1	3,356	100
Fell Asleep	0	0	12,657	100	12,657	100
Total	1,990,909	90.3	212,880	9.7	2,203,789	100

Table A2.13 Truck Collisions, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Truck Collisions of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes				Fatigue-related	Total
	N	%	N	%	N	%	%	%
Truck Collision								
No	2,081,508	98.8	26,153	1.2	2,107,661	100		
Yes	94,258	98.1	1,870	1.9	96,128	100	4.36%	6.67%
Total	2,175,766	98.7	28,023	1.3	2,203,789	100		

Table A2.14 Truck Collisions, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Truck Collisions of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes					
	N	%	N	%	N	%	%	%
Truck Collision								
No	1,905,601	90.4	202,060	9.6	2,107,661	100		
Yes	85,308	88.7	10,820	11.3	96,128	100	4.36%	5.08%
Total	1,990,909	90.3	212,880	9.7	2,203,789	100		

Table A2.15 Alcohol Involvement, Fatigue-Related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Alcohol involved of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
Alcohol Involvement								
No	1,937,097	98.7	25,896	1.3	1,962,993	100		
Yes	238,669	99.1	2,127	0.9	240,796	100	10.93%	7.59%
Total	2,175,766	98.7	28,023	1.3	2,203,789	100		

Table A2.16 Alcohol Involvement, Fatigue-Related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Alcohol involved of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
Alcohol Involvement								
No	1,773,799	90.4	189,194	9.6	1,962,993	100		
Yes	217,110	90.2	23,686	9.8	240,796	100	10.93%	11.13%
Total	1,990,909	90.3	212,880	9.7	2,203,789	100		

Table A2.17 Urbanicity, Fatigue-related Injury Collisions, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Urban Collisions of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
Urbanicity								
Urban	1,701,593	99.2	14,467	0.8	1,716,060	100		
Rural	474,173	97.2	13,556	2.8	487,729	100	22.13%	48.37%
Total	2,175,766	98.7	28,023	1.3	2,203,789	100		

Table A2.18 Urbanicity, Fatigue-related Injury Collisions, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction Urban Collisions of Total Collisions	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
Urbanicity								
Urban	1,561,611	91	154,449	9	1,716,060	100		
Rural	429,298	88	58,431	12	487,729	100	22.13%	27.45%
Total	1,990,909	90.3	212,880	9.7	2,203,789	100		

Table A2.19 State Highway Status, Fatigue-Related Injury Collision, Strict Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction State Highway of all Highways of Known Status	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
State Highway Status								
Unknown	109	100	0	0	109	100		
No	1,504,591	99.2	12,724	0.8	1,517,315	100		
Yes	671,066	97.8	15,299	2.2	686,365	100	31.15%	54.59%
Total	2,175,766	98.7	28,023	1.3	2,203,789	100		

Table A2.20 State Highway Status, Fatigue-Related Injury Collision, Expanded Definition, SWITRS 1995-2005

	Fatigue-Related				Total		Fraction State Highway of all Highways of Known Status	Fraction Truck Collisions of Total Collisions
	No		Yes					Total
	N	%	N	%	N	%	%	%
State Highway Status								
Unknown	105	96.3	4	3.7	109	100		
No	1,381,000	91	136,315	9	1,517,315	100		
Yes	609,804	88.8	76,561	11.2	686,365	100	31.15%	35.97%
Total	1,990,909	90.3	212,880	9.7	2,203,789	100		

Table A2.21 Culpability, fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%
Party At-Fault		
No	3,014	12.0
Yes	22,013	88.0
Total	25,027	100.0

Table A2.22 Culpability, fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%
Party At-Fault		
No	3,014	1.1
Yes	265,316	98.9
Total	268,330	100

Table A2.23 Party Type, Fatigued or Sleepy parties, Strict Definition, SWITRS 1995-2005

	N	%
Party Type		
Unknown	16	0.1
Driver	24,894	99.5
Pedestrian	47	0.2
Parked Vehicle	26	0.1
Bicyclist	40	0.2
Other	4	0
Total	25,027	100

Table A2.24 Party Type, Fatigued or Sleepy parties, Expanded Definition, SWITRS 1995-2005

	N	%
Party Type		
Unknown	16	0.0
Driver	268,197	1.000
Pedestrian	47	0.0
Parked Vehicle	26	0.0
Bicyclist	40	0.0
Other	4	0.0
Total	268,330	100.0

Table A2.25 Party Age, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%
Party Age		
0 - 4	2	0
5-14	17	0.1
15 - 24	9,758	39
25 - 34	5,395	21.6
35 - 44	3,858	15.4
45 - 54	2,601	10.4
55 - 64	1,441	5.8
65 - 74	1,052	4.2
75 - 84	691	2.8
85 and over	96	0.4
Unknown	116	0.5
Total	25,027	100

Table A2.26 Party Age, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%
Party Age		
0 - 4	16	0
5 - 14	504	0.2
15 - 24	81,862	30.5
25 - 34	55,886	20.8
35 - 44	45,070	16.8
45 - 54	30,271	11.3
55 - 64	16,941	6.3
65 - 74	11,802	4.4
75 - 84	9,557	3.6
85 and over	2,306	0.9
Unknown	14,115	5.3
Total	268,330	100

Table A2.27 Party Race, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party race			
Not Stated	17,186	68.7	
Asian	527	2.1	6.72%
Black	730	2.9	9.31%
Hispanic	2,163	8.6	27.59%
Other	450	1.8	5.74%
White	3,971	15.9	50.64%
Total	25,027	100	

Table A2.28 Party Race, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party race			
Not Stated	173,083	64.5	
Asian	5,709	2.1	5.99%
Black	8,196	3.1	8.60%
Hispanic	30,426	11.3	31.94%
Other	4,959	1.8	5.21%
White	45,957	17.1	48.25%
Total	268,330	100	

Table A2.29 Party Sobriety, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party Sobriety			
Unknown	8,737	34.9	
Had Not Been Drinking	14,393	57.5	88.35%
Had Been Drinking, Under Influence	796	3.2	4.89%
Had Been Drinking, Not Under Influence	930	3.7	5.71%
Had Been Drinking, Impairment Unknown	171	0.7	1.05%
Total	25,027	100	

Table A2.30 Party Sobriety, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party Sobriety			
Unknown	13,044	4.9	
Had Not Been Drinking	209,754	78.2	82.16%
Had Been Drinking, Under Influence	18,648	6.9	7.30%
Had Been Drinking, Not Under Influence	4,274	1.6	1.67%
Had Been Drinking, Impairment Unknown	2,308	0.9	0.90%
Impairment Unknown	19,630	7.3	7.69%
Not Applicable	672	0.3	0.26%
Total	268,330	100	

Table A2.31 Restraint Use, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%	% of Total Known
Restraint Use			
Unknown	3,960	15.8	
No	1,903	7.6	9.03%
Yes	19,164	76.6	90.97%
Total	25,027	100	

Table A2.32 Restraint Use, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%	% of Total Known
Restraint Use			
Unknown	56,144	20.9	
No	11,403	4.2	5.37%
Yes	200,783	74.8	94.63%
Total	268,330	100	

Table A2.33 Party Violation, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party Violation			
Unknown	18,543	74.1	
City Ordinance	1	0	0.02%
Hit and Run	5	0	0.08%
Driving or Bicycling Under the Influence of Alcohol or Drug	16	0.1	0.25%
Improper Lane Change	3	0	0.05%
Impeding Traffic	6	0	0.09%
Failure to Heed Stop Signal	43	0.2	0.66%
Failure to Heed Stop Sign	38	0.2	0.59%
Unsafe Speed	1,523	6.1	23.49%
Reckless Driving	5	0	0.08%
Wrong Side of Road	1,222	4.9	18.85%
Unsafe Lane Change	444	1.8	6.85%
Improper Passing	14	0.1	0.22%
Following Too Closely	27	0.1	0.42%
Improper Turning	2,927	11.7	45.14%
Automobile Right-of-Way	6	0	0.09%
Pedestrian Right-of-Way	2	0	0.03%
Pedestrian Violation	3	0	0.05%
Hazardous Parking	4	0	0.06%
Lights	3	0	0.05%
Brakes	1	0	0.02%
Other Equipment	14	0.1	0.22%
Other Hazardous Movement	97	0.4	1.50%
Other Non-Moving Violation	67	0.3	1.03%
Unsafe Starting or Backing	7	0	0.11%
Seat Belt	5	0	0.08%
Seat Belt (Equipment)	1	0	0.02%
Total	25,027	100	

Table A2.34 Party Violation, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%	% of Total Known
Party Violation			
Unknown	236,839	88.3	
City Ordinance	1	0	0.00%
Health/Safety Code (Misdemeanor)	1	0	0.00%
Penal Code (Misdemeanor)	1	0	0.00%
Hit and Run	685	0.3	2.18%
Driving or Bicycling Under the Influence of Alcohol or Drug	16	0	0.05%
Improper Lane Change	19	0	0.06%
Impeding Traffic	71	0	0.23%
Failure to Heed Stop Signal	1,144	0.4	3.63%
Failure to Heed Stop Sign	831	0.3	2.64%
Unsafe Speed	1,523	0.6	4.84%
Reckless Driving	148	0.1	0.47%
Wrong Side of Road	4,969	1.9	15.78%
Unsafe Lane Change	1,996	0.7	6.34%
Improper Passing	295	0.1	0.94%
Following Too Closely	1,049	0.4	3.33%
Improper Turning	14,370	5.4	45.63%
Automobile Right-of-Way	1,402	0.5	4.45%
Pedestrian Right-of-Way	4	0	0.01%
Pedestrian Violation	7	0	0.02%
Hazardous Parking	32	0	0.10%
Lights	40	0	0.13%
Brakes	120	0	0.38%
Other Equipment	243	0.1	0.77%
Other Hazardous Movement	984	0.4	3.12%
Improper Registration	2	0	0.01%
Other Non-Moving Violation	1,221	0.5	3.88%
Excessive Noise	1	0	0.00%

Oversize	2	0	0.01%
Unsafe Starting or Backing	280	0.1	0.89%
Off-Highway Vehicle Violation	7	0	0.02%
Child Restraint	7	0	0.02%
Seat Belt	19	0	0.06%
Seat Belt (Equipment)	1	0	0.00%
Total	268,330	100	

Table A2.35 Party Preceding Movement, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%
Party Preceding Movement		
Unknown	115	0.5
Stopped	154	0.6
Proceeding Straight	9,335	37.3
Ran Off Road	10,420	41.6
Making Right Turn	101	0.4
Making Left Turn	156	0.6
Making U-Turn	5	0
Backing	13	0.1
Slowing/Stopping	122	0.5
Passing Other Vehicle	28	0.1
Changing Lanes	438	1.8
Parking Maneuver	3	0
Entering Traffic	14	0.1
Other Unsafe Turning	1,079	4.3
Crossed Into Opposing Lane	977	3.9
Parked	24	0.1
Merging	2	0
Traveling Wrong Way	120	0.5
Other	1,921	7.7
Total	25,027	100

Table A2.36 Party Preceding Movement, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

	N	%
Party Preceding Movement		
Unknown	877	0.3
Stopped	3,235	1.2
Proceeding Straight	133,051	49.6
Ran Off Road	28,914	10.8
Making Right Turn	5,192	1.9
Making Left Turn	40,488	15.1
Making U-Turn	3,757	1.4
Backing	1,617	0.6
Slowing/Stopping	6,953	2.6
Passing Other Vehicle	2,150	0.8
Changing Lanes	12,033	4.5
Parking Maneuver	159	0.1
Entering Traffic	7,020	2.6
Other Unsafe Turning	5,837	2.2
Crossed Into Opposing Lane	4,325	1.6
Parked	75	0
Merging	453	0.2
Traveling Wrong Way	893	0.3
Other	11,301	4.2
Total	268,330	100

Table A2.37 Party Vehicle, Fatigued or Sleepy Parties, Strict Definition, SWITRS 1995-2005

	N	%
Party Vehicle		
Unknown	671	2.7
Passenger Car/Station Wagon	17,820	71.2
Passenger Car with Trailer	40	0.2
Motorcycle/Scooter	70	0.3
Pickup or Panel Truck	5,341	21.3
Pickup or Panel Truck w/Trailer	175	0.7
Truck or Truck Tractor	236	0.9
Truck or Truck Tractor w/Trailer	437	1.7
Schoolbus	6	0
Other Bus	32	0.1
Emergency Vehicle	54	0.2
Bicycle	39	0.2
Other Vehicle	64	0.3
Pedestrian	42	0.2
Total	25,027	100

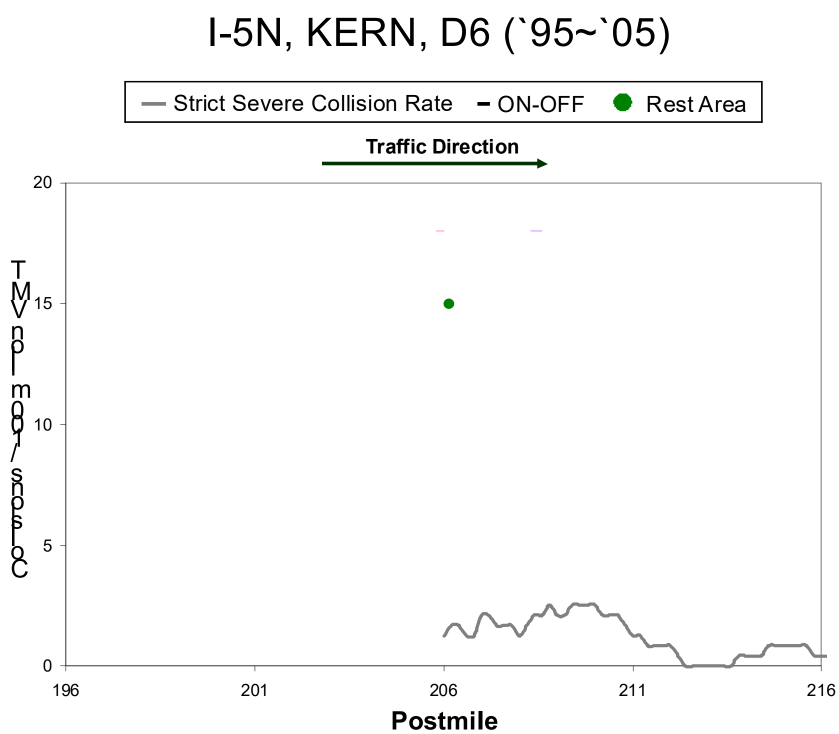
Table A2.38 Party Vehicle, Fatigued or Sleepy Parties, Expanded Definition, SWITRS 1995-2005

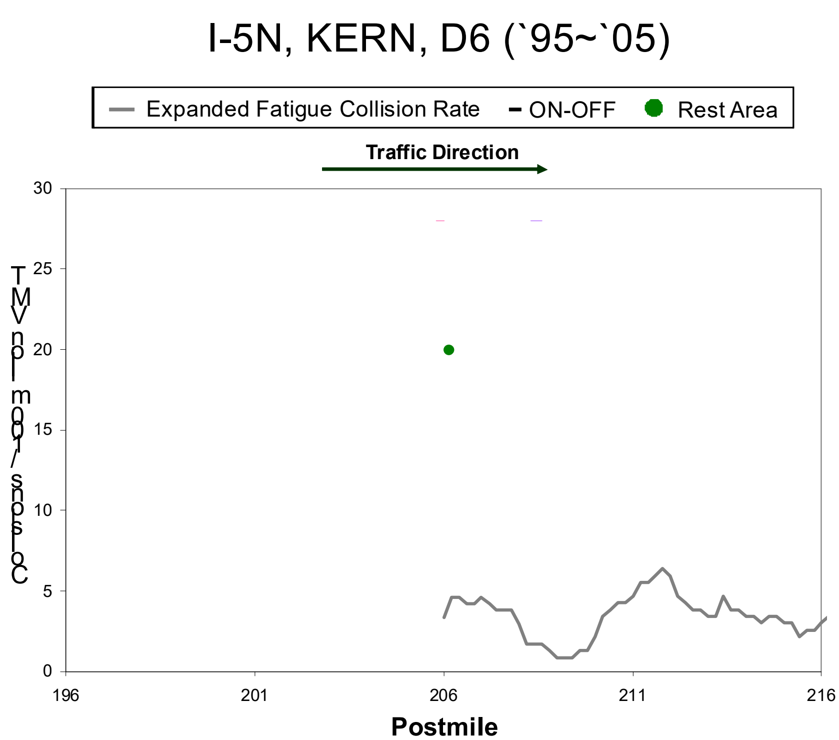
	N	%
Party Vehicle		
Unknown	10,796	4
Passenger Car/Station Wagon	189,229	70.5
Passenger Car with Trailer	358	0.1
Motorcycle/Scooter	5,315	2
Pickup or Panel Truck	50,337	18.8
Pickup or Panel Truck w/Trailer	1,993	0.7
Truck or Truck Tractor	3,068	1.1
Truck or Truck Tractor w/Trailer	3,831	1.4
School bus	328	0.1
Other Bus	609	0.2
Emergency Vehicle	850	0.3
Highway Construction Equipment	22	0
Bicycle	45	0
Other Vehicle	1,444	0.5
Pedestrian	46	0
Moped	59	0
Total	268,330	100

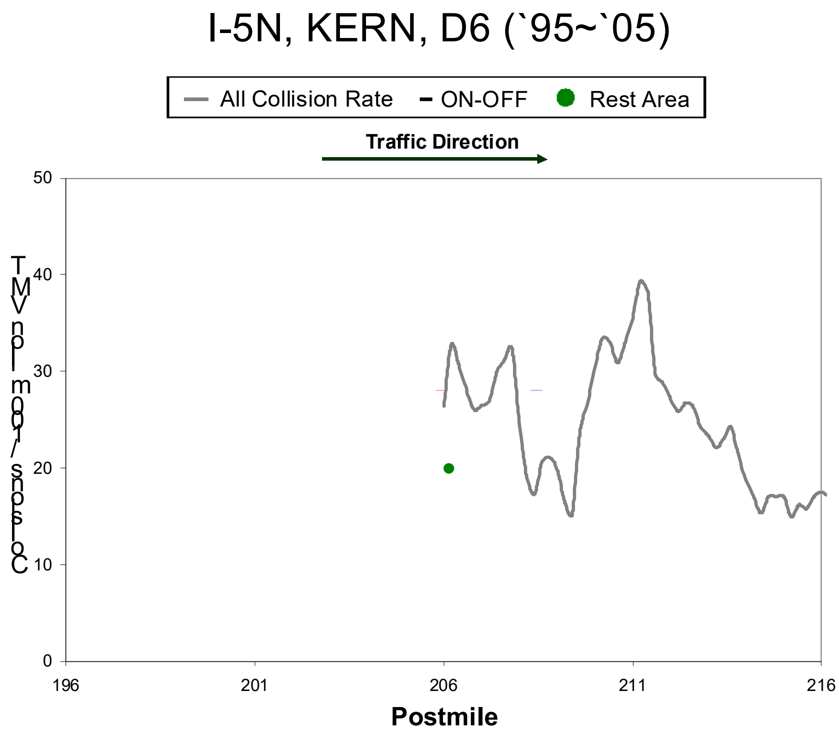
APPENDIX 3: SPATIAL ANALYSIS – WITHIN ±10 MILES OF REST STOPS

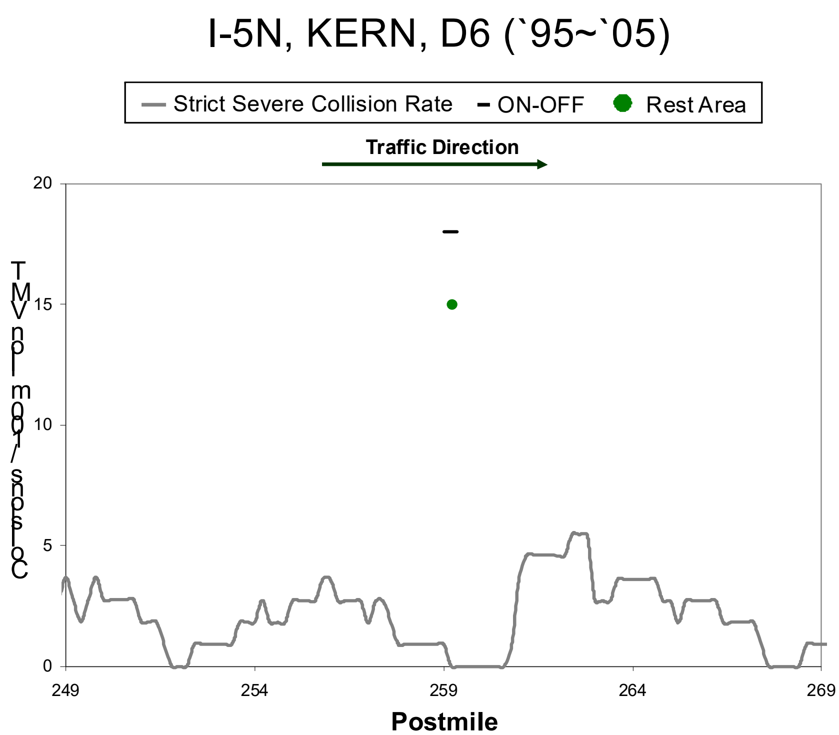
The spatial analysis presented here analyzed collision rates before (upstream) and after (downstream) rest stops within 10 miles of individual rest stops in both directions of I-5 (from Kern county to the Oregon border). Results from the analysis of rest stop vicinities in the northbound direction are presented first, followed by results from the southbound direction. The following figures include information about the location of each rest stop, including route direction, county, and district. In the figures, the location of each rest stop is represented by a green dot. Detailed explanations of data and methodologies used in this analysis can be found in the main report.

A3.1 I-5 Northbound






I-5N, KERN, D6 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
50
40
30
20
10
0
Collisions/100m VMT
196
201
206
211
216
Postmile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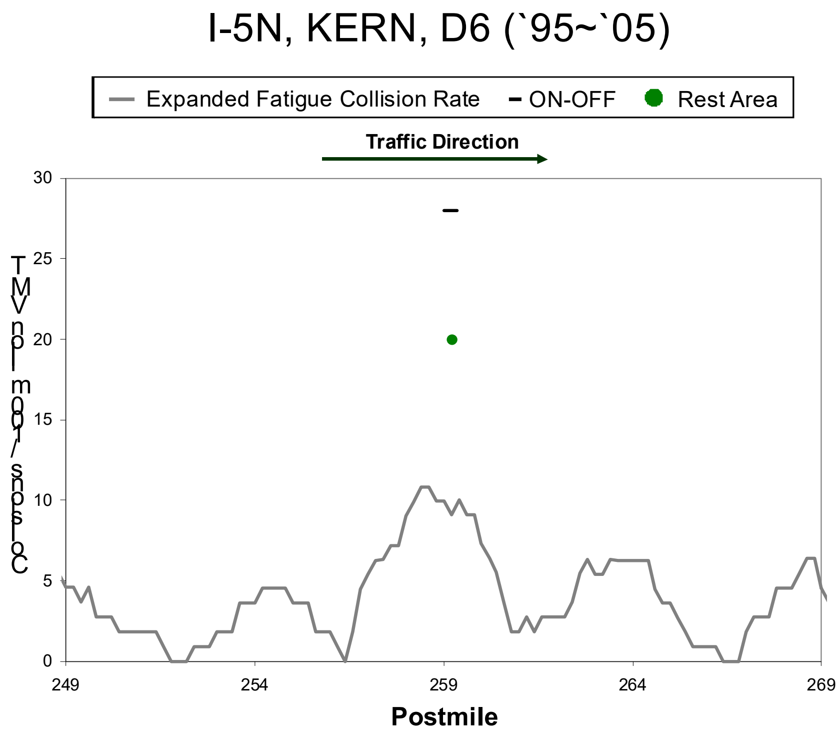
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
Collisions/100m VMT
249
254
259
264
269
Postmile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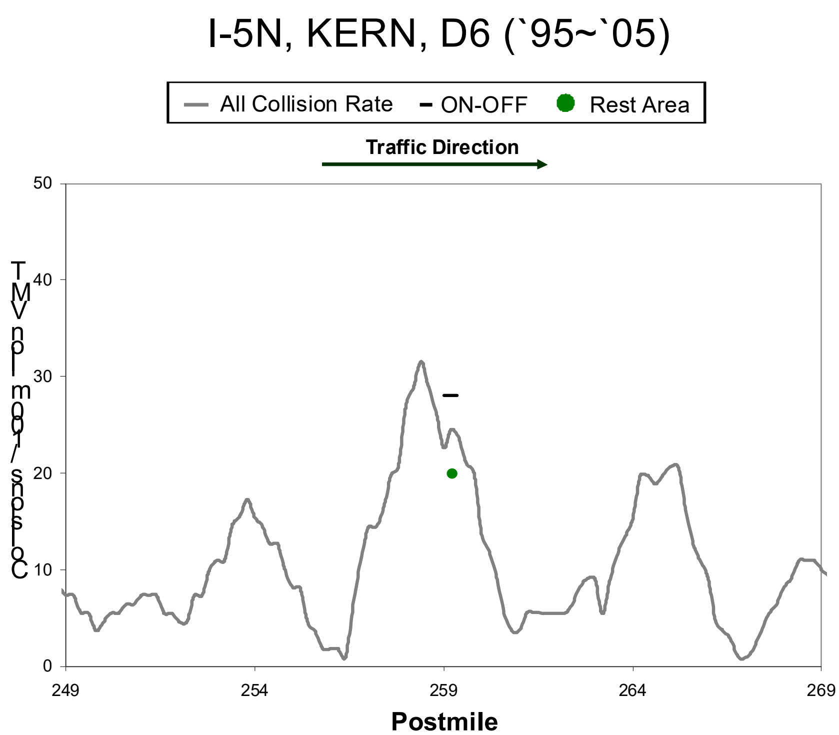
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/sions/100 mln VMT
30
25
20
15
10
5
0
249
254
259
264
269
Postmile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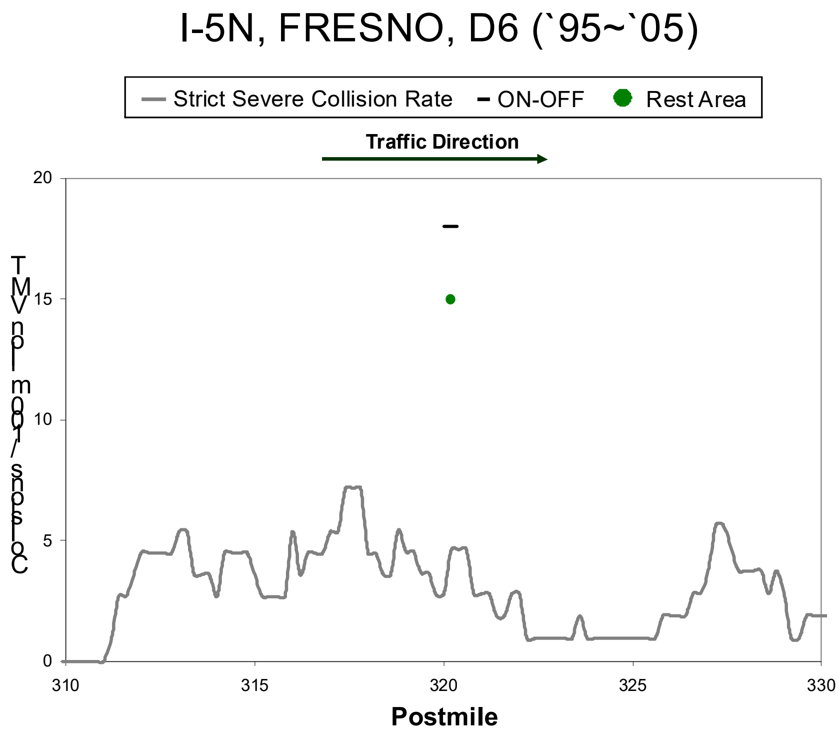
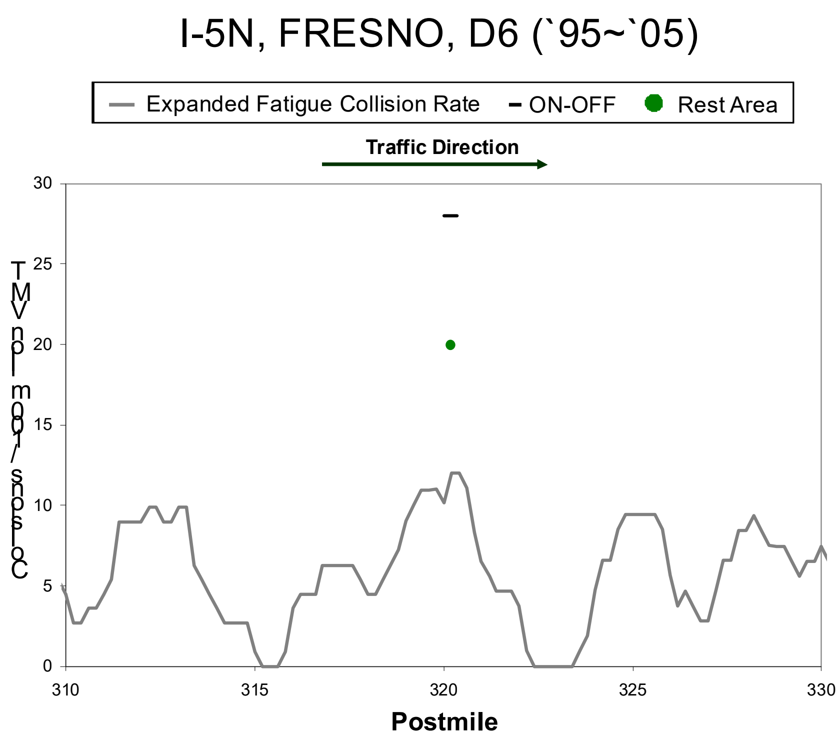
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/sions/100 mln VMT
50
40
30
20
10
0
249
254
259
264
269
Postmile


I-5N, FRESNO, D6 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/s/100m/VMT
0
5
10
15
20
310
315
320
325
330
Postmile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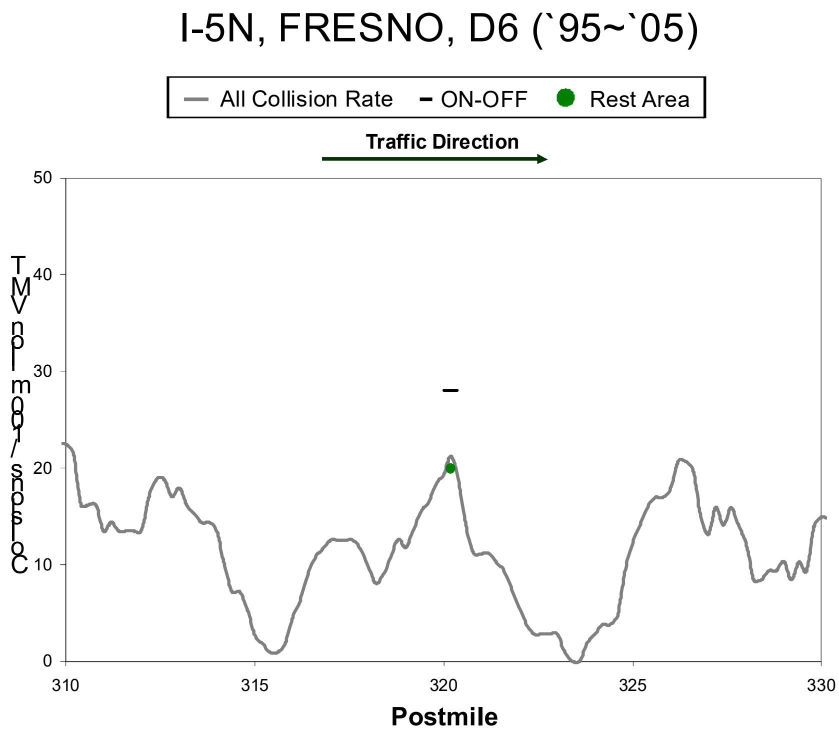
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/s/100m/VMT
0
5
10
15
20
25
30
310
315
320
325
330
Postmile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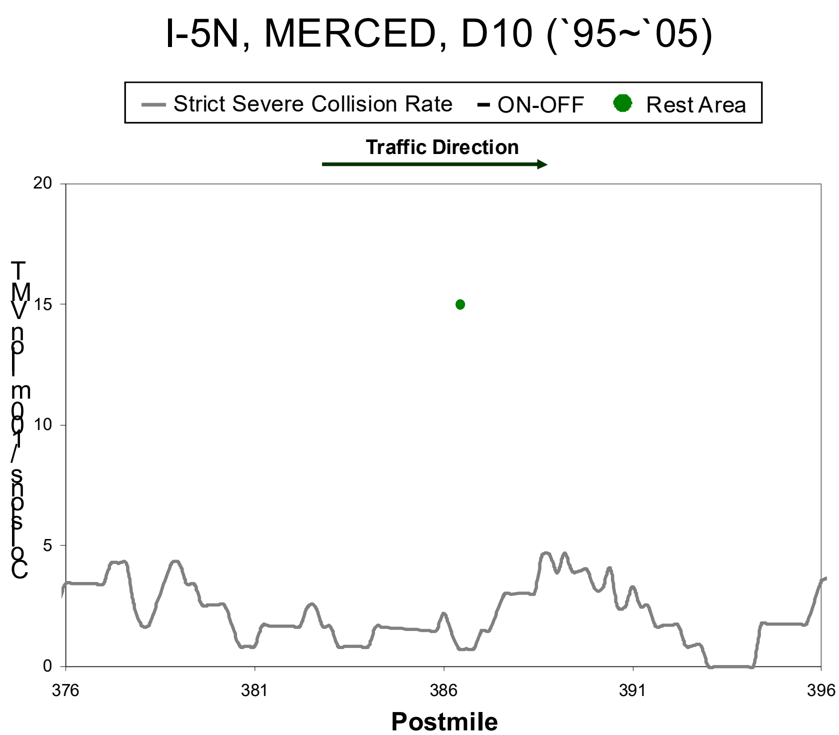
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / 100 mil VMT
0
10
20
30
40
50
310
315
320
325
330
Postmile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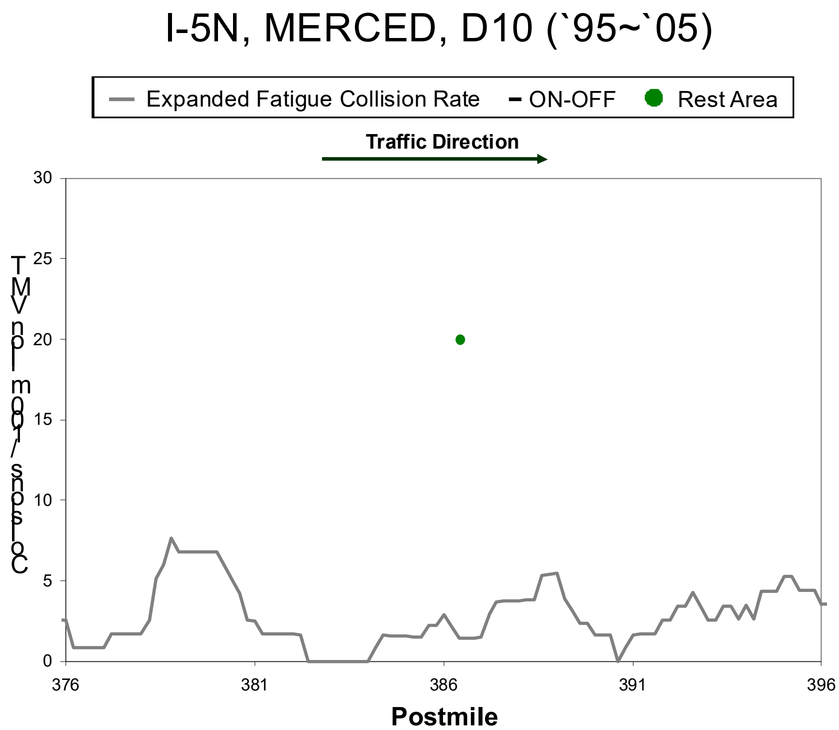
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / 100 mil VMT
0
5
10
15
20
376
381
386
391
396
Postmile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Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / mil VMT
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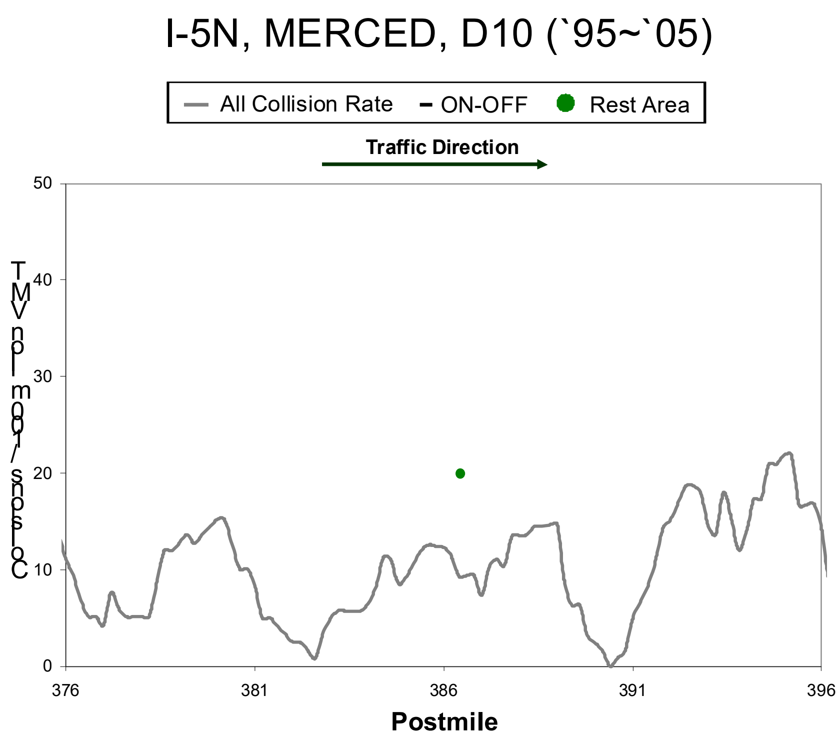
25
20
15
10
5
0
376
381
386
391
396
Postmile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All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / mil VMT
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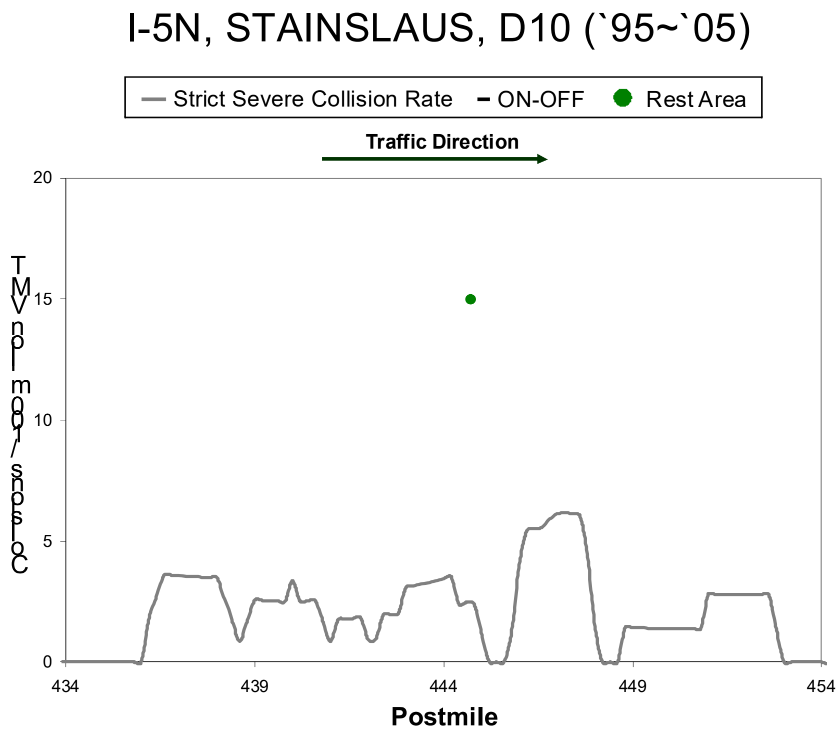
40
30
20
10
0
376
381
386
391
396
Postmile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ON-OFF
Rest Area
Traffic Direction
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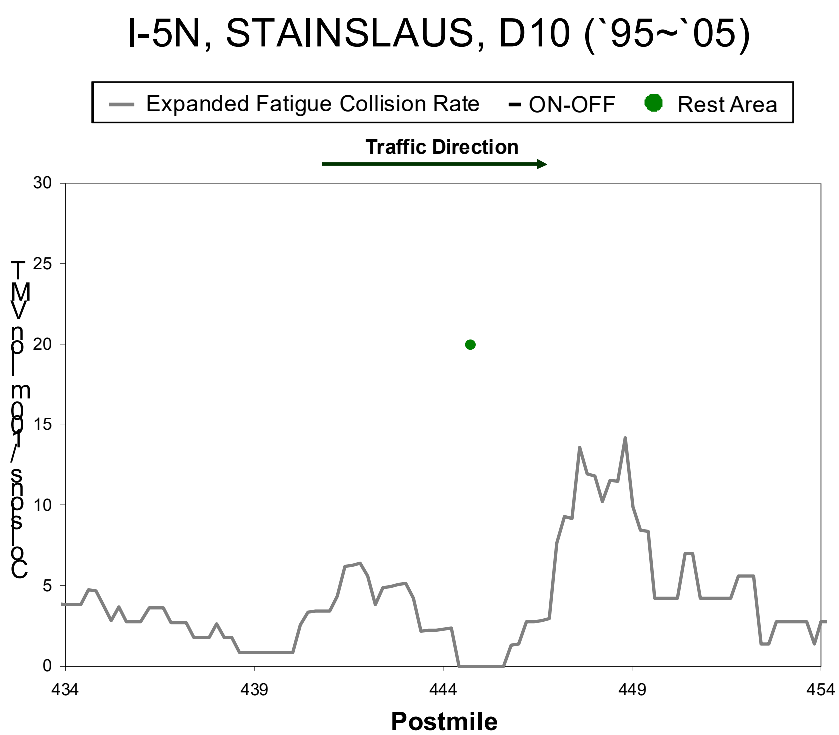
5
10
15
20
434
439
444
449
454
Postmile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Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
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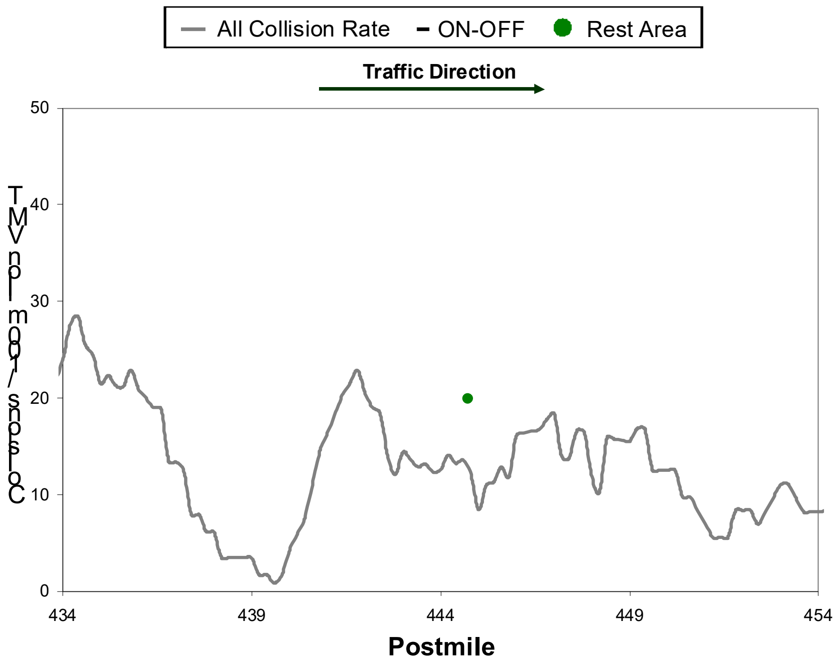
5
10
15
20
25
30
434
439
444
449
454
Postmile

I-5N, STAINSLAUS, D10 (`95~`05)



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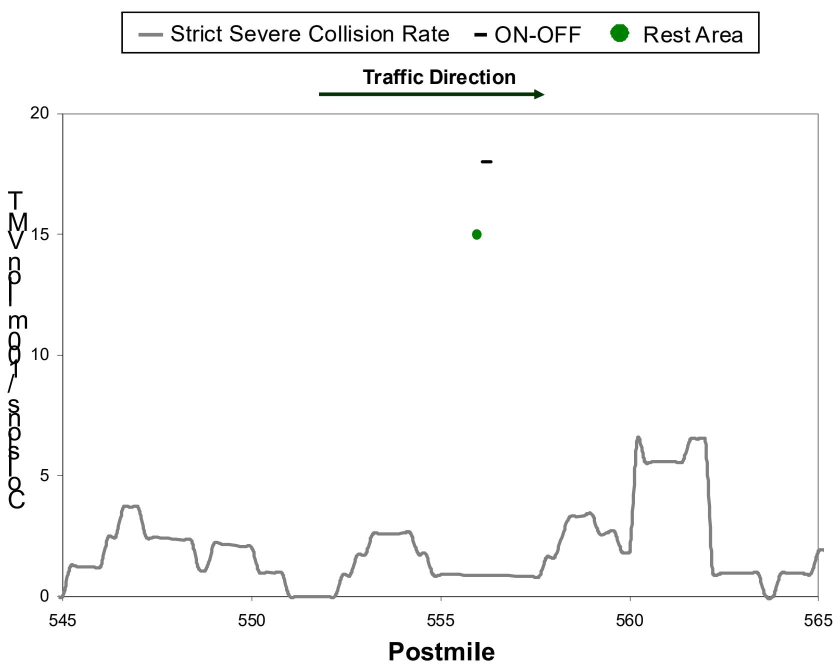

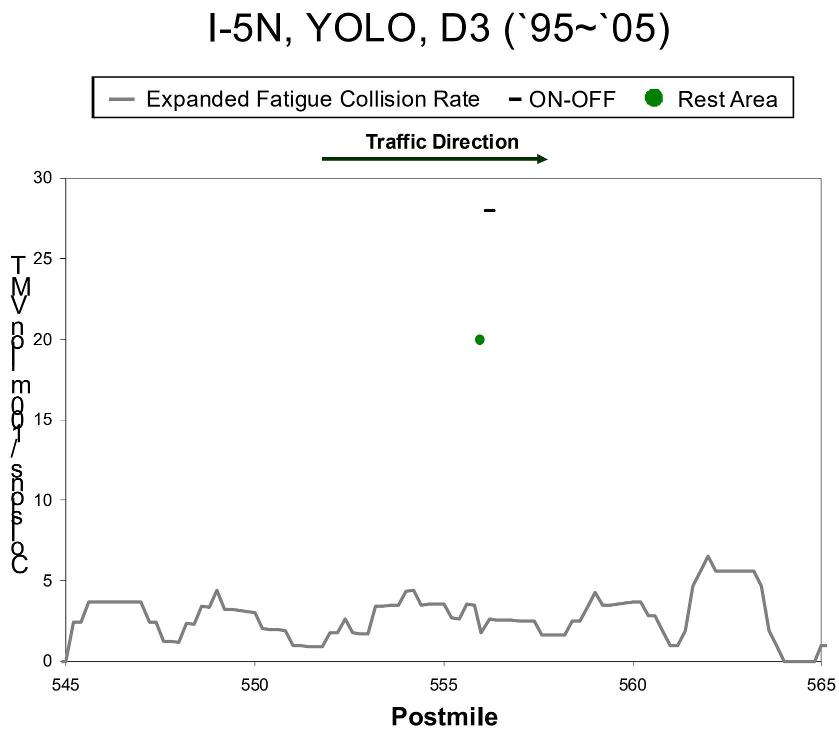
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Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/Million VMT
Postmile
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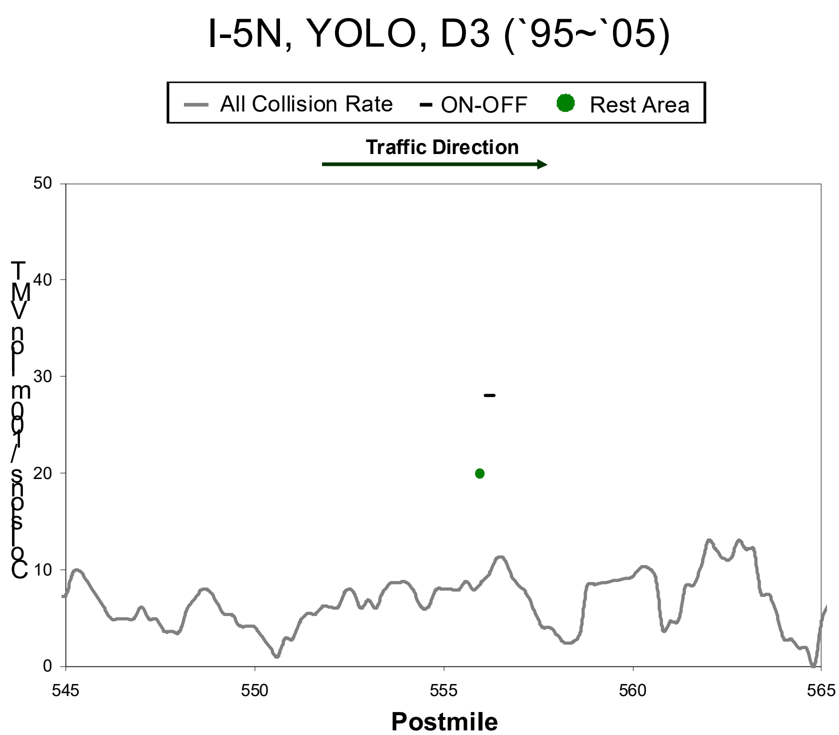
10
15
20
25
30
545
550
555
560
565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All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/Million VMT
Postmile
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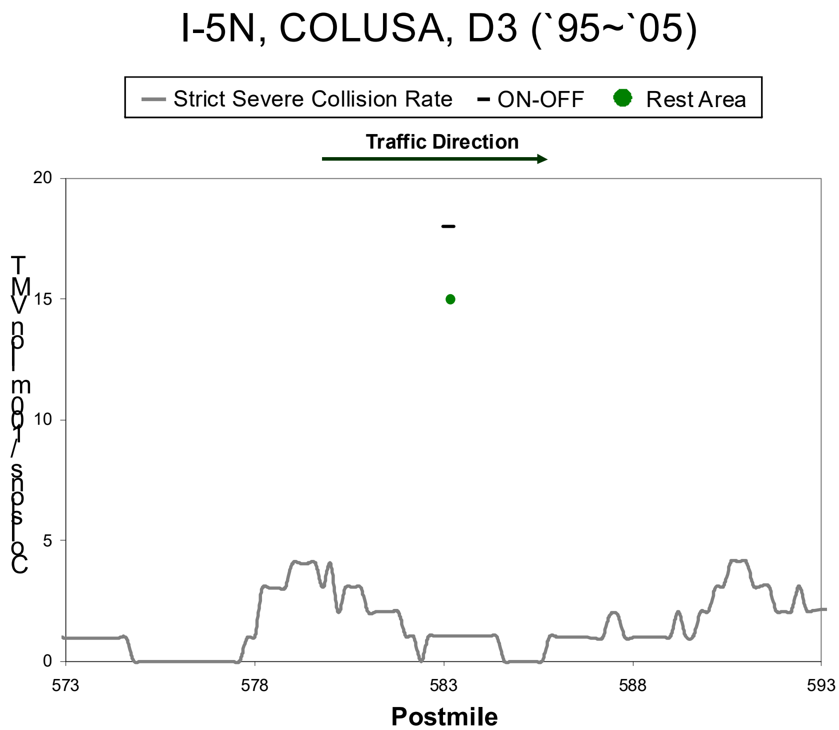
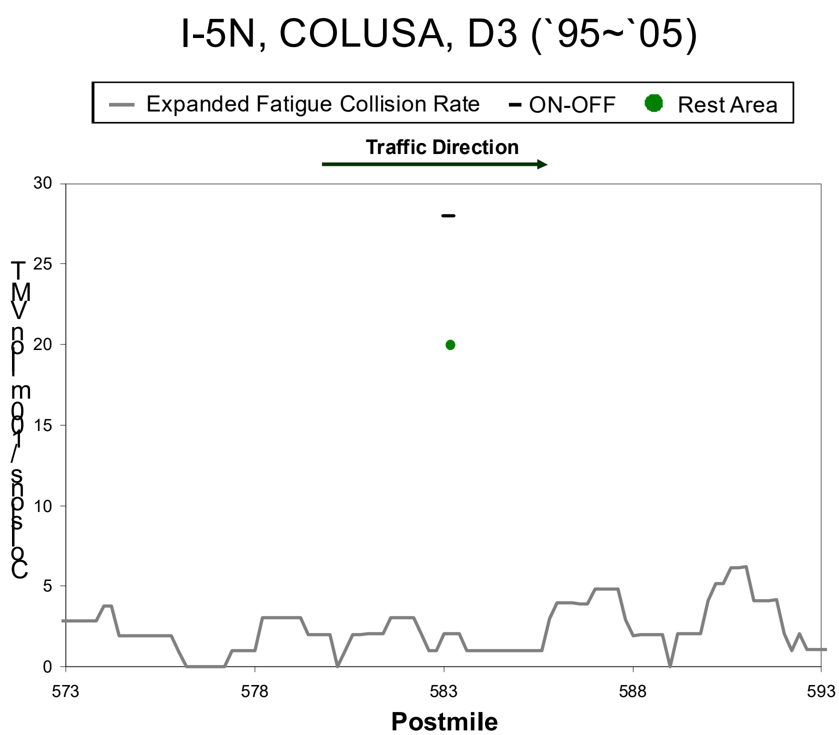
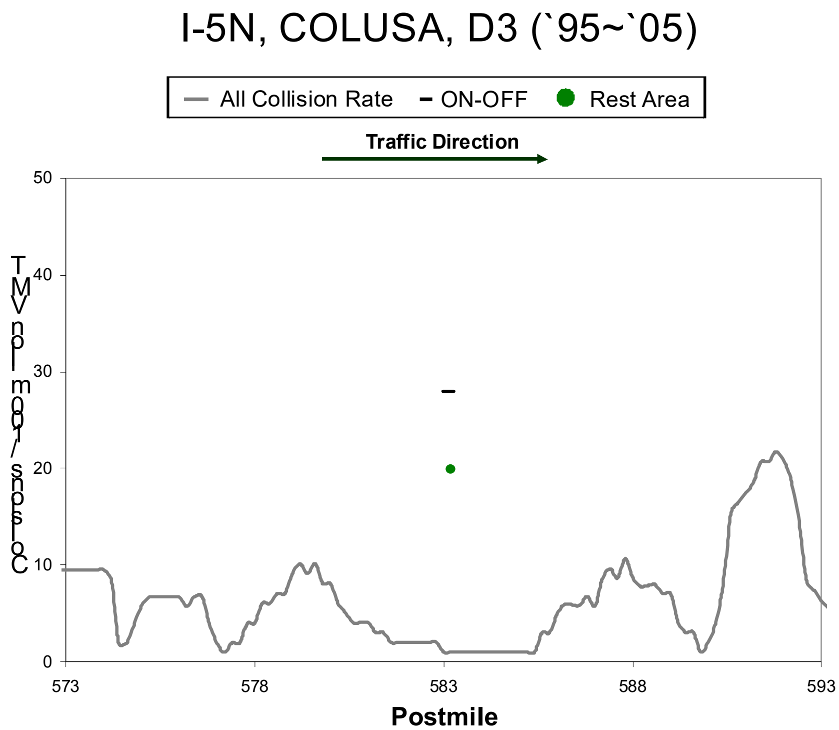
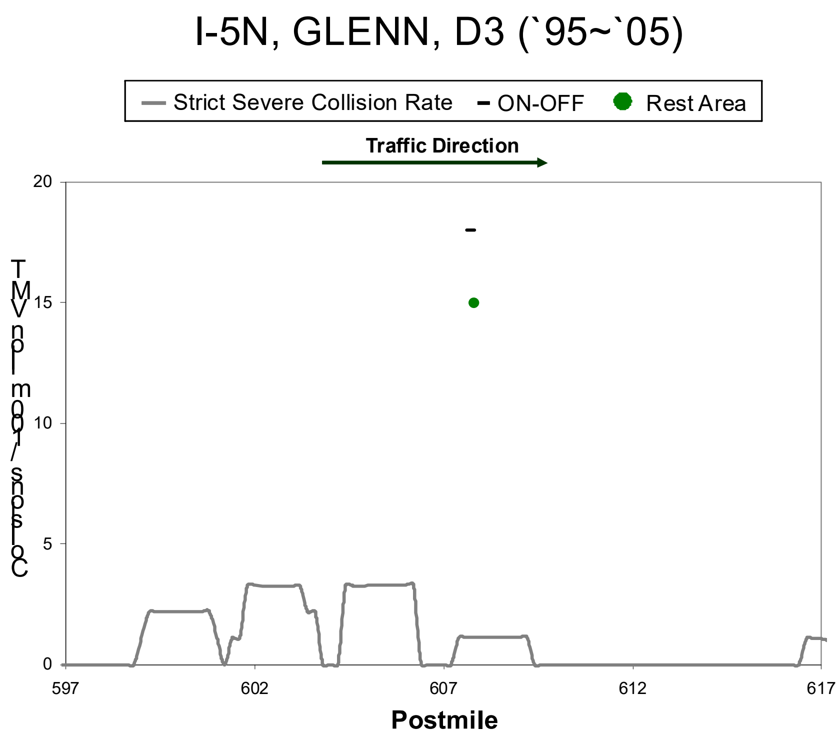
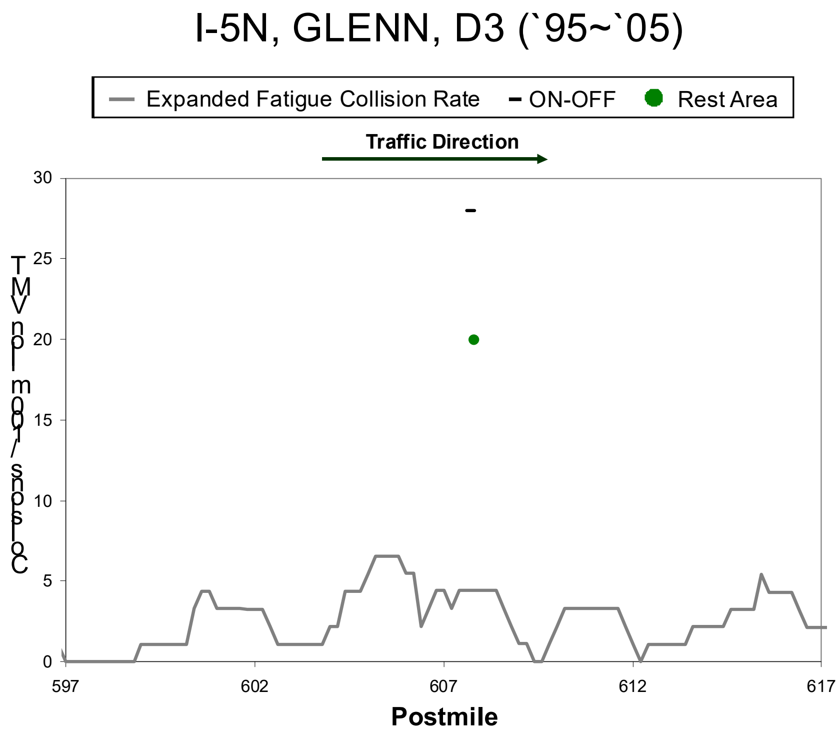
20
30
40
50
545
550
555
560
565


I-5N, COLUSA, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
Collisions/100mln VMT
573
578
583
588
593
Postmile


I-5N, COLUSA, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
30
25
20
15
10
5
0
Collisions/100mln VMT
573
578
583
588
593
Postmile


I-5N, COLUSA, D3 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/mil VMT
50
40
30
20
10
0
573
578
583
588
593
Postmile


I-5N, GLENN, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/mil VMT
20
15
10
5
0
597
602
607
612
617
Postmile


I-5N, GLENN, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m Veh Mi
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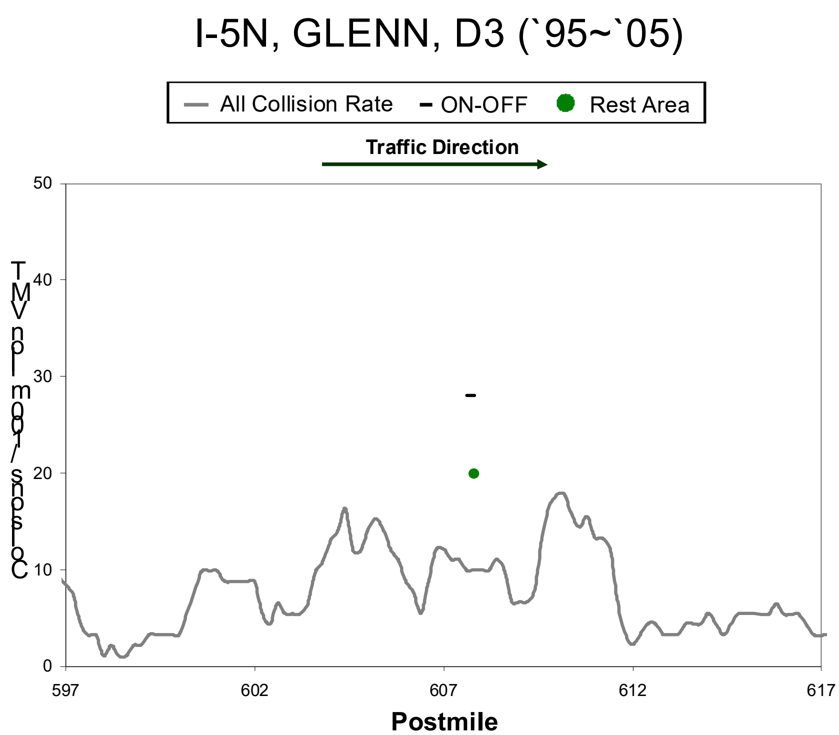
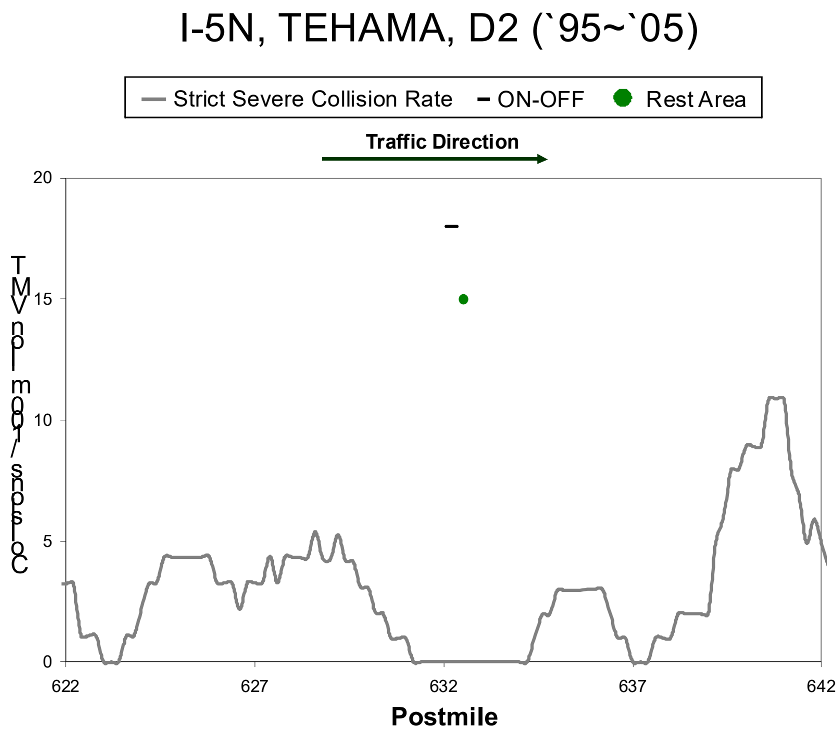
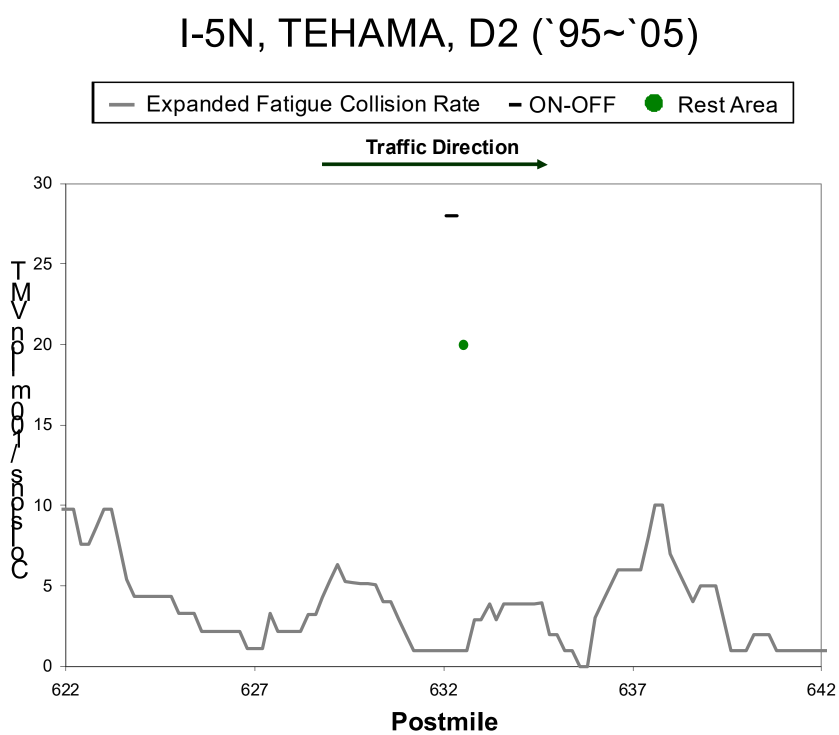
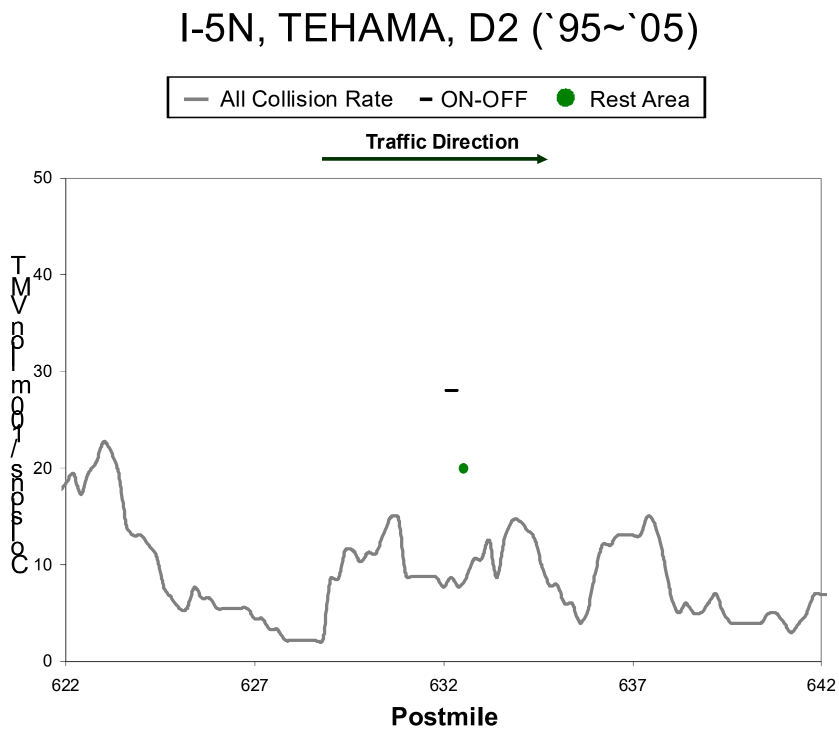
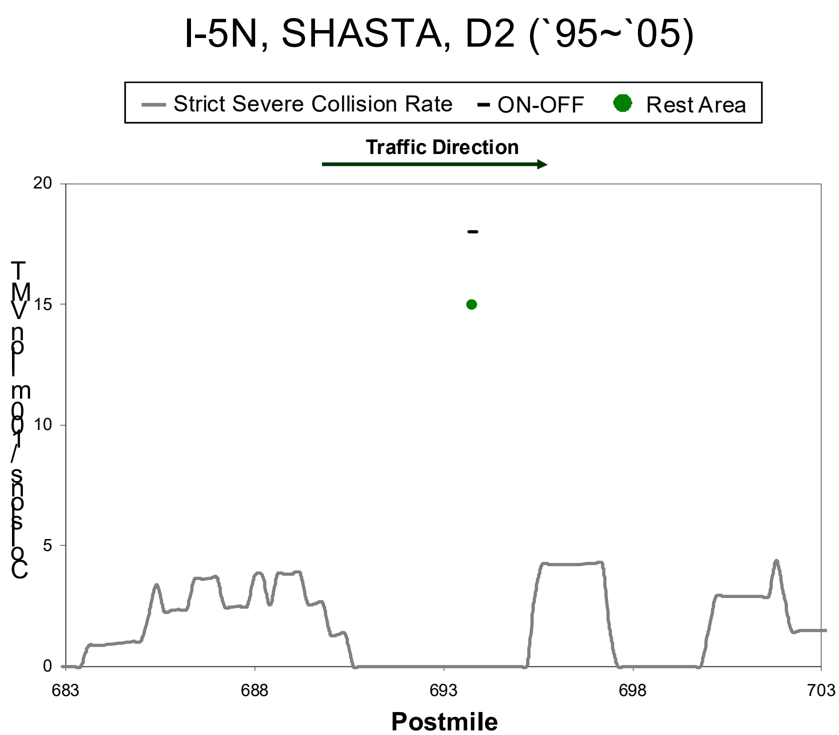
5
10
15
20
25
30
597
602
607
612
617
Postmile

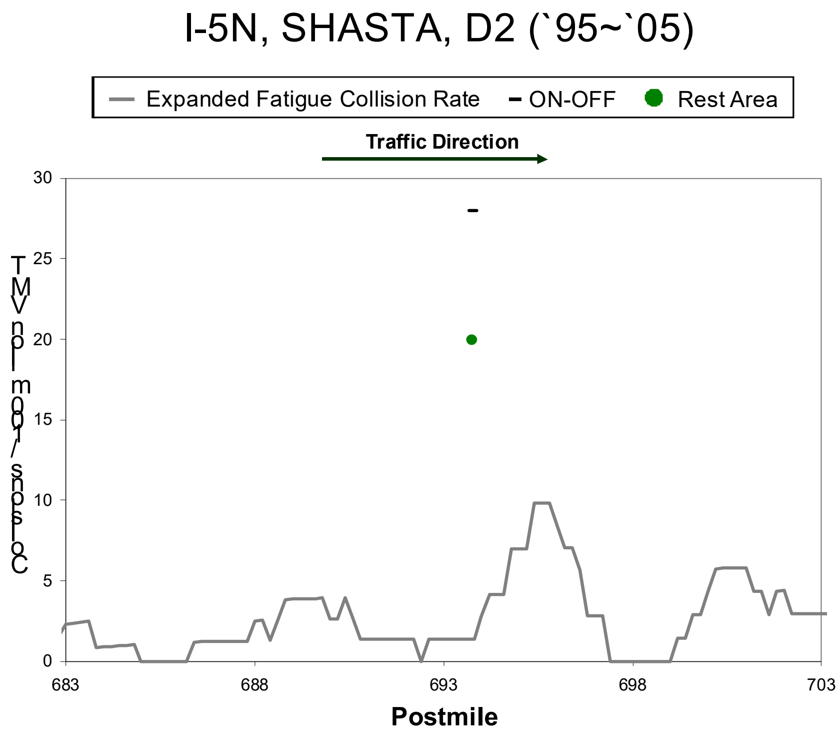

I-5N, GLENN, D3 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m Veh Mi
0
10
20
30
40
50
597
602
607
612
617
Postmile

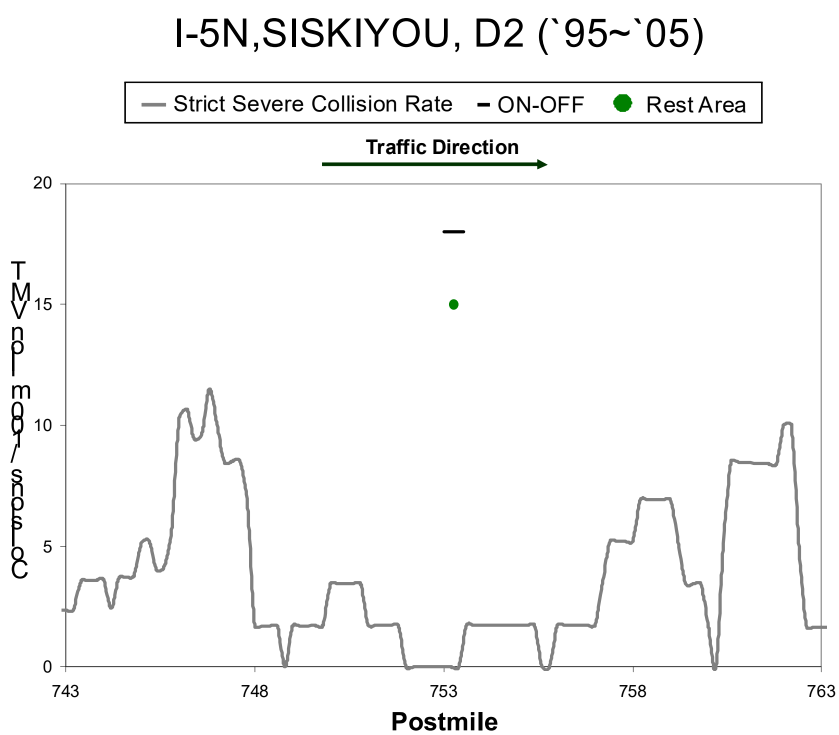

I-5N, TEHAMA, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
622
627
632
637
642
Collisions/100 mln VMT
Postmile

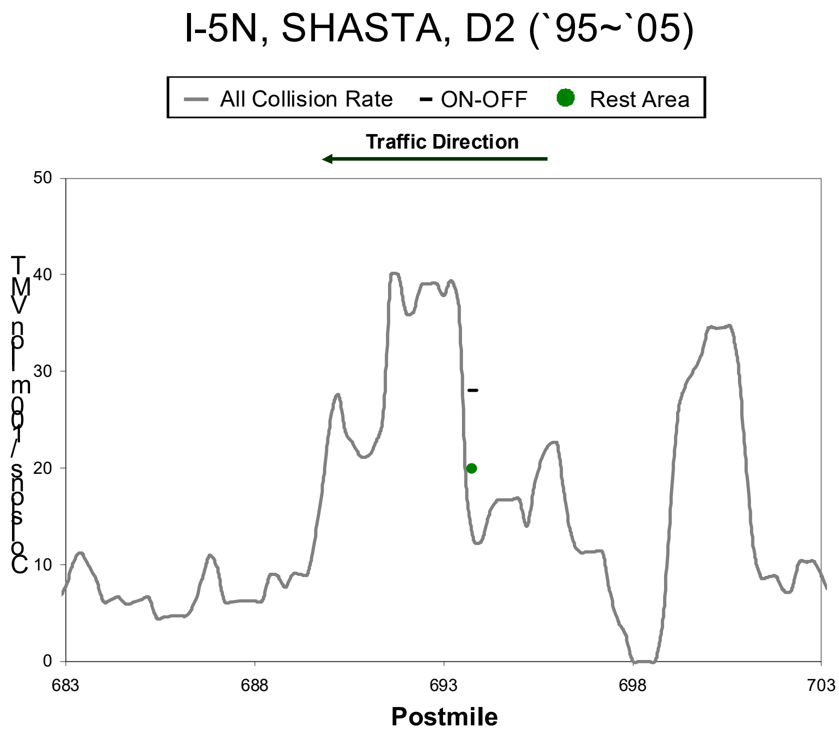

I-5N, TEHAMA, D2 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
30
25
20
15
10
5
0
622
627
632
637
642
Collisions/100 mln VMT
Postmile

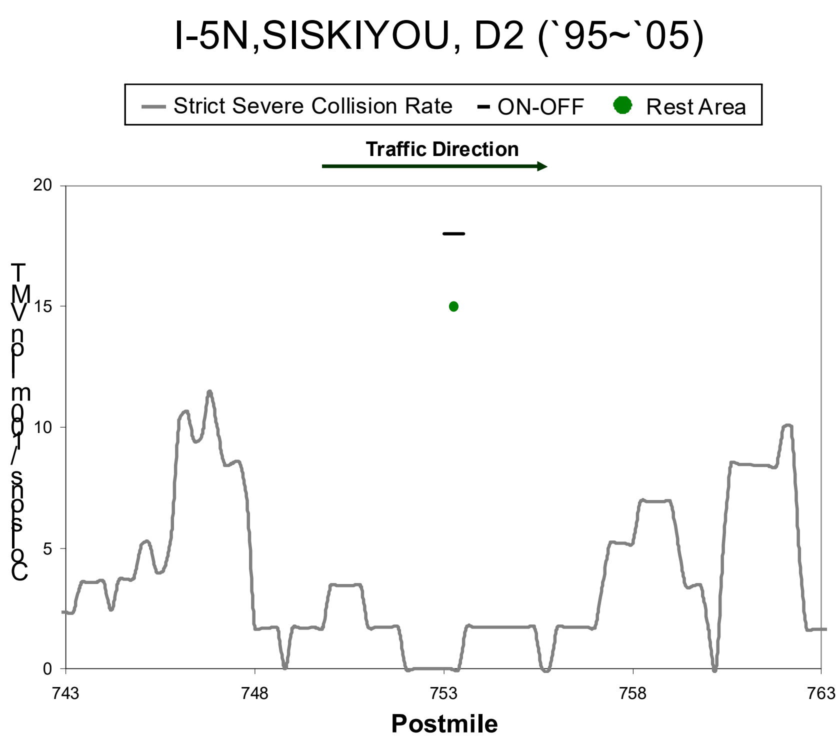

I-5N, TEHAMA, D2 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m
0
10
20
30
40
50
622
627
632
637
642
Postmile


I-5N, SHASTA, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m
0
5
10
15
20
683
688
693
698
703
Postmile

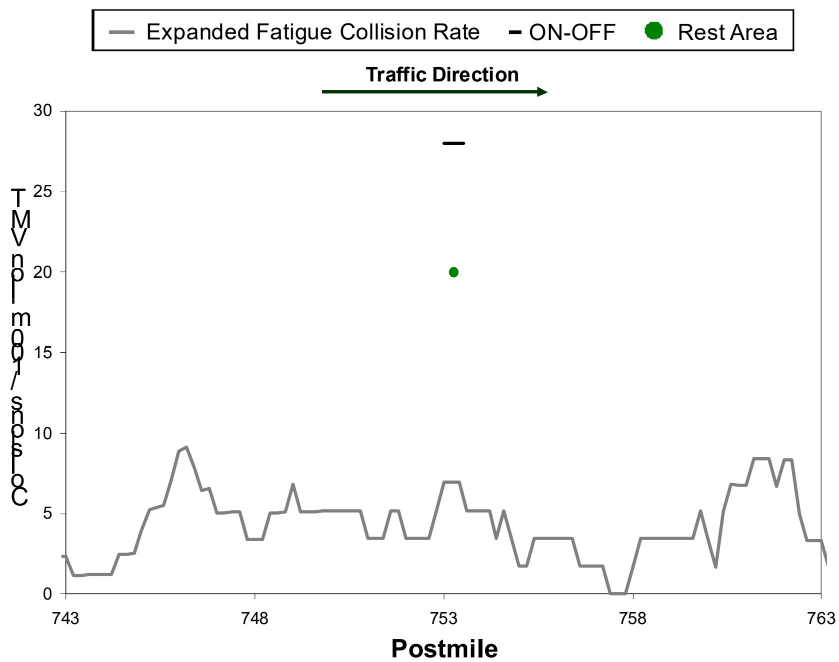

I-5N, SHASTA, D2 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m VMT
Postmile
0
5
10
15
20
25
30
683
688
693
698
703


I-5N,SISKIYOU, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m VMT
Postmile
0
5
10
15
20
743
748
753
758
763


I-5N, SHASTA, D2 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Colsions/100 mln VMT
Postmile
50
40
30
20
10
0
683
688
693
698
703

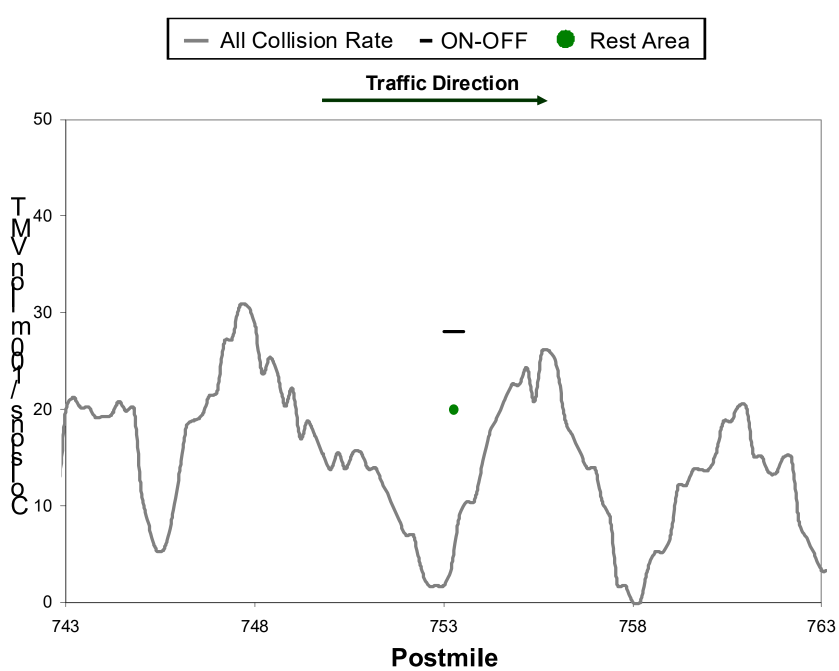

I-5N,SISKIYOU, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Colsions/100 mln VMT
Postmile
20
15
10
5
0
743
748
753
758
763

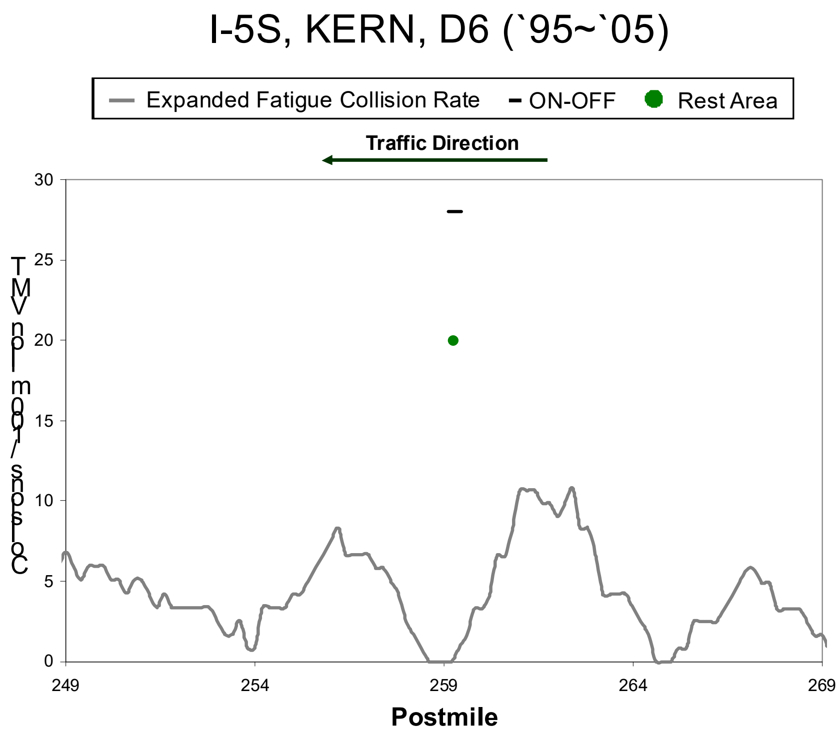
I-5N, SISKIYOU, D2 (`95~`05)

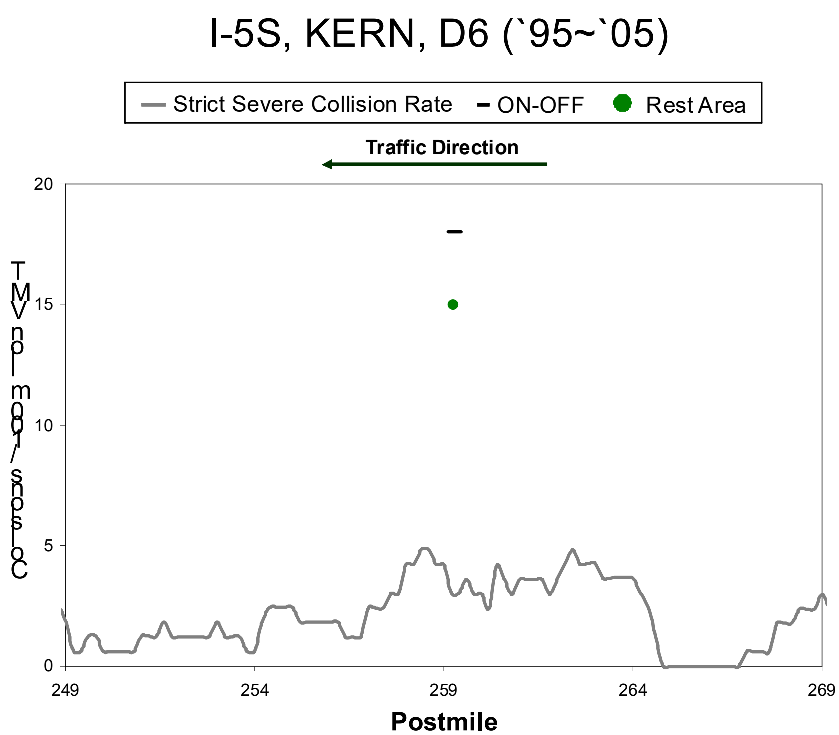


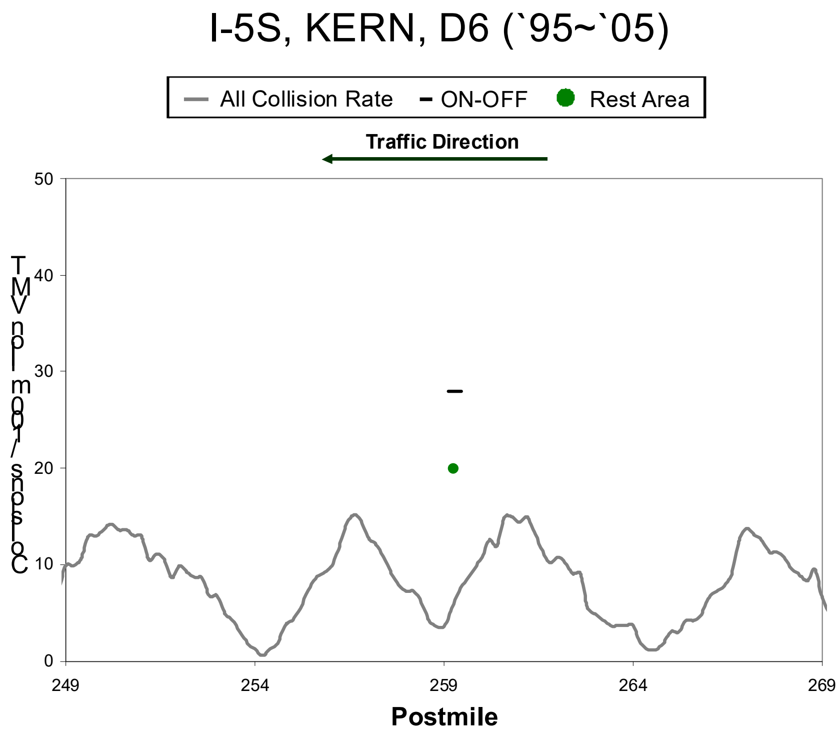
A3.2 I-5 Southbound

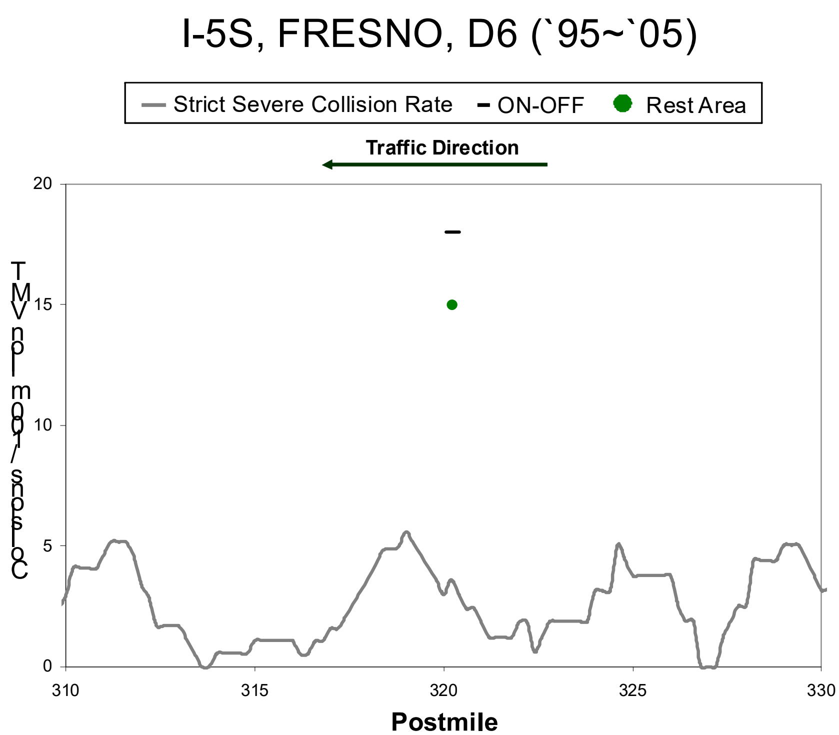
I-5S, SISKIYOU, D2 (`95~`05)

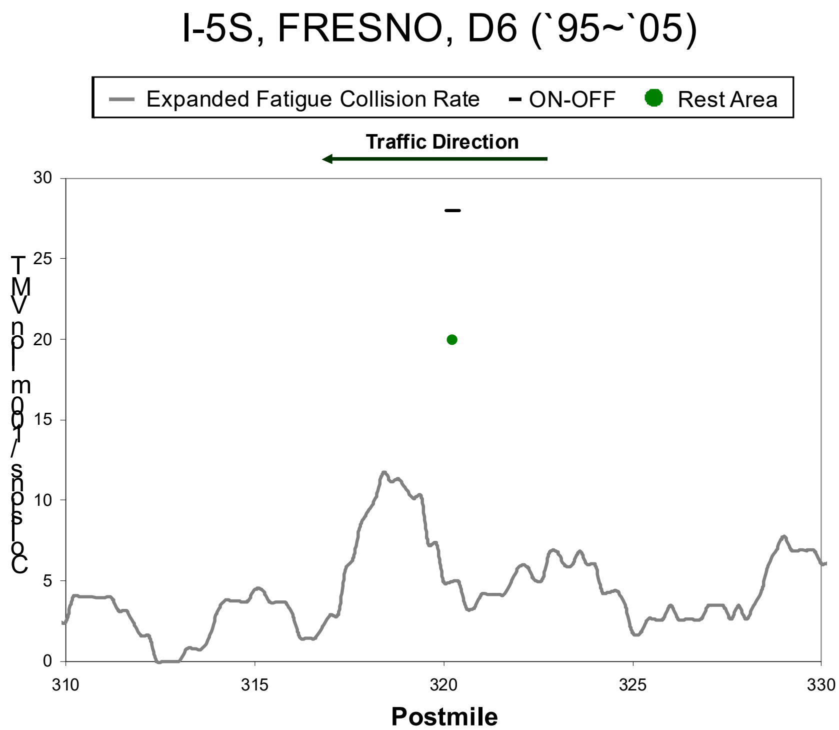


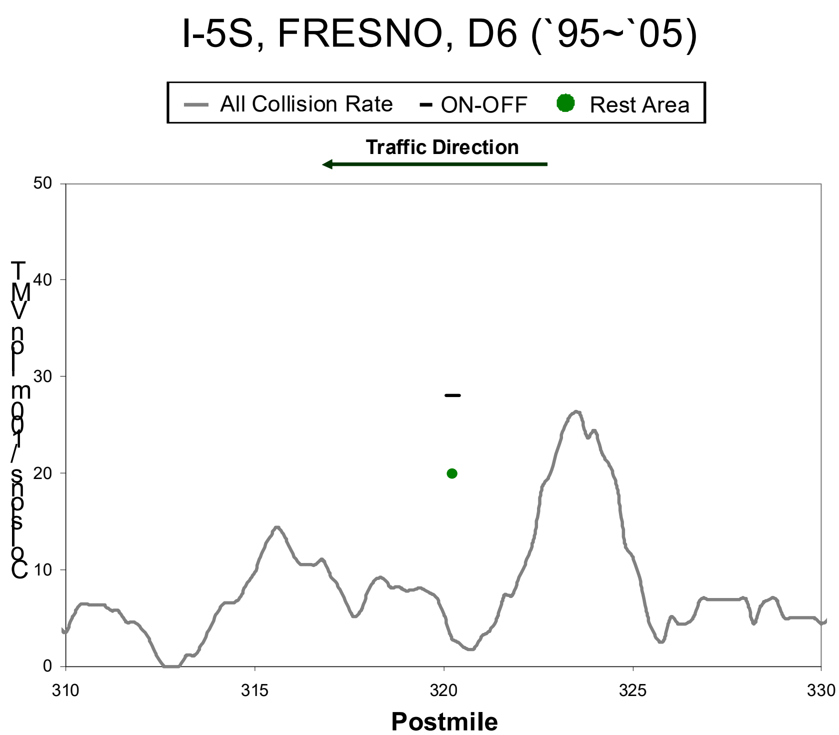

I-5S, KERN, D6 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / mil VMT
0
5
10
15
20
25
30
249
254
259
264
269
Postmile

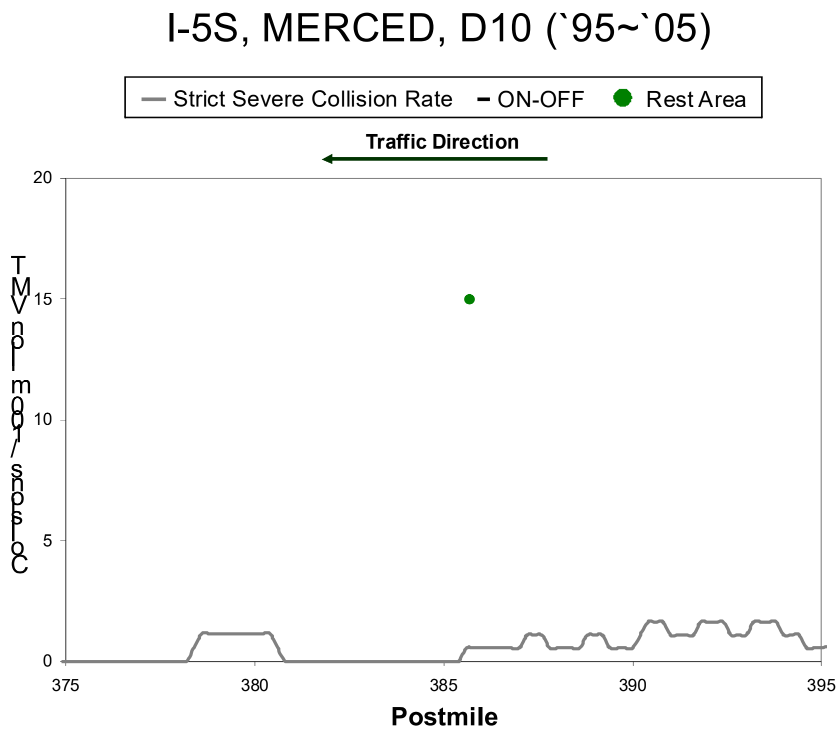

I-5S, KERN, D6 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions / mil VMT
0
5
10
15
20
249
254
259
264
269
Postmile

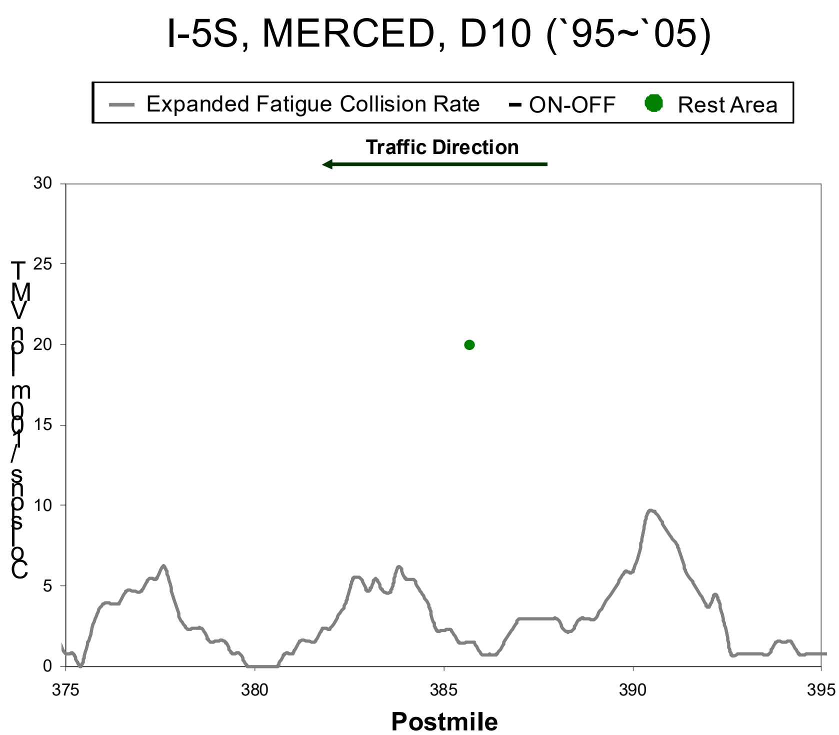

I-5S, KERN, D6 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
50
40
30
20
10
0
Coll/Rate per MVM
249
254
259
264
269
Postmile

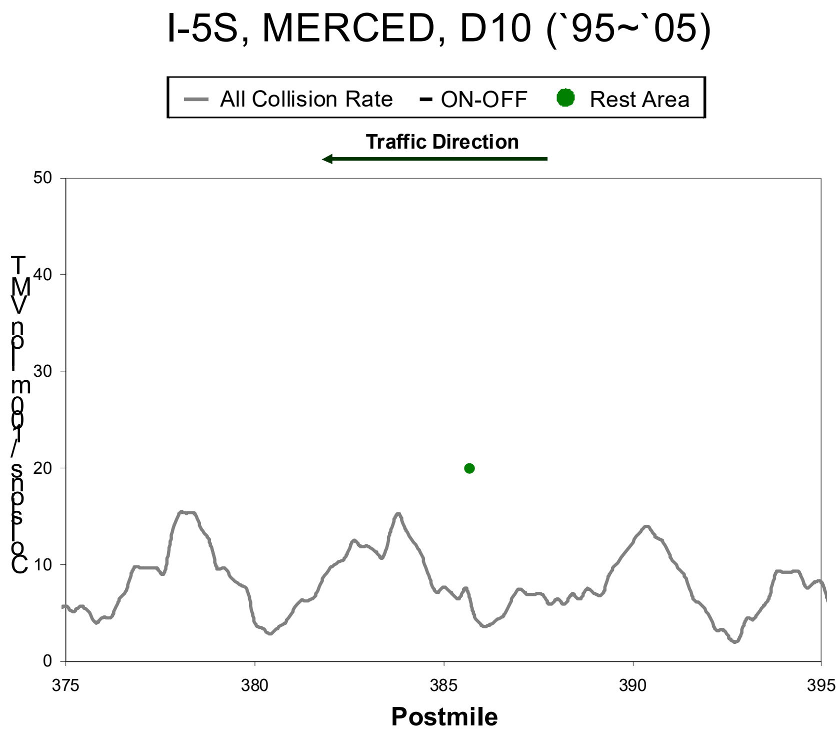

I-5S, FRESNO, D6 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
Coll/Rate per MVM
310
315
320
325
330
Postmile

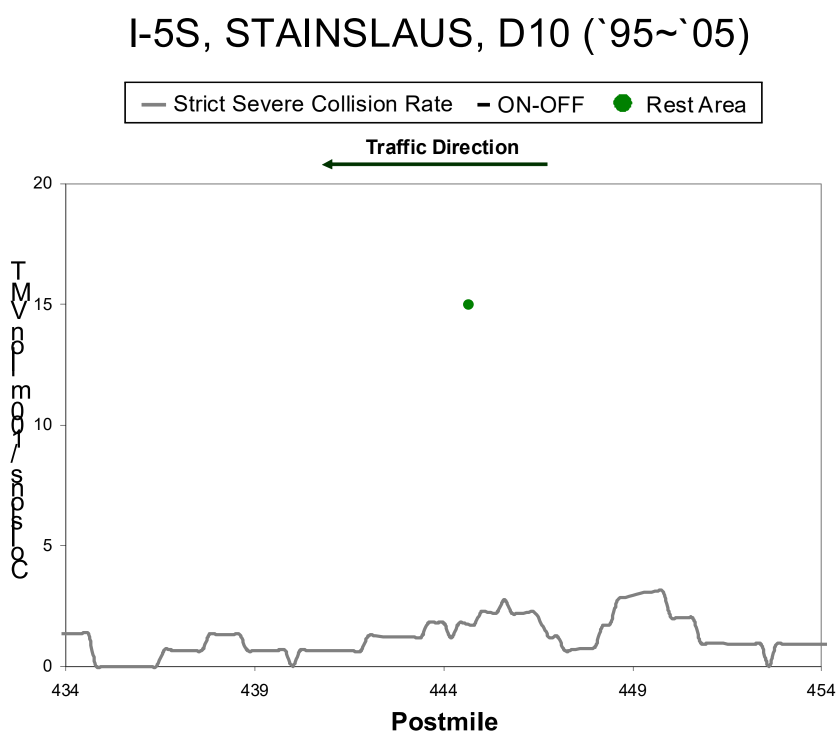

I-5S, FRESNO, D6 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil. VMT
Postmile
0
5
10
15
20
25
30
310
315
320
325
330

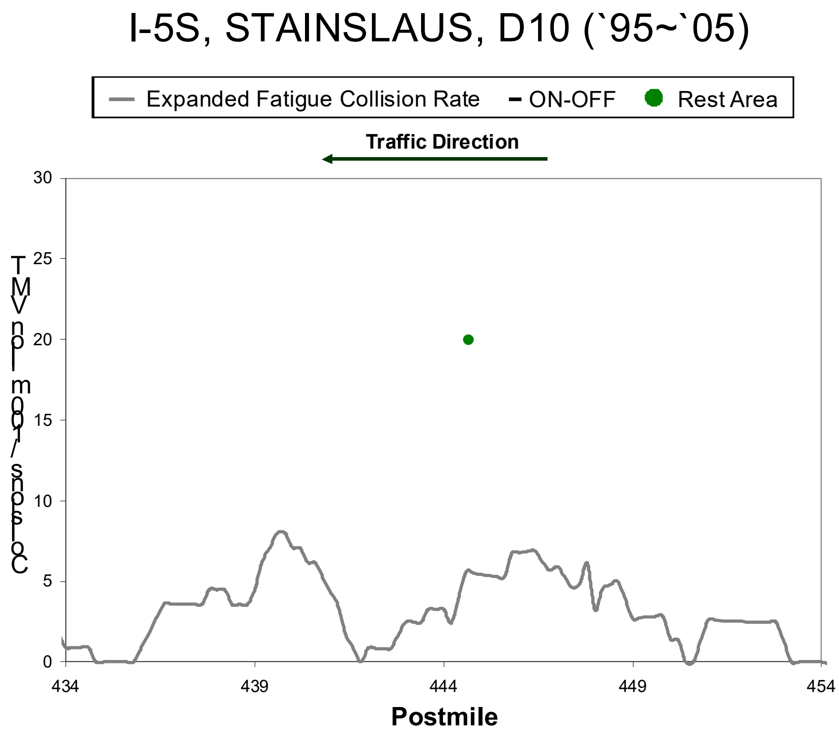

I-5S, FRESNO, D6 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil. VMT
Postmile
0
10
20
30
40
50
310
315
320
325
330

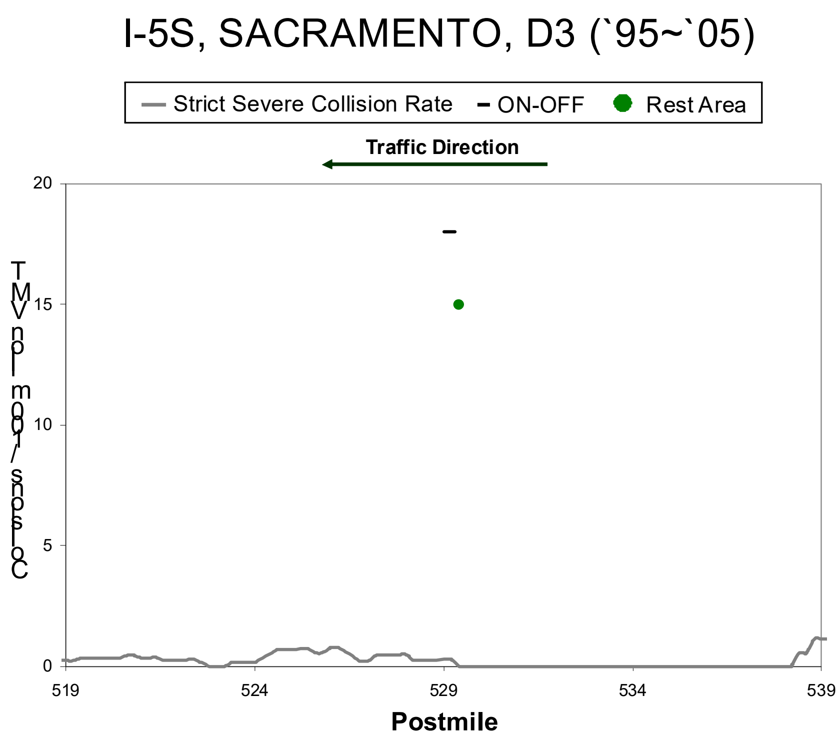

I-5S, MERCED, D10 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll sons / 100 mlon VMT
20
15
10
5
0
375
380
385
390
395
Postmile

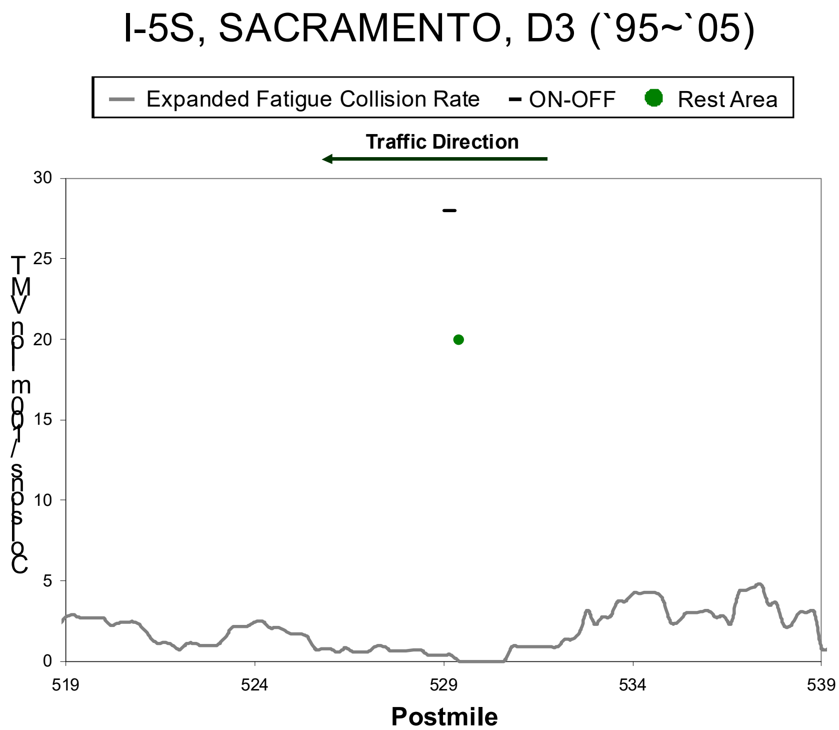

I-5S, MERCED, D10 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll sons / 100 mlon VMT
30
25
20
15
10
5
0
375
380
385
390
395
Postmile

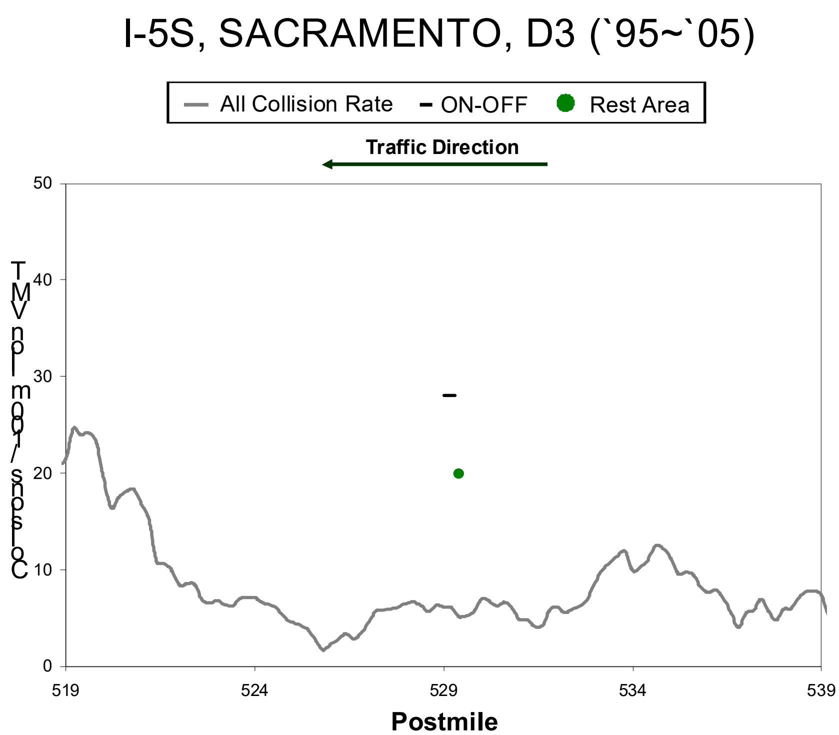

I-5S, MERCED, D10 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 Million VMT
50
40
30
20
10
0
375
380
385
390
395
Postmile

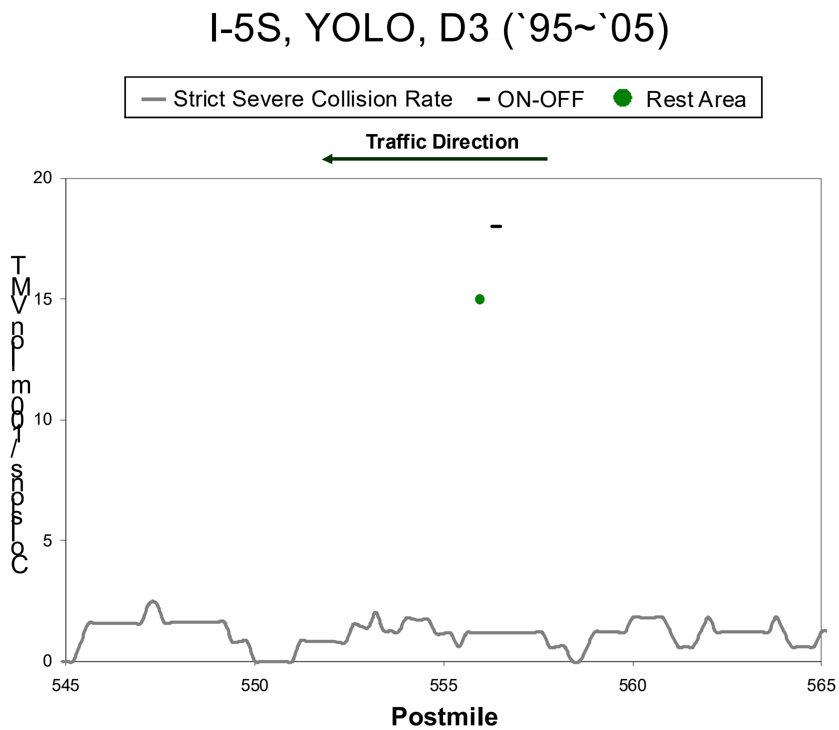

I-5S, STAINSLAUS, D10 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 Million VMT
20
15
10
5
0
434
439
444
449
454
Postmile

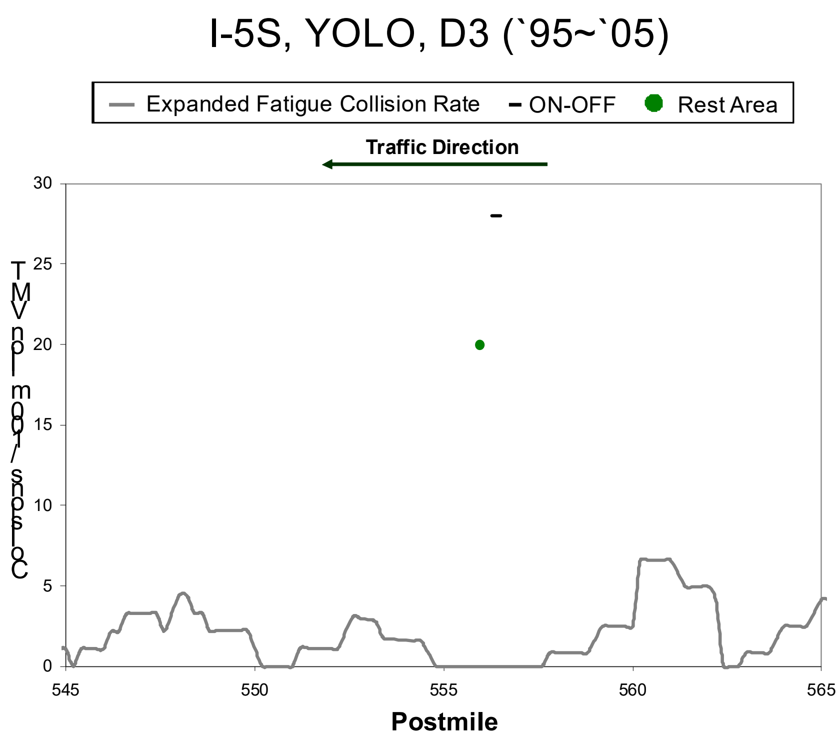

I-5S, STAINSLAUS, D10 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
30
25
20
15
10
5
0
434
439
444
449
454
Postmile

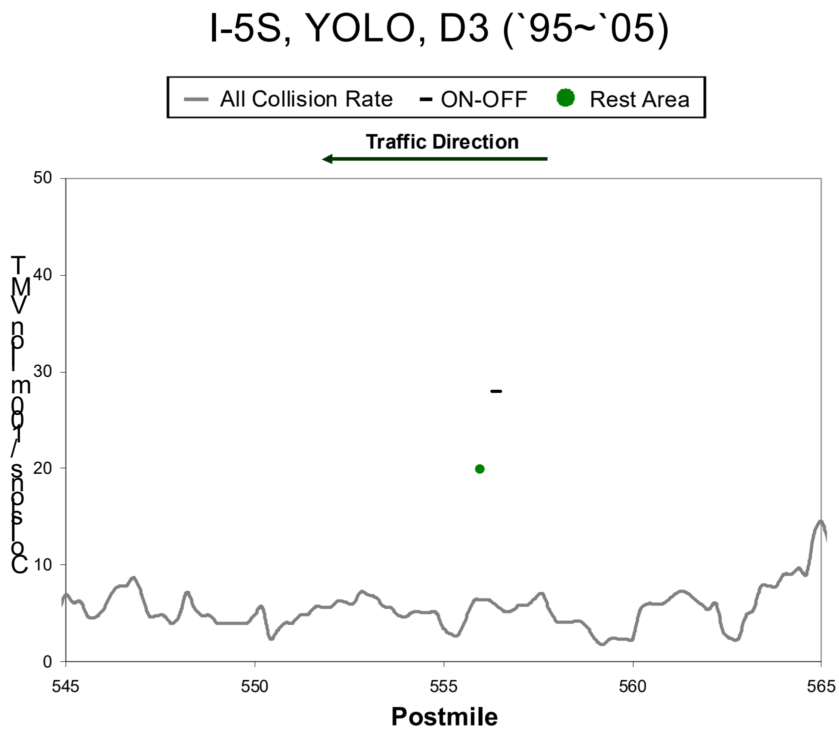

I-5S, SACRAMENTO, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
519
524
529
534
539
Postmile


I-5S, SACRAMENTO, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m on VMT
30
25
20
15
10
5
0
519
524
529
534
539
Postmile


I-5S, SACRAMENTO, D3 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m on VMT
50
40
30
20
10
0
519
524
529
534
539
Postmile


I-5S, YOLO, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/ons/100m no IMVT
0
5
10
15
20
545
550
555
560
565
Postmile


I-5S, YOLO, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Coll/ons/100m no IMVT
0
5
10
15
20
25
30
545
550
555
560
565
Postmile


I-5S, YOLO, D3 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m VMT
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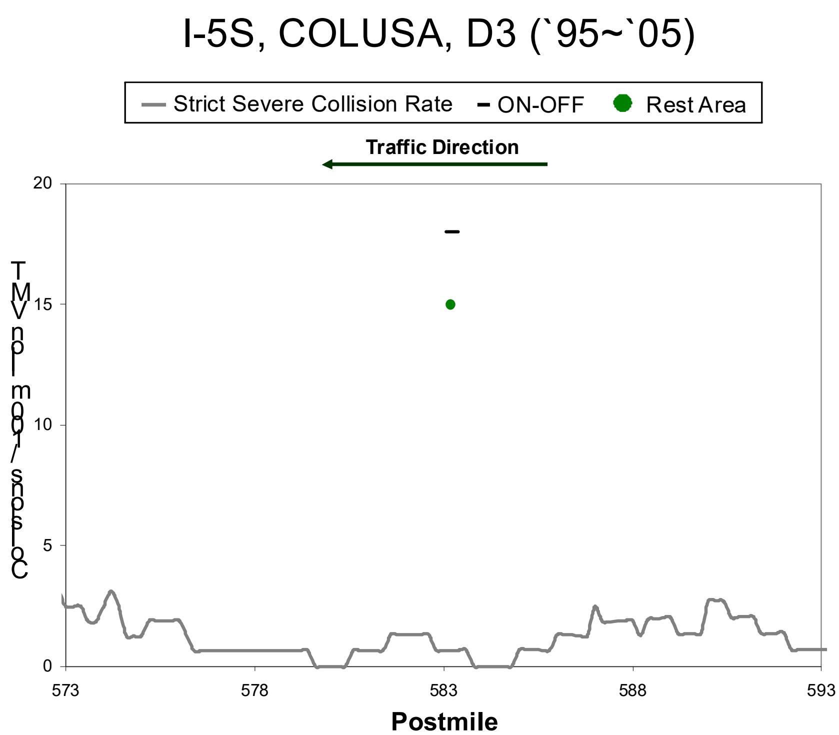
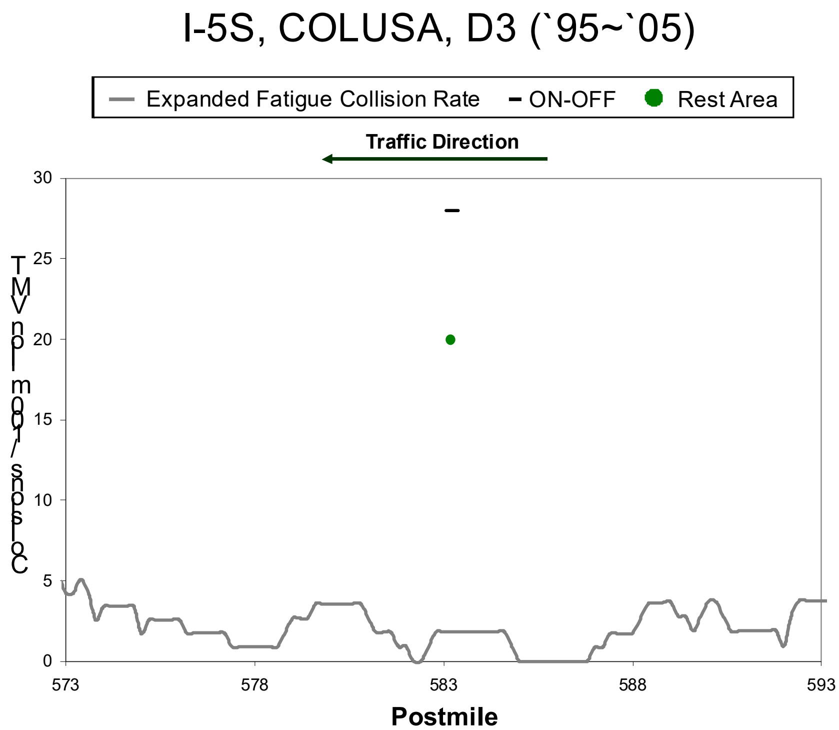
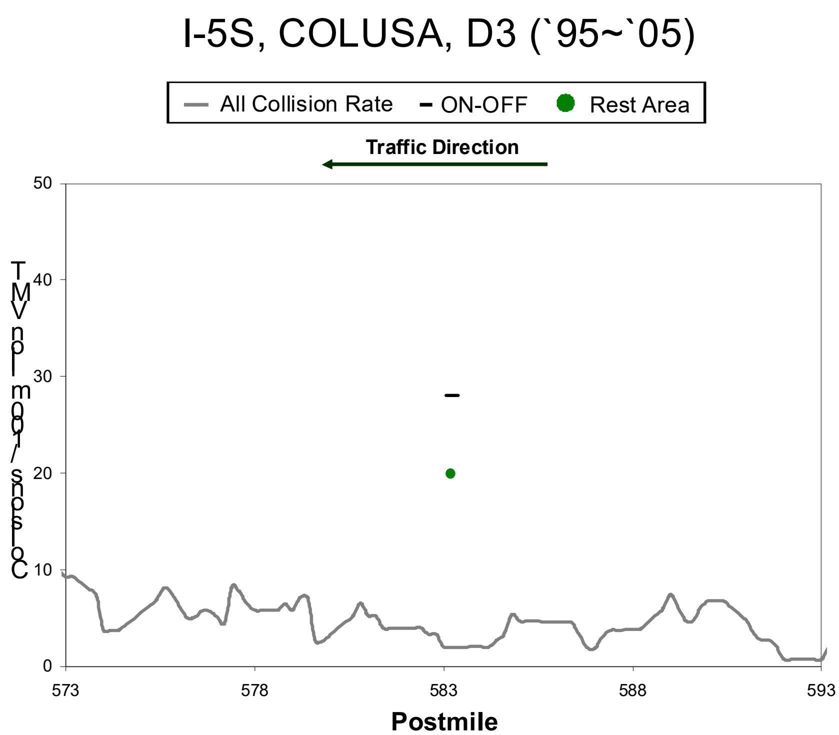
40
30
20
10
0
545
550
555
560
565
Postmile


I-5S, COLUSA, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100m VMT
20
15
10
5
0
573
578
583
588
593
Postmile


I-5S, COLUSA, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisons/100 mil VMT
0
5
10
15
20
25
30
573
578
583
588
593
Postmile


I-5S, COLUSA, D3 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisons/100 mil VMT
0
10
20
30
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50
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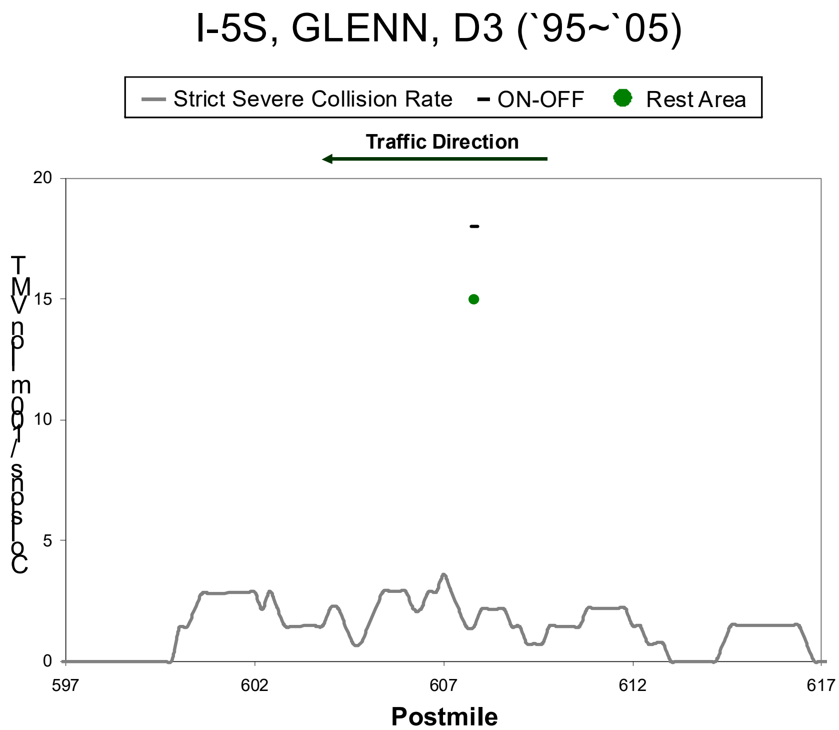
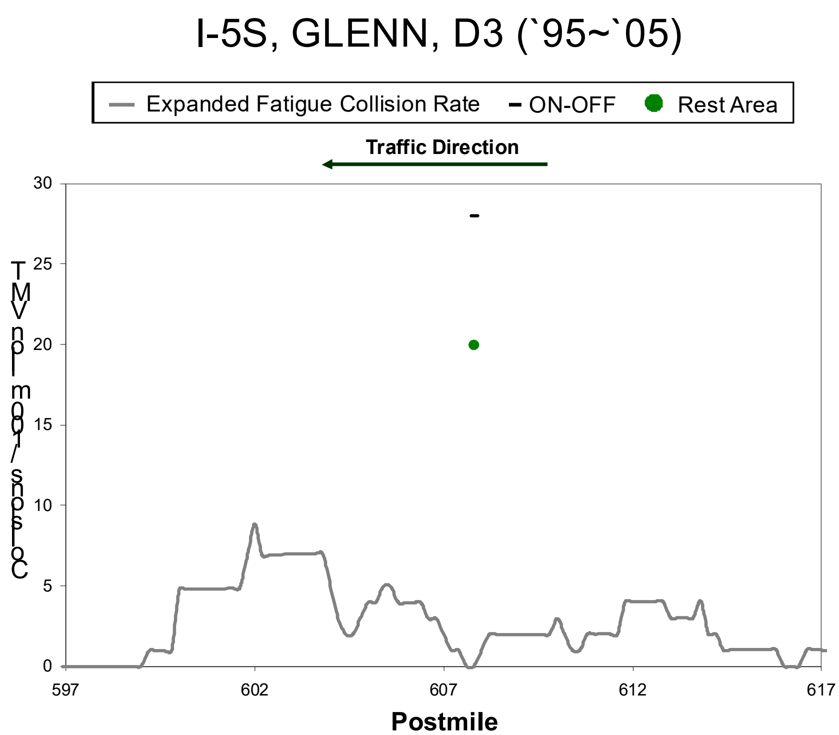
578
583
588
593
Postmile


I-5S, GLENN, D3 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 million VMT
20
15
10
5
0
597
602
607
612
617
Postmile


I-5S, GLENN, D3 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 million VMT
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25
20
15
10
5
0
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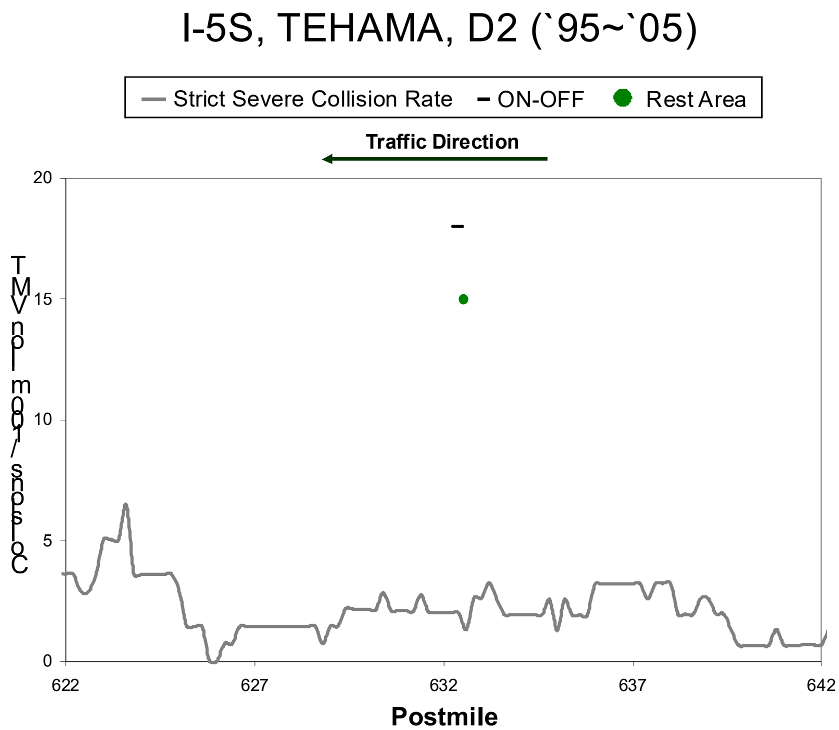
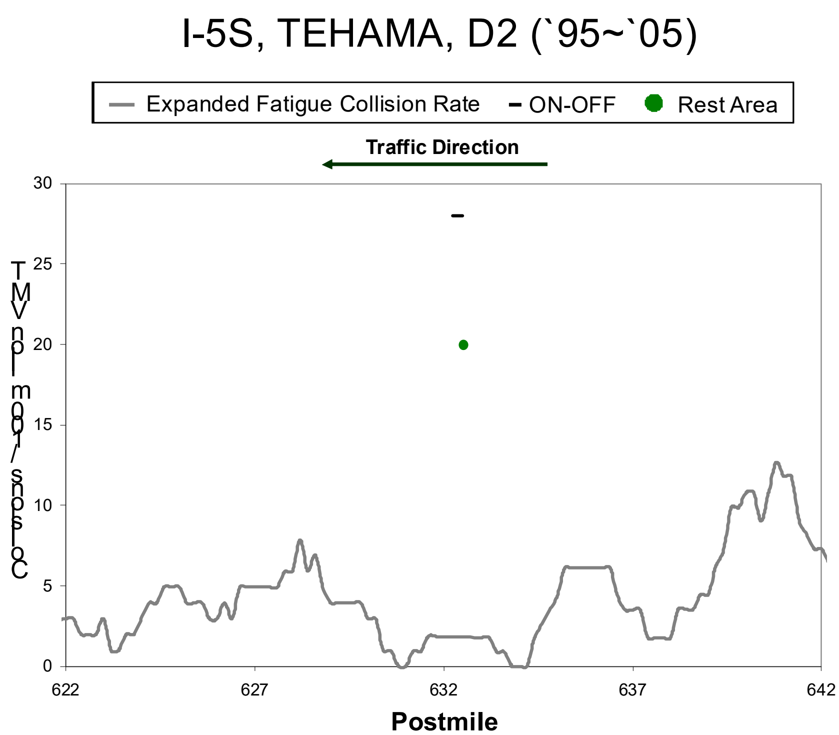
607
612
617
Postmile


I-5S, TEHAMA, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil VMT
20
15
10
5
0
622
627
632
637
642
Postmile


I-5S, TEHAMA, D2 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil VMT
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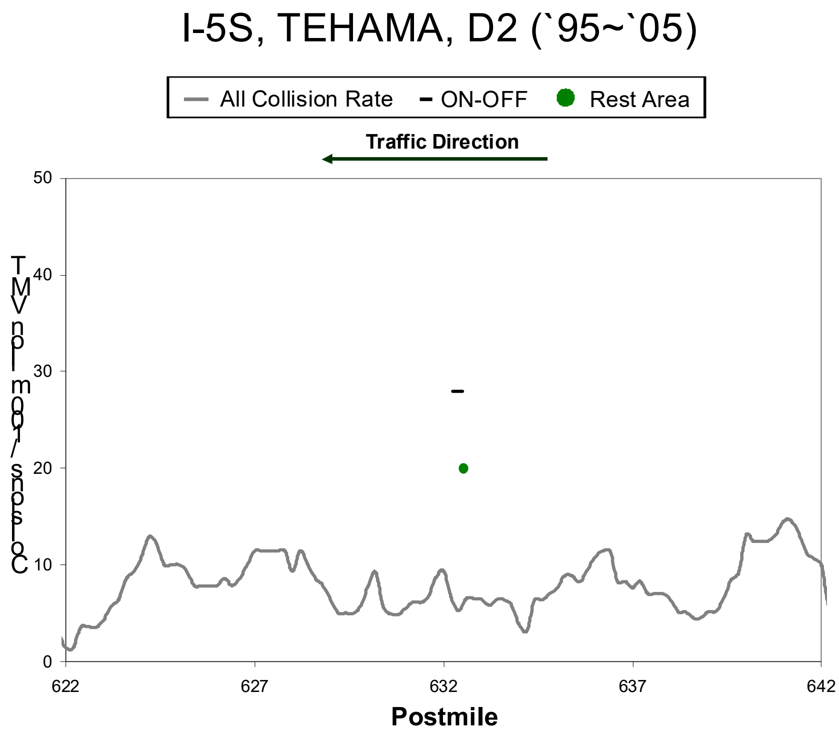
25
20
15
10
5
0
622
627
632
637
642
Postmile


I-5S, TEHAMA, D2 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
50
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10
0
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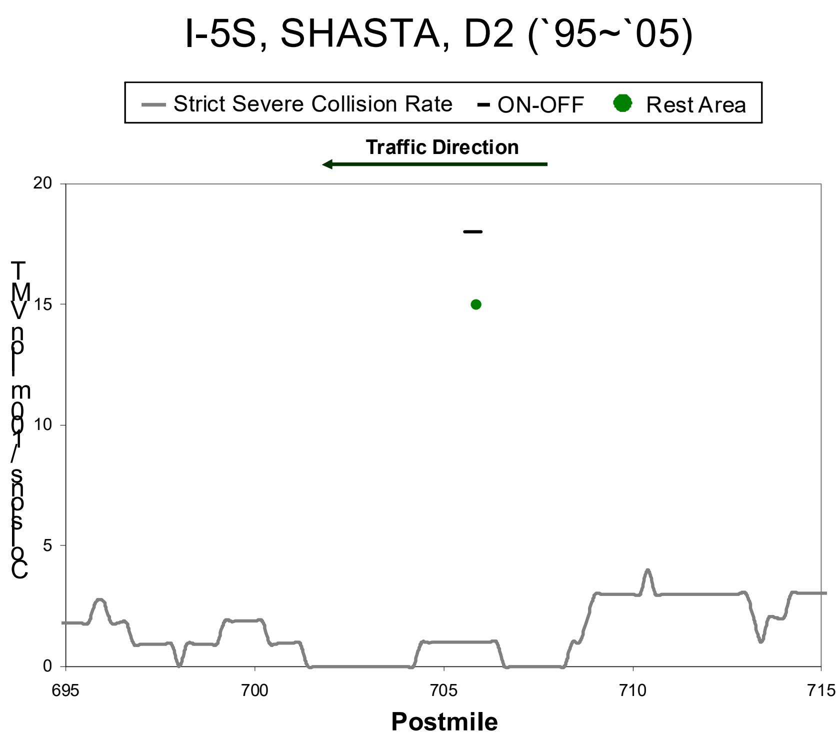
627
632
637
642
Postmile


I-5S, SHASTA, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
20
15
10
5
0
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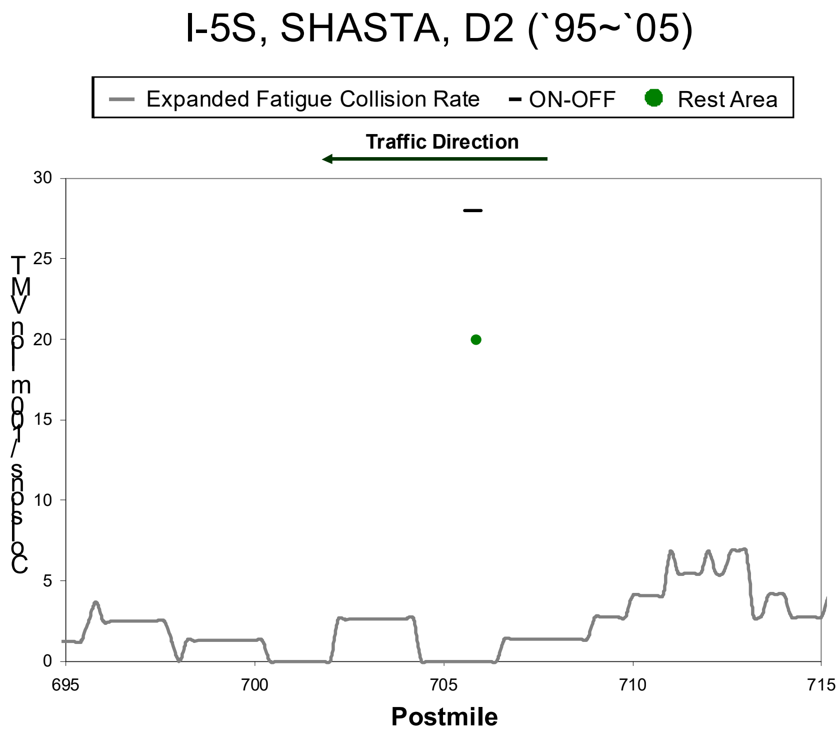
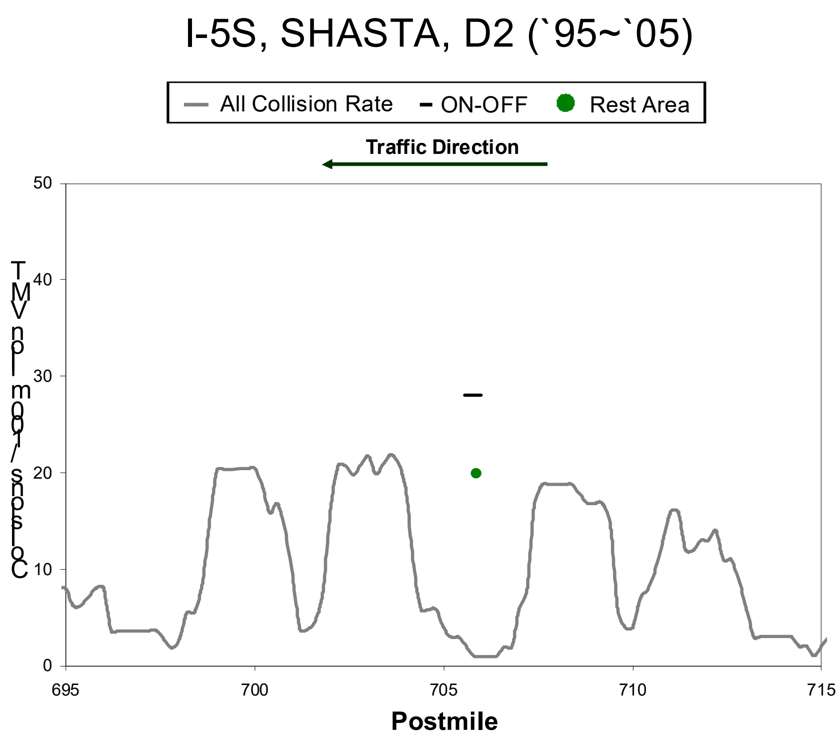
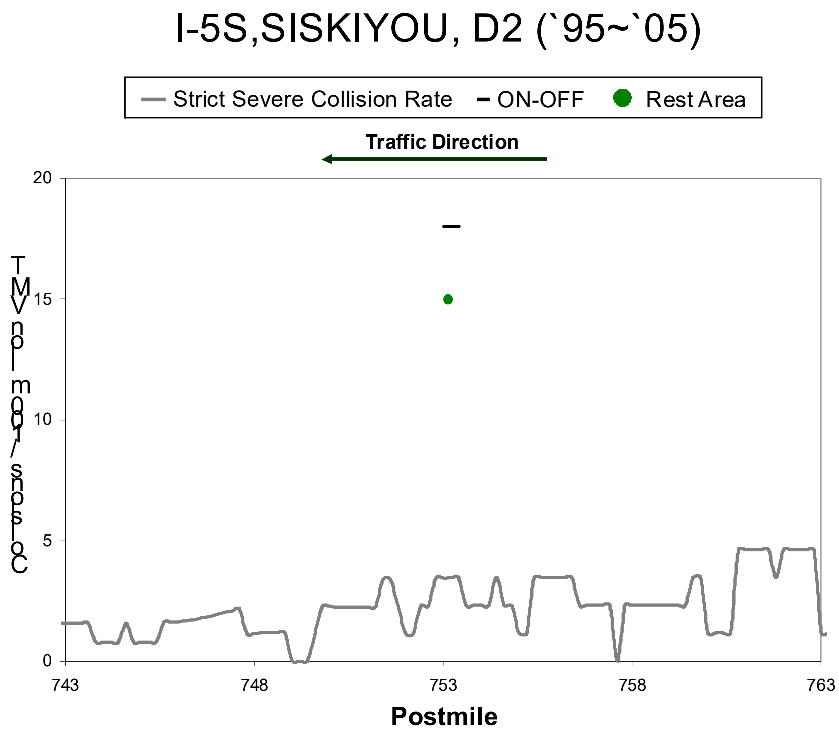
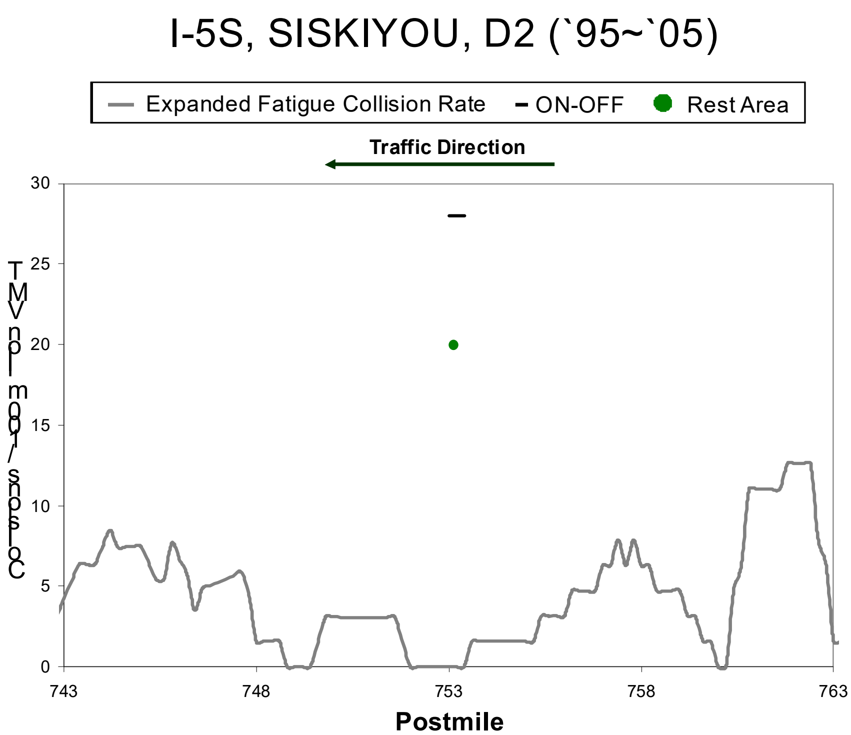
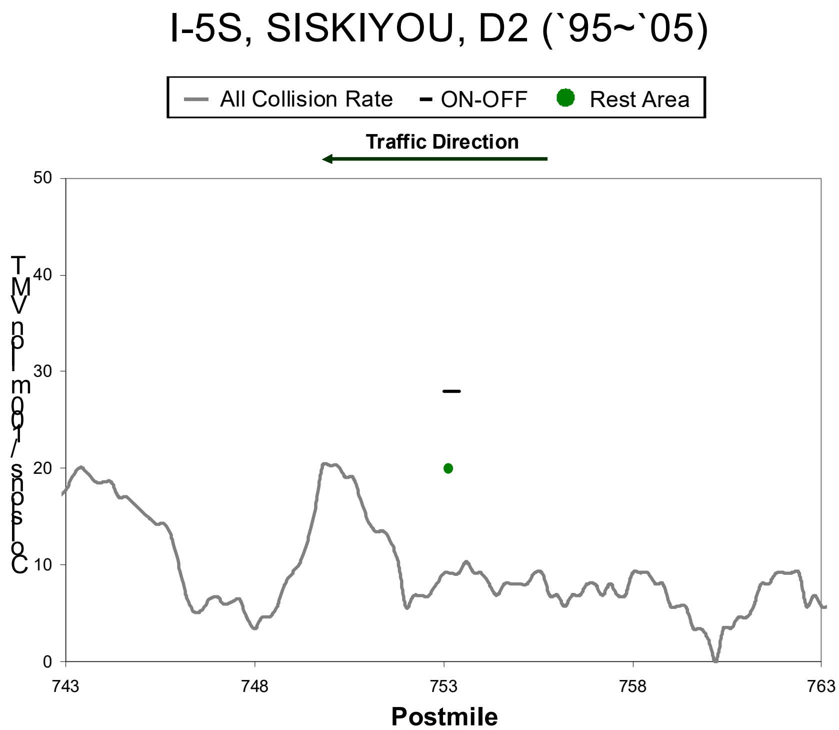
700
705
710
715
Postmile


I-5S, SHASTA, D2 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil. VMT
30
25
20
15
10
5
0
695
700
705
710
715
Postmile


I-5S, SHASTA, D2 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
Collisions/100 mil. VMT
50
40
30
20
10
0
695
700
705
710
715
Postmile


I-5S,SISKIYOU, D2 (`95~`05)
Strict Severe Collision Rate
ON-OFF
Rest Area
Traffic Direction
Colisons/100 mlon VMT
20
15
10
5
0
743
748
753
758
763
Postmile


I-5S, SISKIYOU, D2 (`95~`05)
Expanded Fatigue Collision Rate
ON-OFF
Rest Area
Traffic Direction
Colisons/100 mlon VMT
30
25
20
15
10
5
0
743
748
753
758
763
Postmile


I-5S, SISKIYOU, D2 (`95~`05)
All Collision Rate
ON-OFF
Rest Area
Traffic Direction
50
40
30
20
10
0
Collisions/Mil. VMT
743
748
753
758
763
Postmile

APPENDIX 4: SPATIAL ANALYSIS – COLLISIONS AS A FUNCTION OF DISTANCE FROM REST STOPS

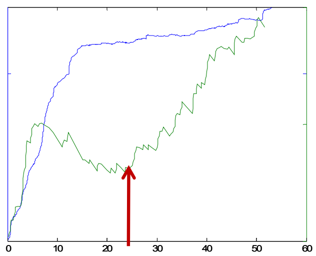
The spatial analysis examined the two types of fatigue collisions defined in section 5 in addition to their counterparts caused by other factors. Compared with the spatial analysis of collisions in the 10-mile vicinity of rest stops as presented in section 5, the focus of this section is the spatial patterns of fatigue collisions between two successive rest stops; how distances traveled by drivers between rest stops influence the likelihood of fatigue-related collisions. The results of analyses on individual freeway segments of I-5, I-8, I-10, and CA-101, are presented in this section. Detailed explanations of data and methodologies used in this analysis can be found in the main report.

A4.1 I-5 Northbound

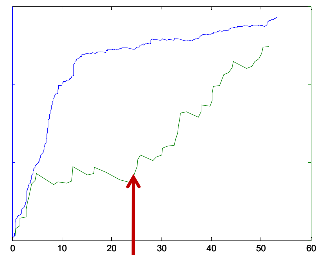
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
6	Ker	1	206.1	*53.1*	Tejon Pass
6	Ker	54.1	259.2	*58.3*	Buttonwillow
6	Fre	1.3	317.5	*65.6*	Coalinga-Avenal
10	Mer	0.7	385.7	*59.0*	John Chuck Erreca
10	Sta	27.2	444.6	*111.3*	Westley
3	Yol	26	555.9	*27.2*	Dunnigan
3	Col	24.3	583.2	*24.6*	Maxwell
3	Gle	14.6	607.8	*24.7*	Willows
2	Teh	10.5	632.5	*24.5*	Lt. John Helmick
2	Teh	35	657.0	*36.7*	Herbert S. Miles
2	Sha	31.1	693.7	*59.5*	O'Brien
2	Sis	25.6	753.3	*32.8*	Weed Airport

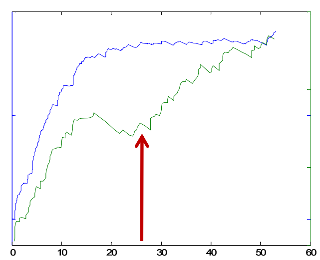
1. North Ker(1) to Ker(54.1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

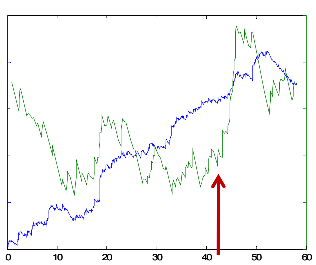
Green: fatigue only

Blue: Others

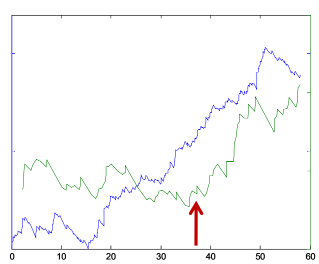
I-5

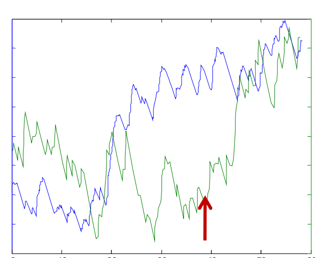
2. North Ker(54.1) to Fre(1.3)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

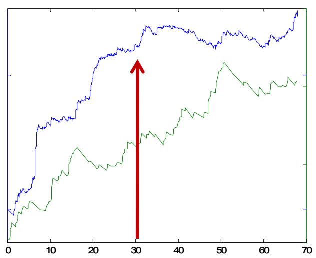
Green: fatigue only

Blue: Others

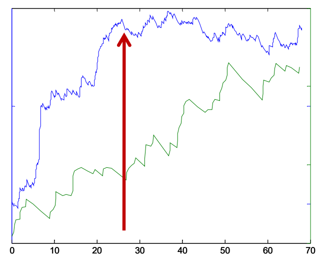
I-5

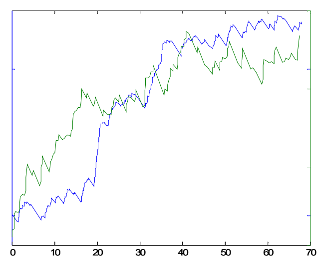
3. North Fre (1.3) to Mer(0.7)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

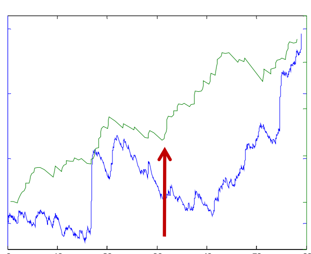
Green: fatigue only

Blue: Others

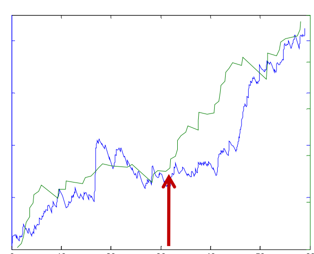
I-5

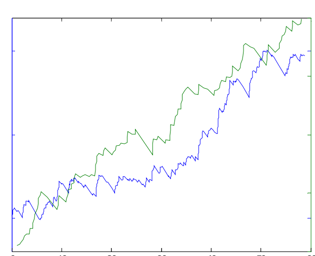
4. North Mer(0.7) to Sta(27.2)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

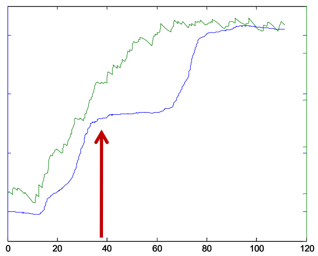
Green: fatigue only

Blue: Others

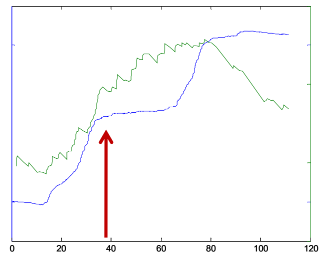
I-5

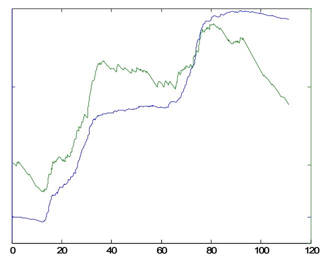
5. North Sta(27.2) to Yol(26)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

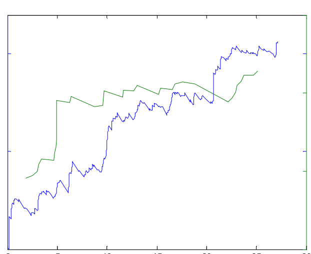
Green: fatigue only

Blue: Others

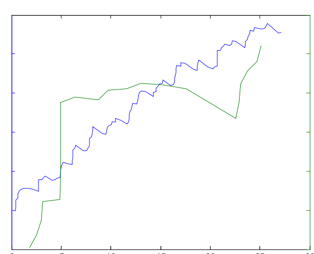
I-5

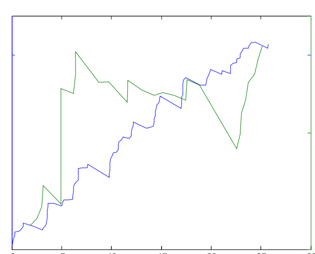
6. North Yol(26) to Col(24.3)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

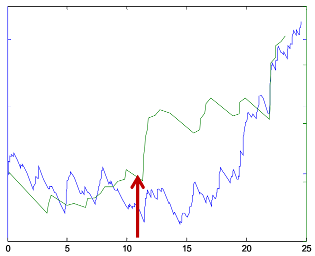
Green: fatigue only

Blue: Others

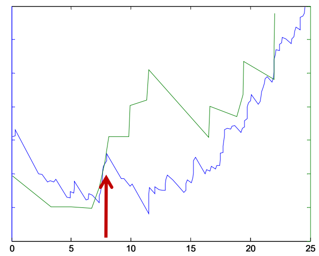
I-5

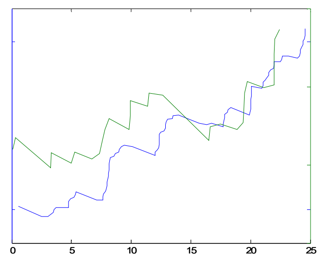
7. North Col(24.3) to Gle(14.6)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

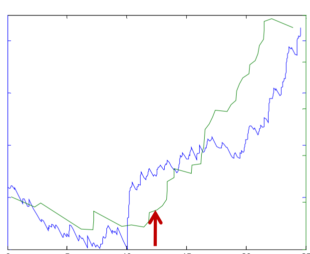
Green: fatigue only

Blue: Others

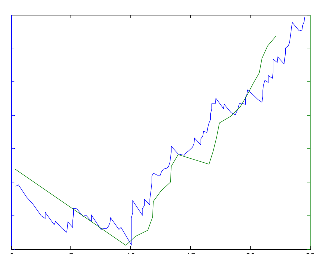
I-5

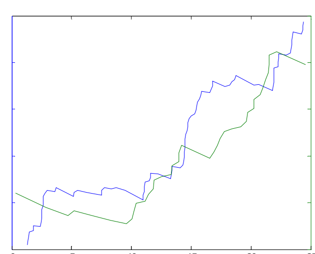
8. North Gle(14.6) to Teh(10.5)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

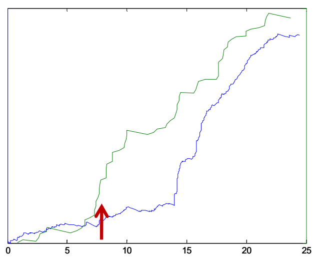
Green: fatigue only

Blue: Others

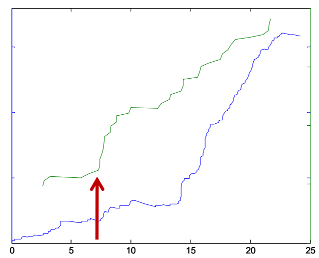
I-5

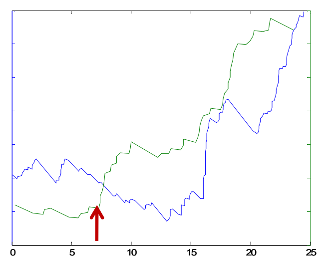
9. North Teh(10.5) to Teh(35)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

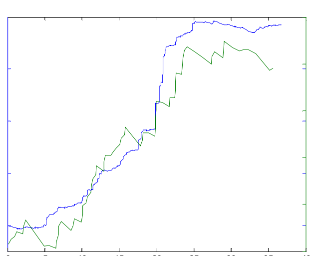
Green: fatigue only

Blue: Others

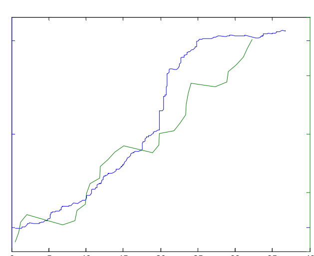
I-5

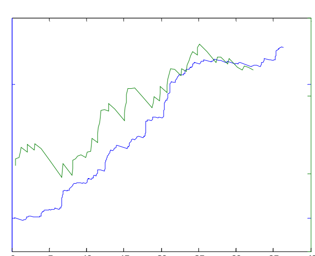
10. North Teh(35) to Sha(31.1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

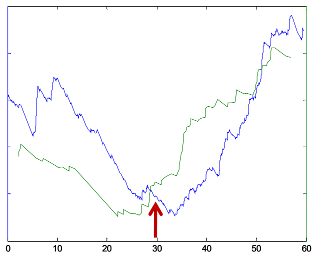
Green: fatigue only

Blue: Others

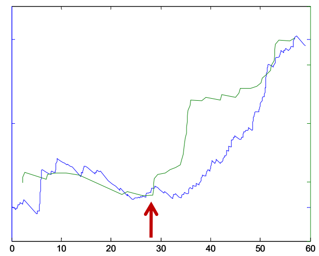
I-5

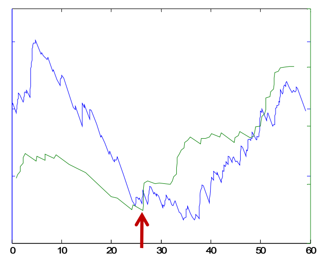
11. North Sha(31.1) ~ Sis(25.6)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

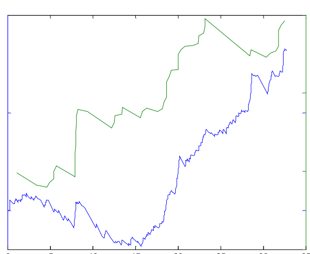
Green: fatigue only

Blue: Others

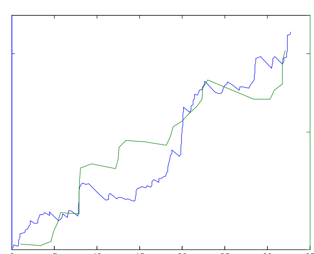
I-5

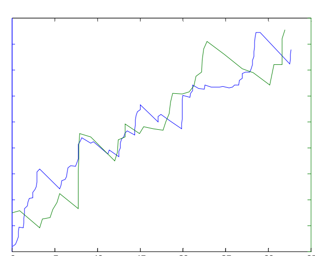
12. North Sis(25.6) to Sis(58.4)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

Green: fatigue only

Blue: Others

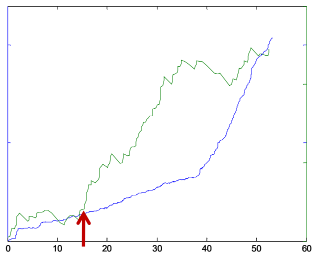
I-5

A4.2 I-5 Southbound

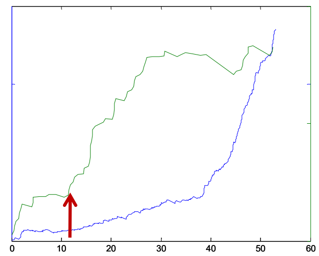
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area

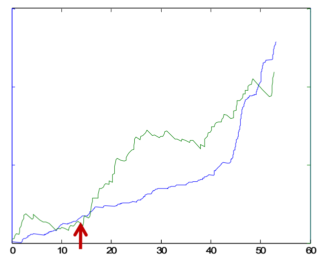
1. South Ker(54.1) to Ker(1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

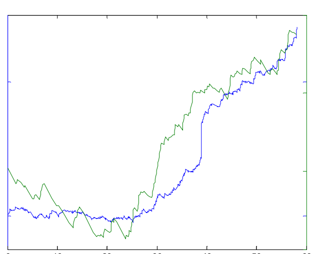
Green: fatigue only

Blue: Others

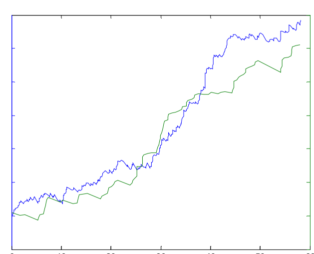
I-5

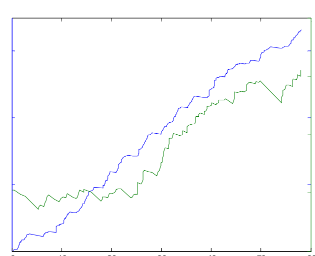
2. South Fre(1.4) to Ker(54.1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

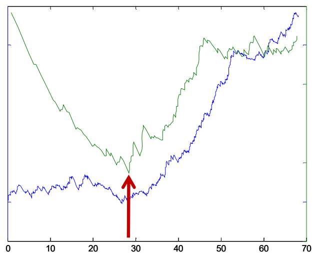
Green: fatigue only

Blue: Others

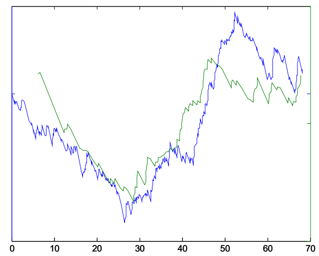
I-5

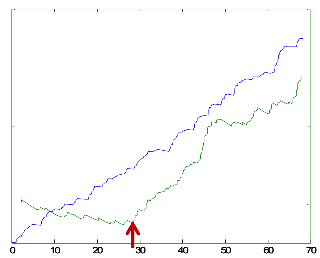
3. South Mer(0.7) to Fre (1.4)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

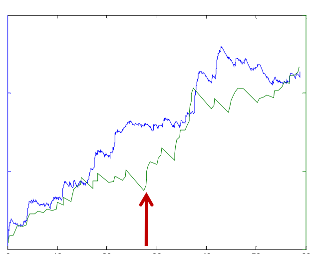
Green: fatigue only

Blue: Others

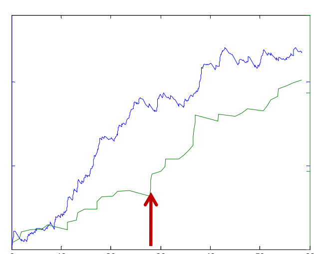
I-5

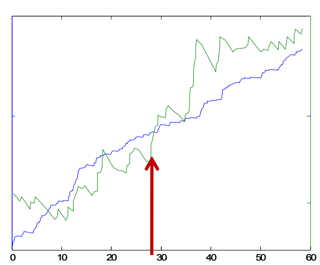
4. South Sta(27.2) to Mer(0.7)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

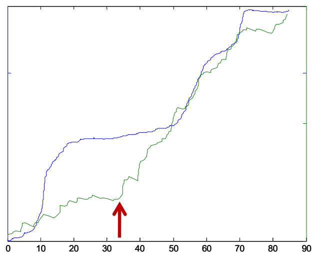
Green: fatigue only

Blue: Others

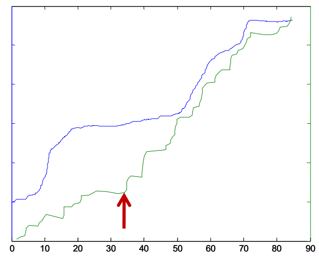
I-5

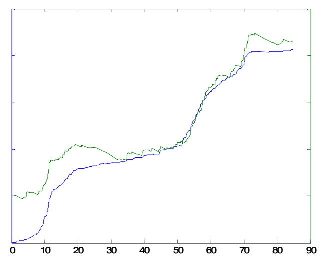
5. South Sac(34.1) to Sta(27.2)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

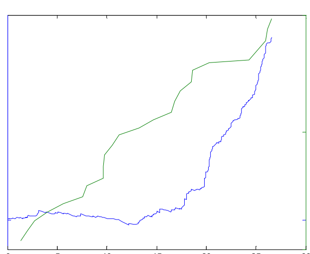
Green: fatigue only

Blue: Others

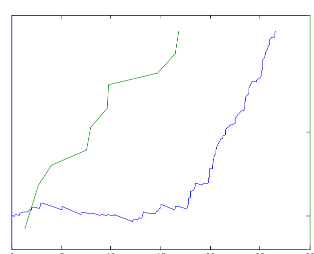
I-5

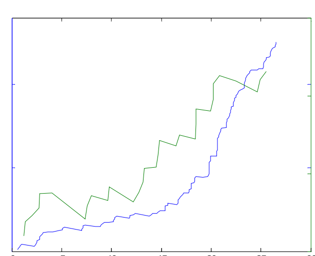
6. South Yol(26) to Sac(34.1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

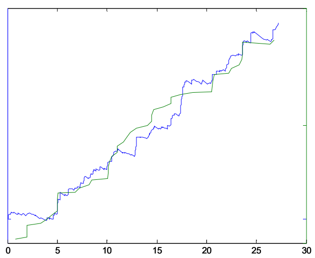
Green: fatigue only

Blue: Others

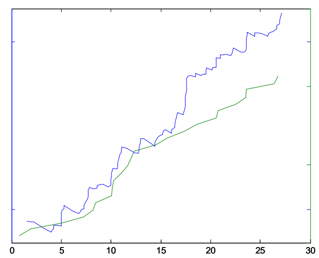
I-5

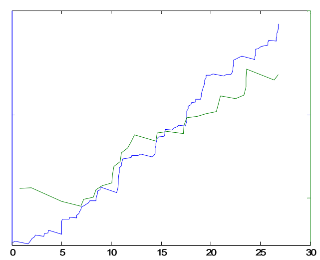
7. South Col (24.3) to Yol(26)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

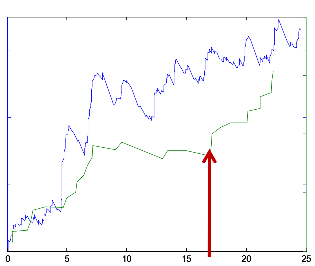
Green: fatigue only

Blue: Others

I-5

8. South Gle(14.6) to Col(24.3)

PCF= all with PDO



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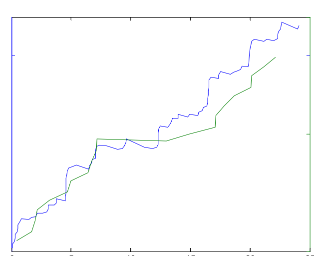
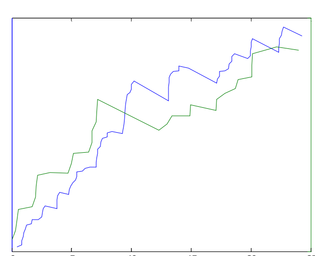




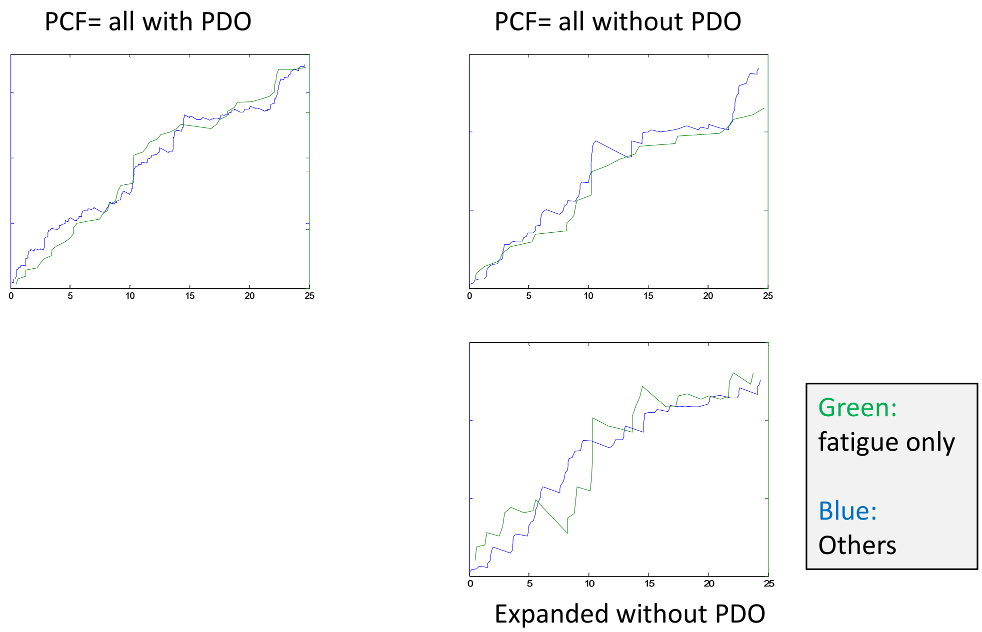
Expanded without PDO

Green: fatigue only

Blue: Others

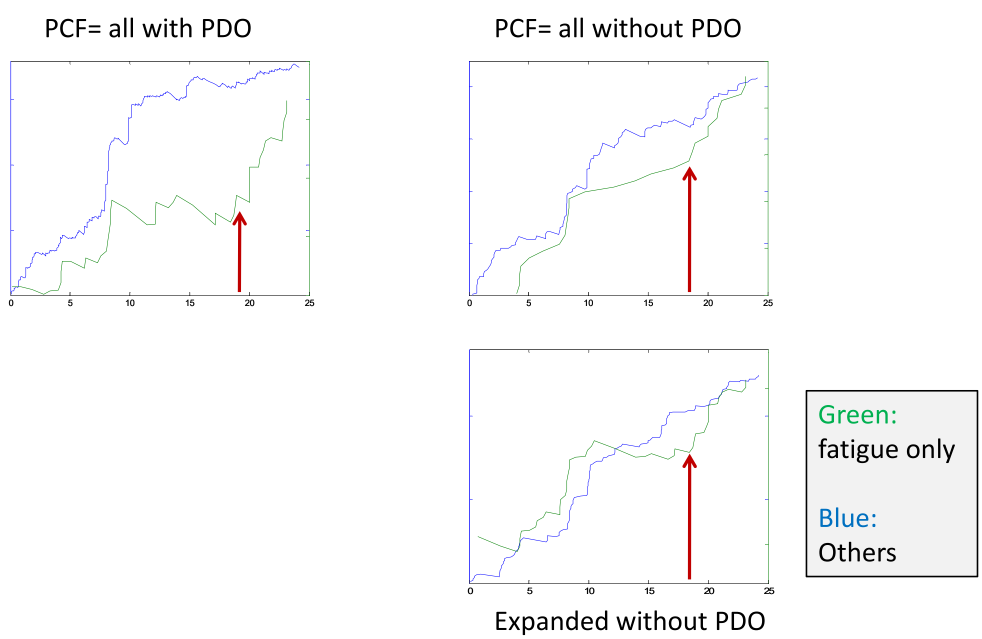
I-5

9. South Teh(10.5) to Gle(14.6)



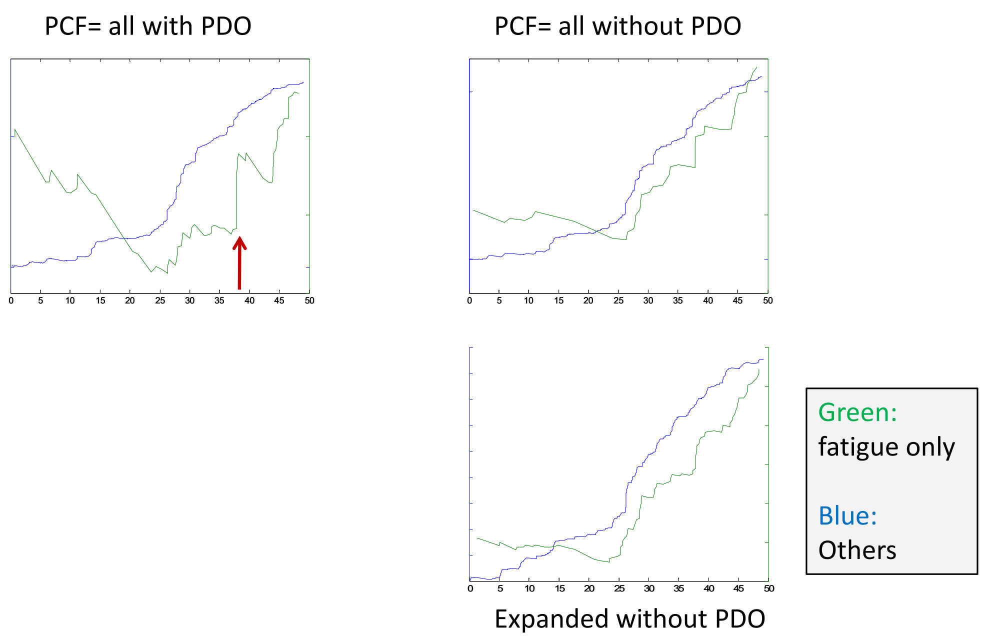
I-5

10. South Teh(34.7) to Teh(10.5)



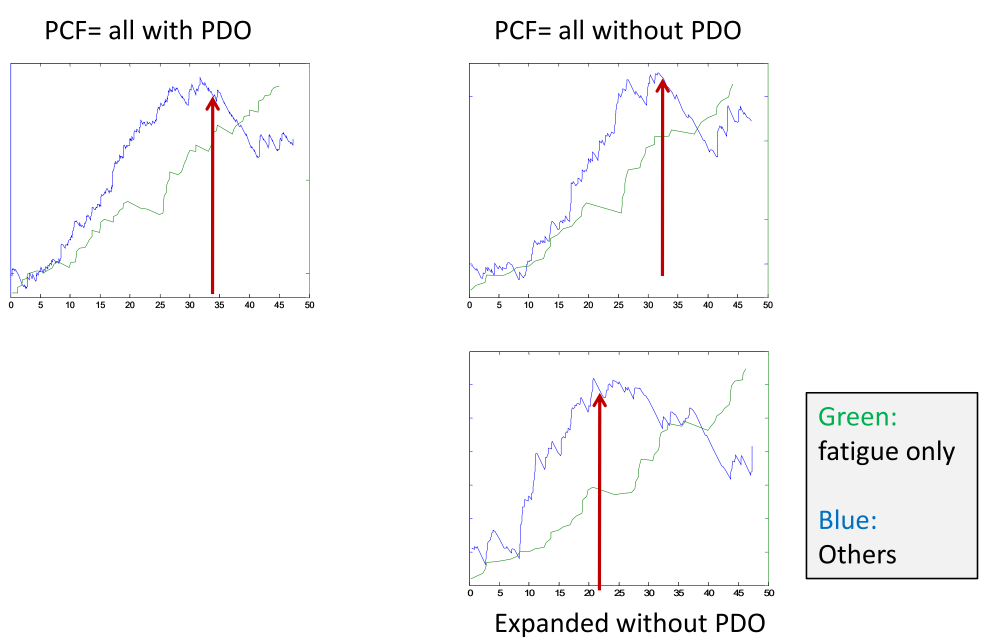
I-5

11. South Sha(43.2) to Teh(34.7)



I-5

12. South Sis(25.6) to Sha(43.2)



I-5

13. South Sis(58.4) to Sis(25.6)

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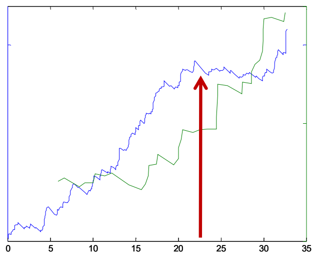

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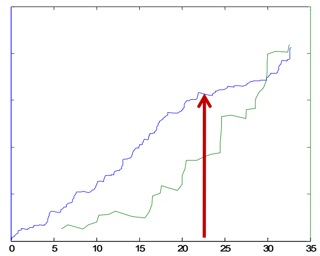
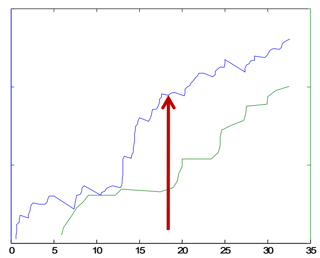




Expanded without PDO

Green: fatigue only

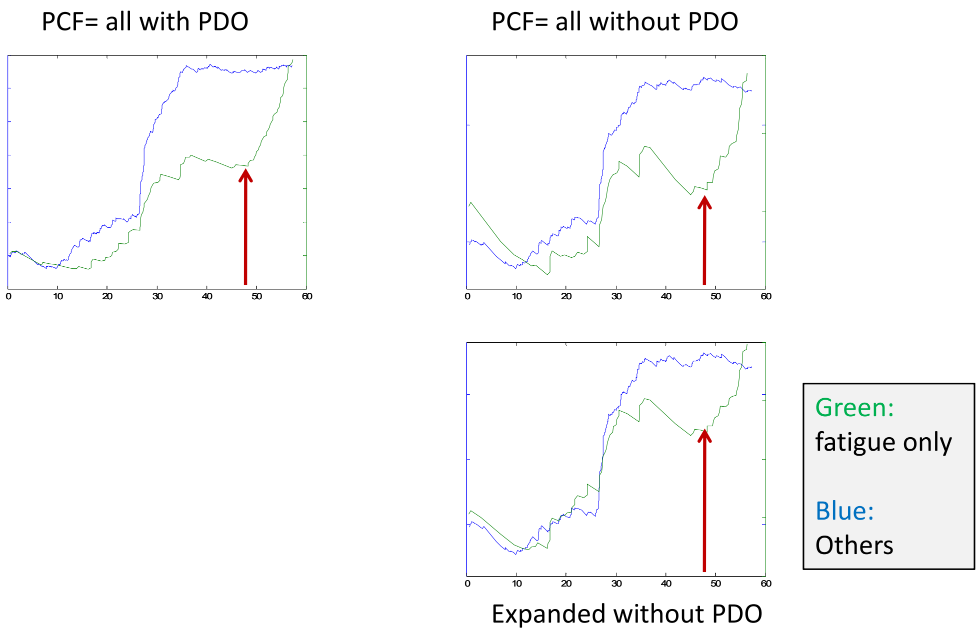
Blue: Others

I-5

A4.3 I-8 Eastbound

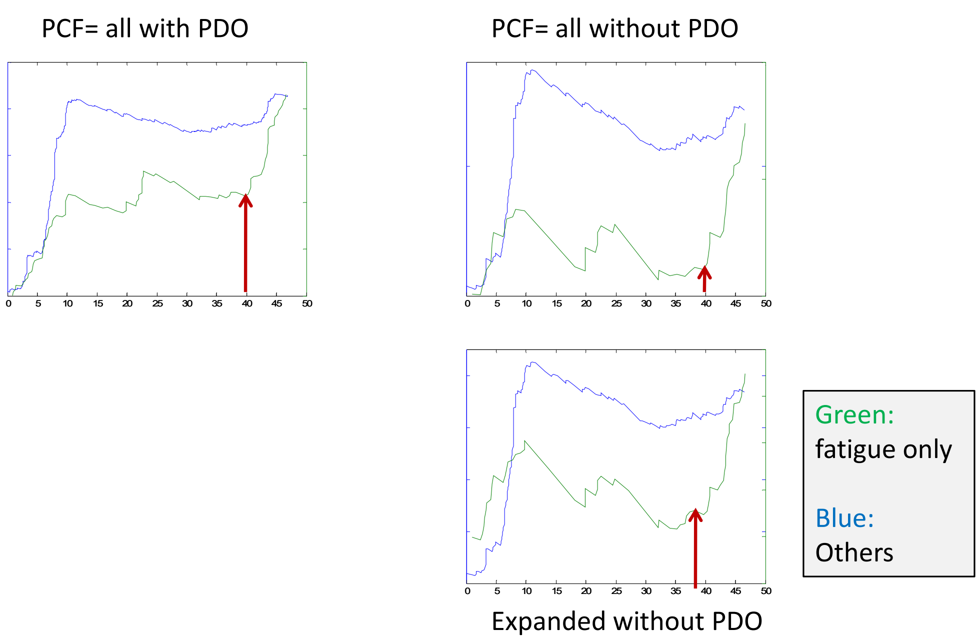
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops s*	Rest Area
11	SD	49	50.9	*57.3*	Buckman Springs
11	Imp	31.2	108.2	*46.9*	Sunbeam

1. East SD(49) to Imp(31.2)



I-8

2. East Imp(31.2) to Imp(80.2)



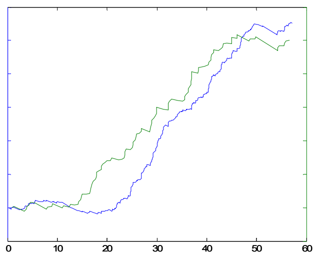
I-8

A4.4 I-8 Westbound

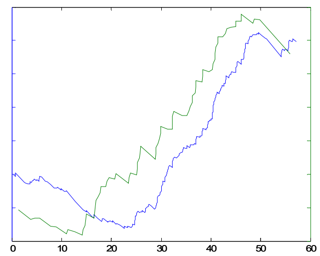
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
11	Imp	31.2	108.2	*57.3*	Sunbeam
11	Imp	80.2	155.1	*46.9*	Sand Hills

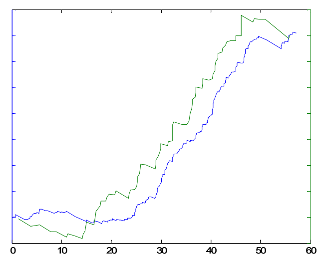
1. West Imp(31.2) to SD(49)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

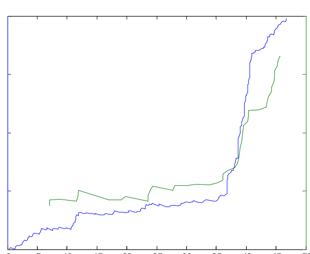
Green: fatigue only

Blue: Others

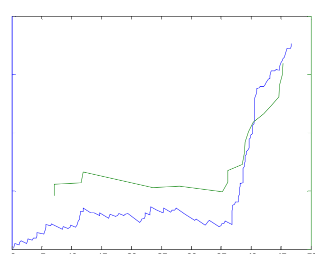
I-8

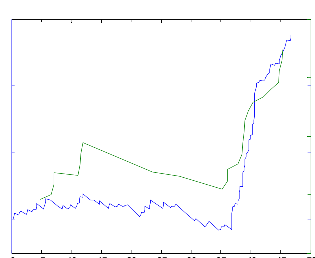
2. West Imp(80.2) to Imp(31.2)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

Green: fatigue only

Blue: Others

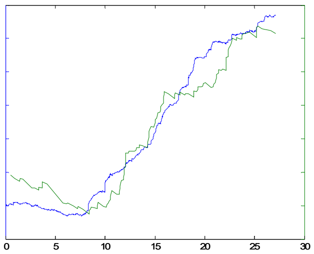
I-8

A4.5 I-10 Eastbound

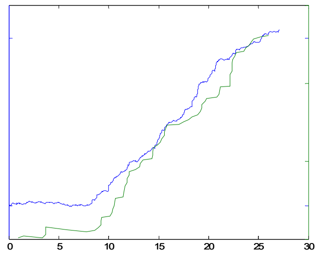
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
				27.1	
				44.8	
8	Riv	71.8	156.9	63.1	Cactus City

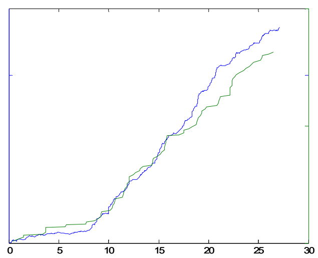
1. East Sbd(38.2) to Riv(26.2)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

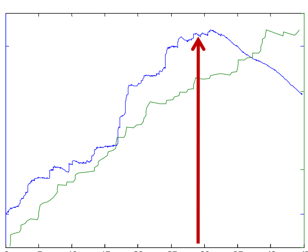
Green: fatigue only

Blue: Others

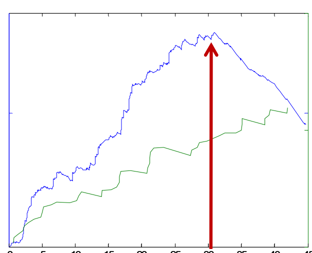
I-10

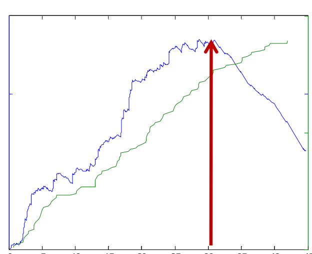
2. East Riv(26.2) to Riv(71.8)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

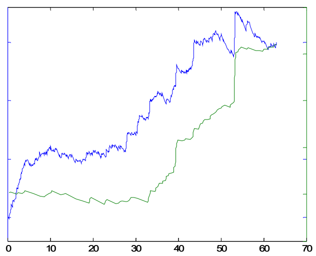
Green: fatigue only

Blue: Others

I-10

2. East Riv(71.8) to Riv(134.9)

PCF= all with PDO



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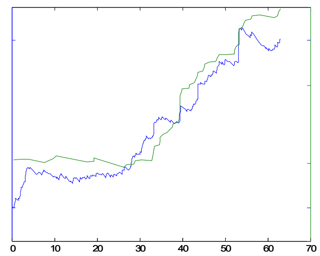
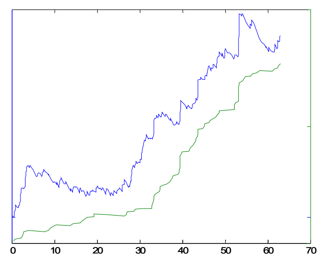




Expanded without PDO

Green: fatigue only

Blue: Others

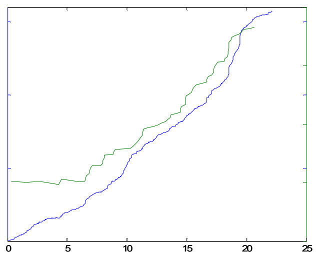
I-10

A4.6 I-10 Westbound

District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
				22.2	
8	Riv	71.8	156.9	44.8	Cactus City

1. West Riv(26.2) to Riv(4)

PCF= all with PDO



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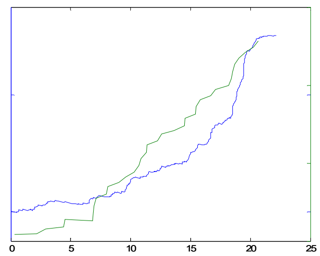
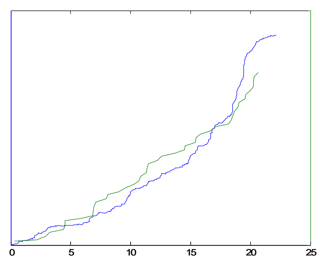




Expanded without PDO

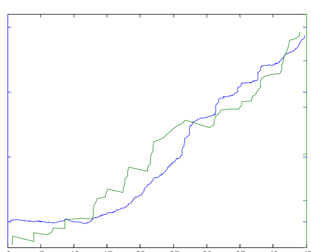
Green: fatigue only

Blue: Others

I-10

2. West Riv(71.8) to Riv(26.2)

PCF= all with PDO



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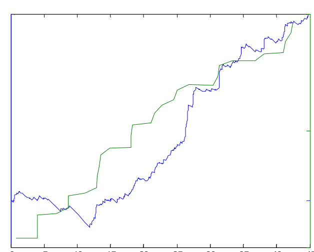
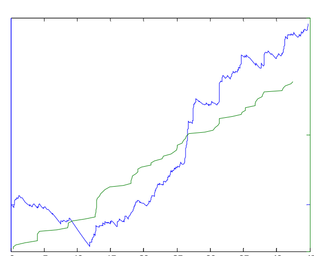




Expanded without PDO

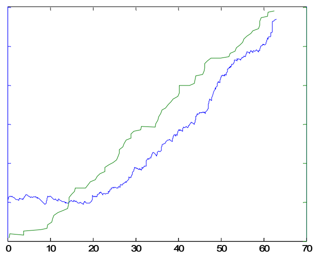
Green: fatigue only

Blue: Others

I-10

3. West Riv(134.9) to Riv(71.8)

PCF= all with PDO



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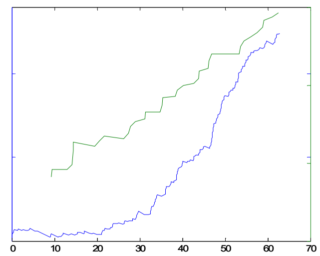
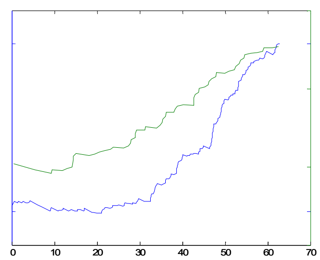




Expanded without PDO

Green: fatigue only

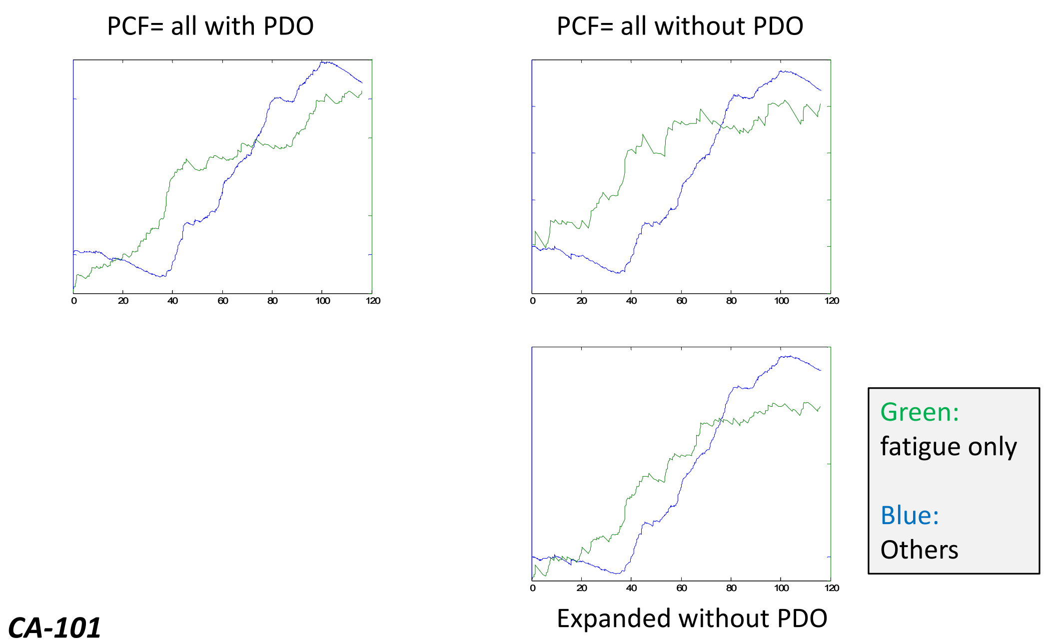
Blue: Others

I-10

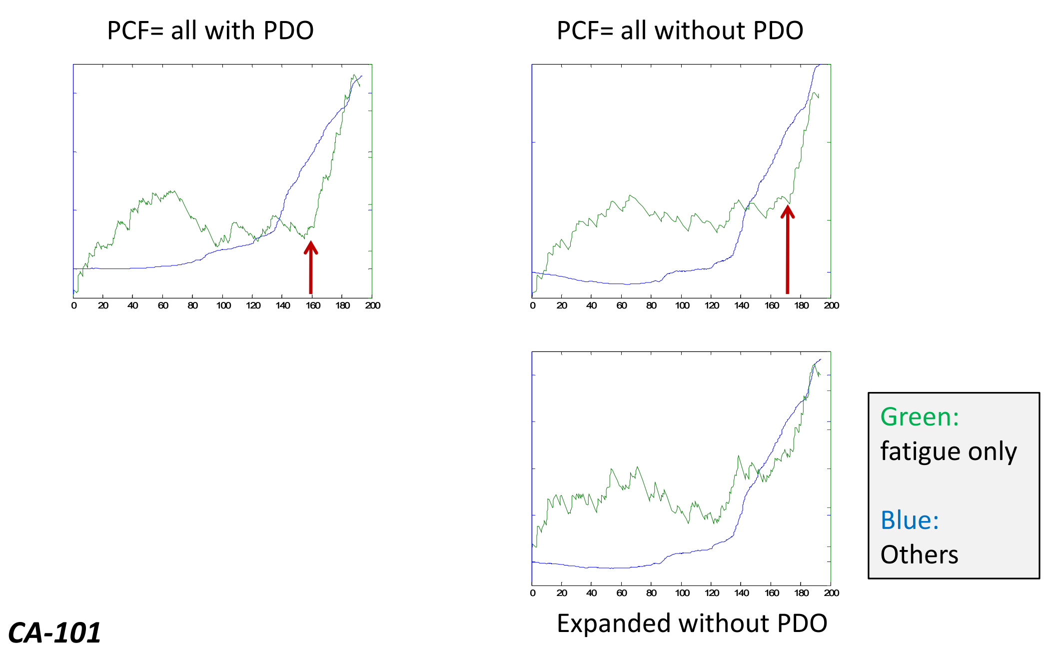
A4.7 CA-101 Northbound

District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
5	SB	46.9	129.6	*116.3*	Gaviota
5	Mon	3.1	245.9	*193.9*	Camp Roberts
4	Mar	0.0	439.8	*145.4*	H. Dana Bowers
1	Men	61.5	585.3	*21.0*	Irvine Lodge
1	Men	82.5	606.2	*126.5*	Empire Camp

1. North SB(46.9) to Mon(3.1)

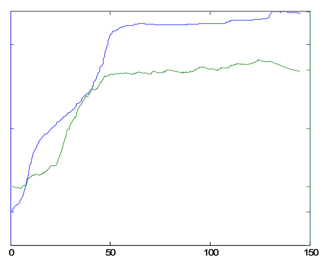


2. North Mon(3.1) to Mar(0)

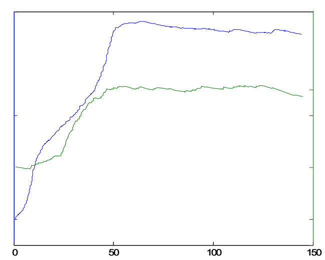


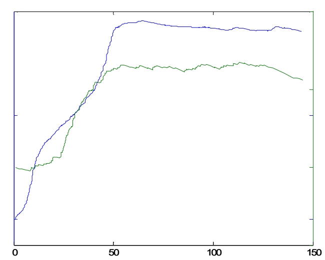
3. North Mar(0) to Men(61.5)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

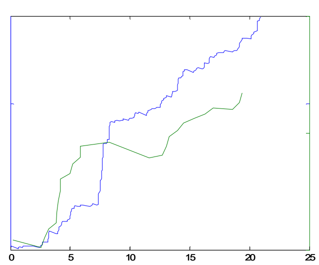
Green: fatigue only

Blue: Others

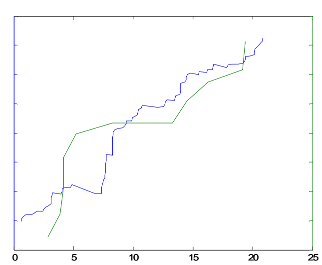
CA-101

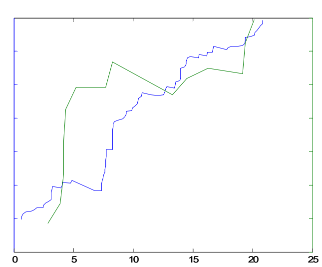
4. North Men(61.5) to Men(82.5)

PCF= all with PDO



PCF= all without PDO





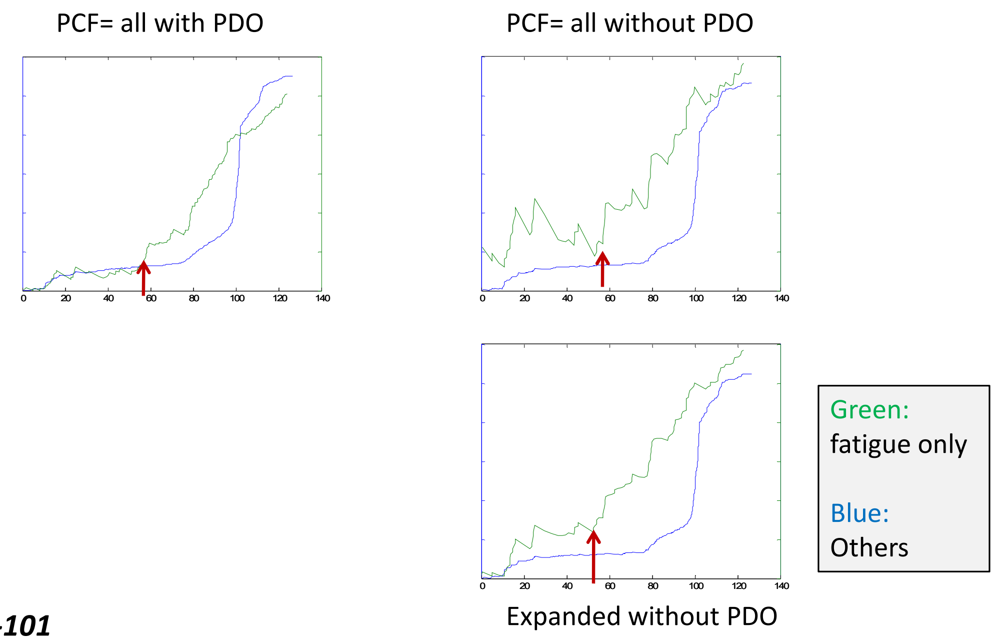
Expanded without PDO

Green: fatigue only

Blue: Others

CA-101

5. North Men(82.5) to Hum(105.9)



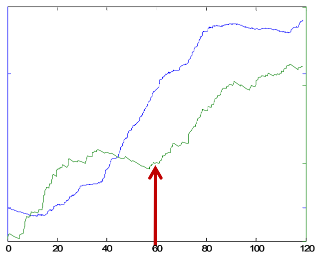
CA-101

A4.8 CA-101 Southbound

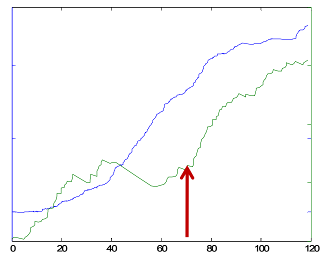
District	County	Postmile	ABS_postmile	*Distance Between Rest Stops*	Rest Area
5	Mon	5.1	247.9	*118.9*	Camp Roberts
1	Men	58.9	582.7	*334.8*	Moss Cove
1	Hum	105.2	732.0	*149.4*	Trinidad

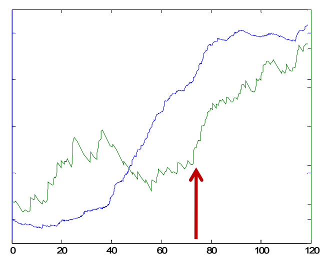
1. South Mon(5.1) to SB(46.3)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

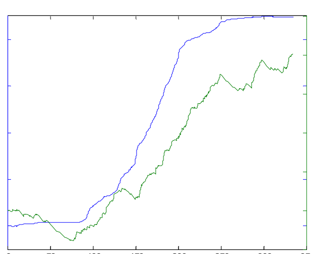
Green:
fatigue only

Blue:
Others

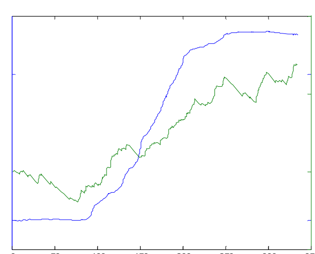
CA-101

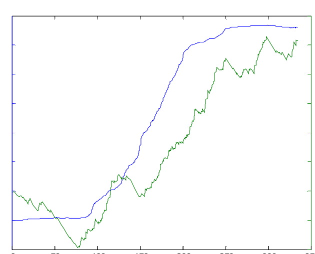
2. South Men(58.9) to Mon(5.1)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

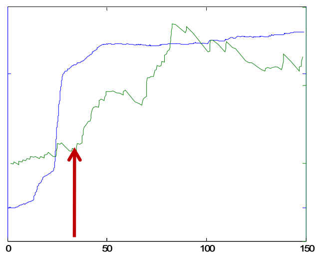
Green:
fatigue only

Blue:
Others

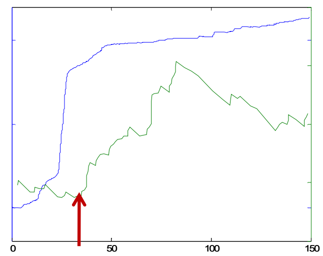
CA-101

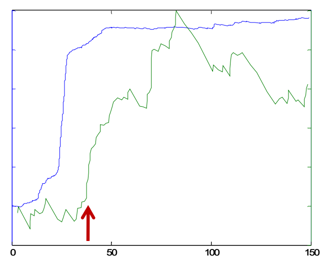
3. South Hum(105.2) to Men(58.9)

PCF= all with PDO



PCF= all without PDO





Expanded without PDO

Green: fatigue only

Blue: Others

CA-101

APPENDIX 5: FATIGUE RAMP ANALYSIS

The ramp analysis studied ramp collisions on I-5, using TASAS 1994 - 2004 data. In the analysis, the quantity and characteristics of collisions on on- and off-ramps connected to rest areas were compared with data for other ramps on I-5. Highway collisions were not included in this analysis. This analysis did not include collisions in Districts 7, 11 and 12 (LA, SD and ORA).

A5.1 Intersection/Ramp Accident Location (IRL)

TASAS data uses the following code for Intersection/Ramp Accident Location. Any collision within 50 feet from the entrance of a ramp was marked "ramp entry collision" and was labeled as IRL #3. Location of IRL#3 is schematically represented in Figure 1.

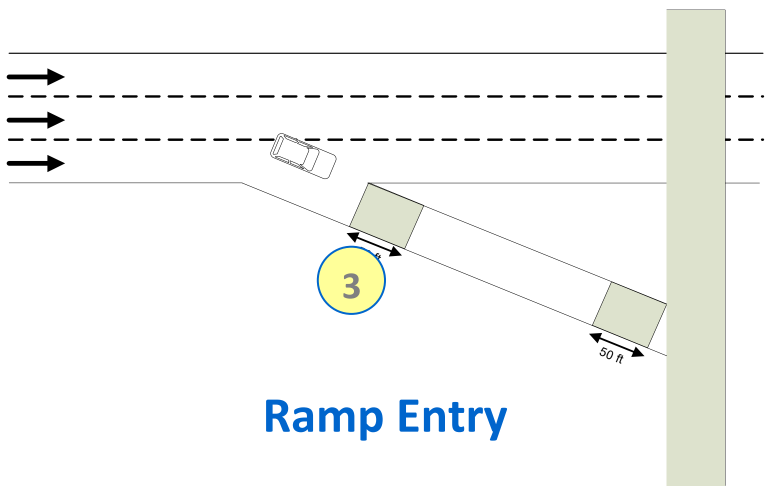


Figure A5.1: Locations of Collisions Marked IRL #3 or Ramp Entry Collisions

All collisions located on the ramp, but not within 50 feet of either the entrance or the exit of the ramp were marked "ramp collision" and labeled as IRL #2. Collision type IRL #2 is represented in Figure 2.

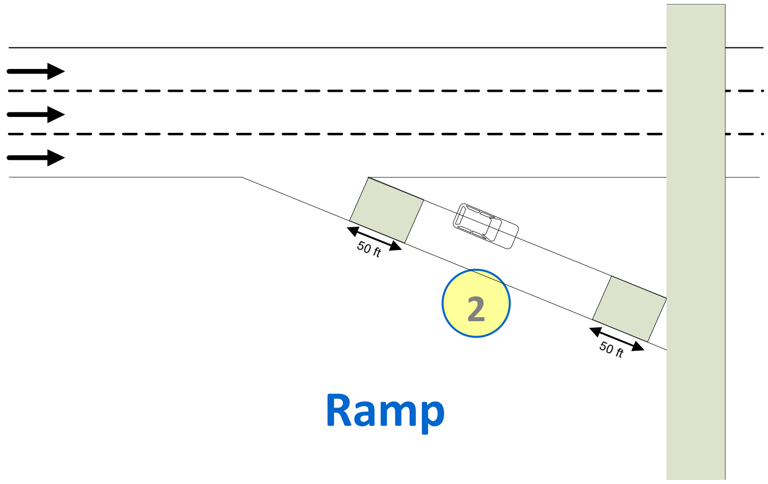


Figure A5.2: Location of Collisions Marked IRL #2 or Ramp Collisions

Those collisions that are located within 50 feet of the ramp exit are marked as "ramp intersection (exit) collisions" and are labeled as IRL #1. This is shown in Figure 3.

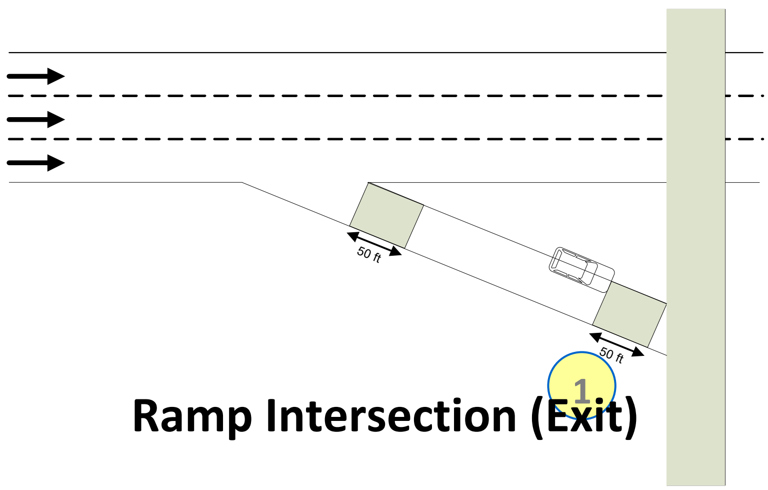


Figure A5.3: Location of Collisions Marked IRL #1 or Ramp Intersection (Exit) Collisions

Collisions located on the highway at its junction with the ramp are called "ramp area intersection area collisions" and are labeled IRL #4. As will be presented in the subsequent analysis, these collisions comprise a major share of ramp collisions and have different characteristics compared with collisions at other locations on the ramps. Such locations include rest area parking lots, resulting in a substantial increase in collisions related to rest area parking activities in. Figure 4 shows the location of these collisions.

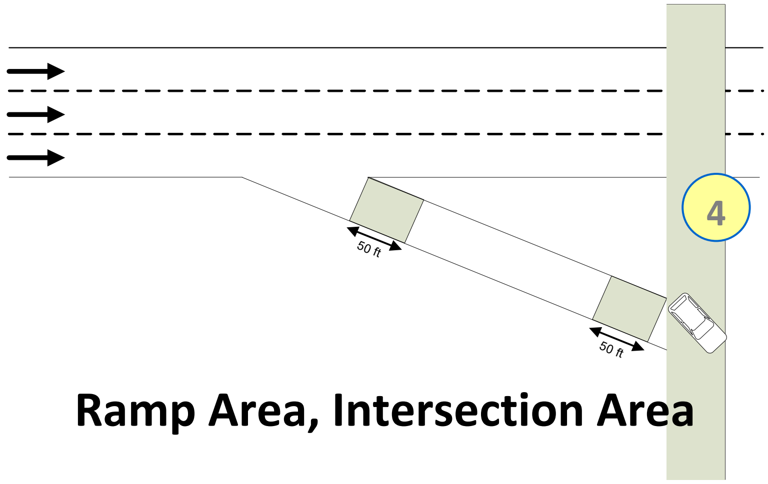


Figure A54: Location of Collisions Marked IRL #4 or Ramp Area Intersection Area Collisions

Table 1 summarizes collisions on ramps connected to rest areas as well as those that are not adjacent to rest areas. As there are fewer ramps that are connected to rest areas, the total number of collisions on ramps connected to rest areas is lower compared with the total number of collisions on other ramps. However, the number of collisions per ramp for ramps connected to rest areas, 4.4, is 65% of the total number of collisions per ramp for all other ramps, 6.8.

On removal of IRL=4 collisions, the number of collisions per ramp on the rest area ramps drops to 1.0, i.e. becomes 23% of the number of collisions per ramp for all the other ramps, 4.3.

Table A5.1: Summary of Collisions on Ramps Connected to Rest Areas and All Others

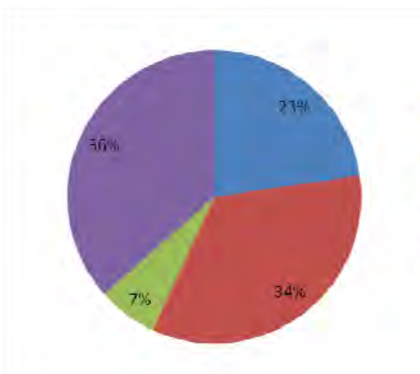
	Others	**Rest-Areas**
Total # of Collisions	5641	367
Total # of Ramps	826	83
Collision per Ramp	6.8	4.4
Total # of Collisions except IRL=4	3580	84
Collision per Ramp except IRL=4	4.3	1.0

A5.2 Comparative Analysis

The characteristics of collisions on ramps connected to rest areas (rest area ramp collisions) and those on ramps not adjacent to rest areas ('other' ramp collisions) were compared. The characteristics were found to differ considerably when IRL=4 collision type (collisions within the parking lots of rest areas) were removed.

Analysis of ramp collisions by difference in location revealed that 77% of the rest area ramp collisions and 36% of the 'other' ramp collisions were found to be IRL=4 (collisions within the parking lots of rest areas). The results indicate that many collisions in rest areas took place in their parking lots. This was followed by 34% of the 'other' ramp collisions being IRL=2, compared with 15% of the rest area ramp collisions. Ramp exit collisions, IRL=1, were next in percentage contribution, and the lowest percentage of collisions were those located at the ramp entry, IRL=3.

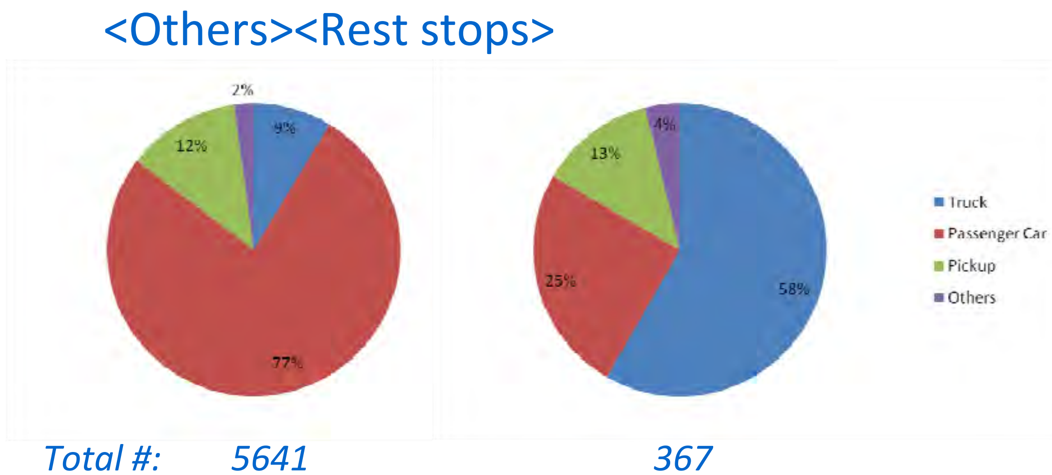
<Others><Rest stops>



Total #: *5641* *367*

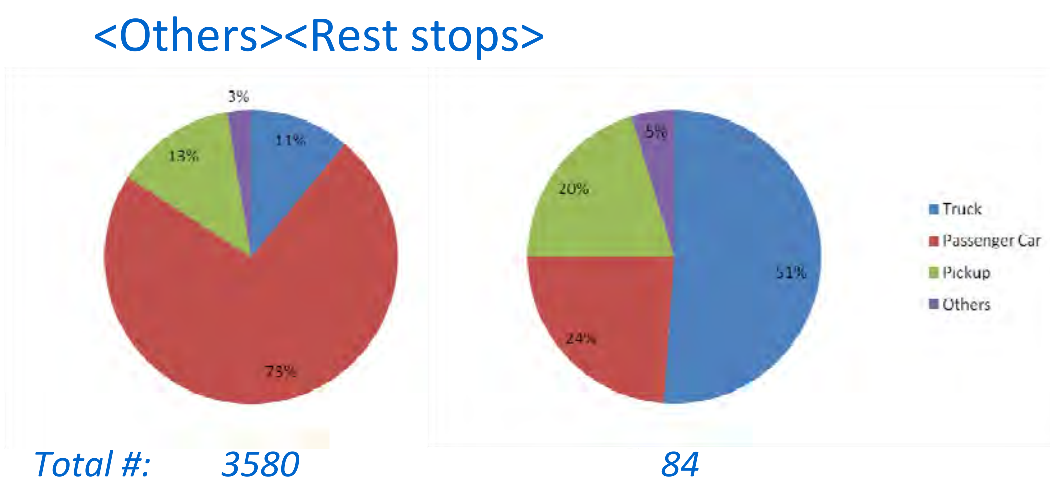
A5.3 Vehicle Type

An analysis of vehicle types found that the largest share (58%) of rest area ramp collisions involved trucks, compared with the largest share (77%) of the 'other' ramp collisions, which involved passenger cars. Only 25% of rest stop ramp collisions involved passenger cars and only 9% of the 'other' ramp collisions involved trucks. The percentage of collisions that involved pickup trucks and other vehicles was approximately the same for both ramp types.



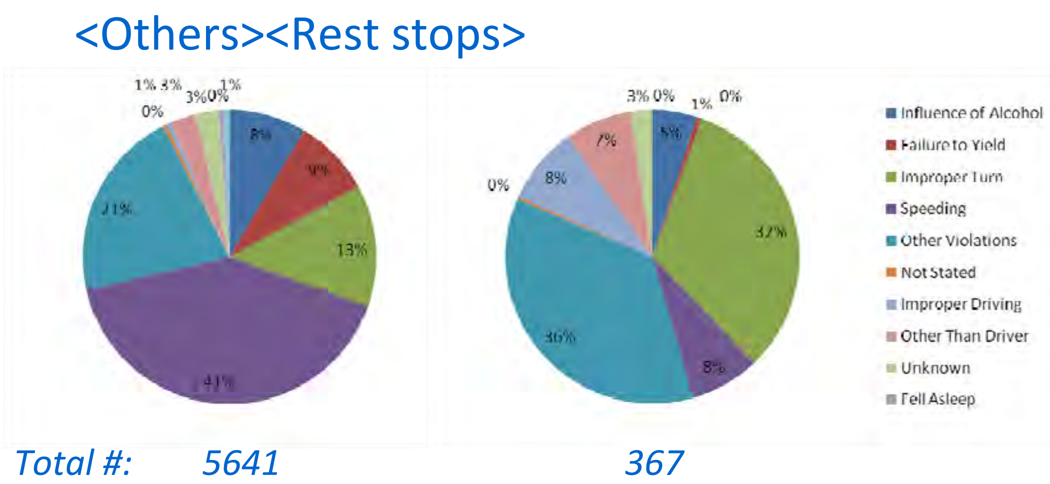
A5.4 Vehicle Type Excluding IRL=4

A collision analysis of vehicle types, excluding the collisions at IRL=4, found that the percentage of truck collisions at rest stop ramps decreased along with a proportional increase in the percentage of pickup truck collisions. For ‘other’ ramp collisions, a reduction in the percentage of passenger car collisions is offset by an increase in all the other categories.



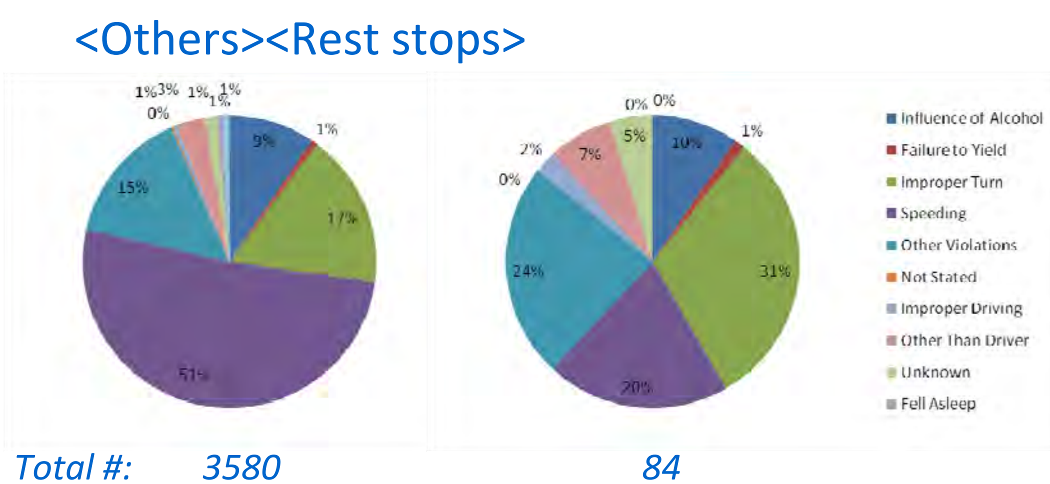
A5.5 Primary Collision Factor

Speeding constituted the largest share (41%) of ‘other’ ramp collisions, followed by ‘other violations’ (21%) and improper turns (13%). For rest stop ramp collisions, the largest share was ‘other violations’ (36%), followed by improper turns (32%). It is theorized that other violations and improper turns in rest areas are related to parking activities. Speeding constituted a mere 8%.



A5.6 Primary Collision Factor Excluding IRL=4

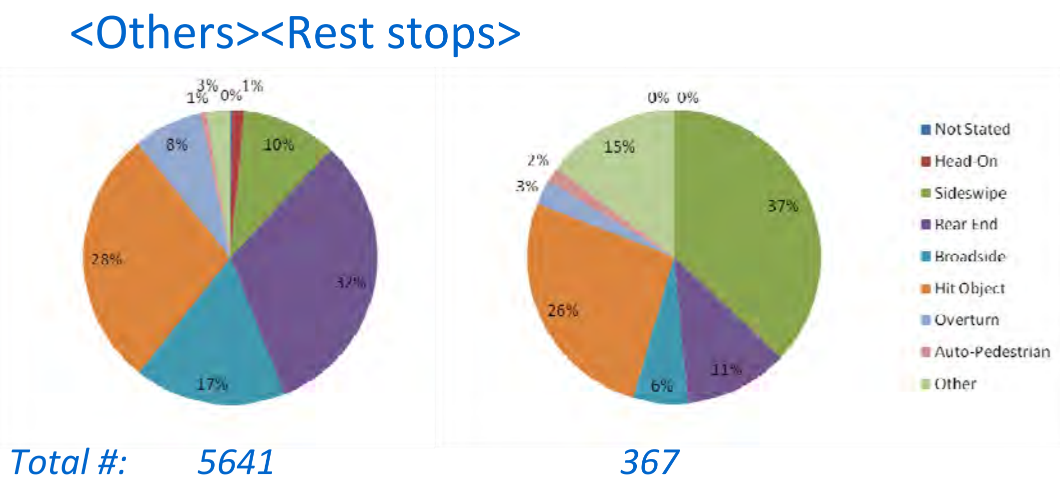
When IRL=4 collisions were removed from the analysis, it was found that for rest stop collisions the percentage of 'other violations' was reduced to 24%, which was offset by an increase in speeding-related collisions to 20%. There were minor variations in the other categories, including a decrease in improper driving as the primary collision factor, from 8% to 2%. In this analysis, improper turns (31%) were the most likely cause of rest stop ramp collisions.



For other ramp collisions, an increase in the percentage of collisions due to speeding and improper turns were offset by a reduction in the percentage of other violations and of failure to yield, among others. Speeding remained the single most likely cause of collisions on 'other' ramps.

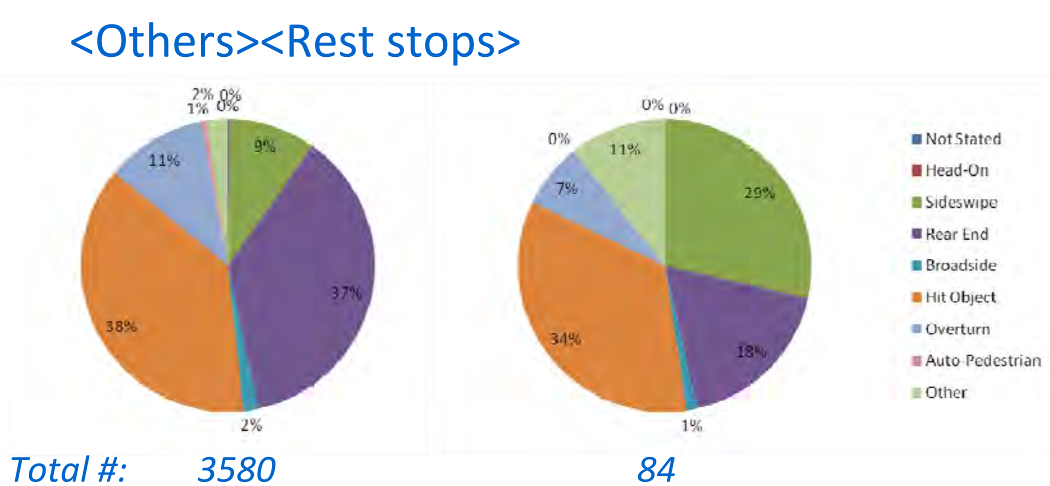
A5.7 Type of Collision

The largest share (37%) of rest stop ramp collisions was of the ‘sideswipe’ type, followed by ‘hit object’ (26%) and ‘other’ (15%). Of the ‘others’ ramp collisions, the largest share were rear-end collisions (32%), followed by ‘hit object’ (28%) and ‘broadside’ collisions (17%). A higher percentage of sideswipe collisions in rest areas indicates that collisions in these locations are related to parking activities.



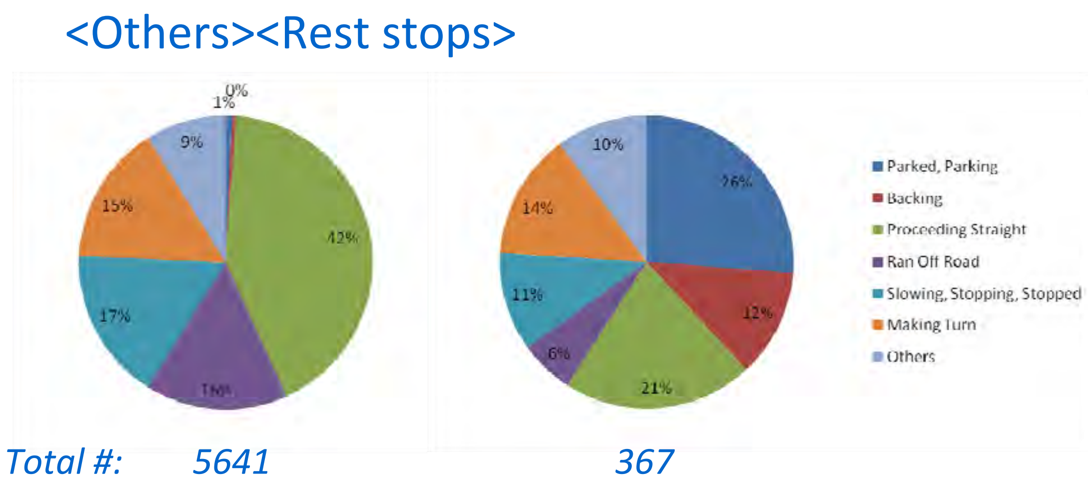
A5.8 Type of Collision Excluding IRL=4

When IRL=4 collisions were removed, there was an increase in the percentage of ‘hit object’ in rest stop ramp collisions, from 26% to 34%. The percentage of sideswipe collisions decreased to 29%, and rear end collisions increased to 18%. Percentages of collisions of all other types decreased except for an increase in ‘overturn’ collisions. For the ‘others’ ramp collisions, both the share of ‘hit object’ and ‘rear end’ collisions increased, with ‘hit object’ contributing the largest share. There was a substantial decrease in ‘broadside’ collisions, since the possibility of broadside collisions within the ramp, in absence of any intersection with the highway, is very limited.



In the ‘other’ ramp collisions, there was an even greater reduction in the proportion of ‘broadside’ collisions (2%). This was offset by an increase in the ‘hit object’ collisions (38%) and the ‘rear end’ collisions (37%), with ‘hit objects’ being the largest category similar to rest stop ramp collisions.

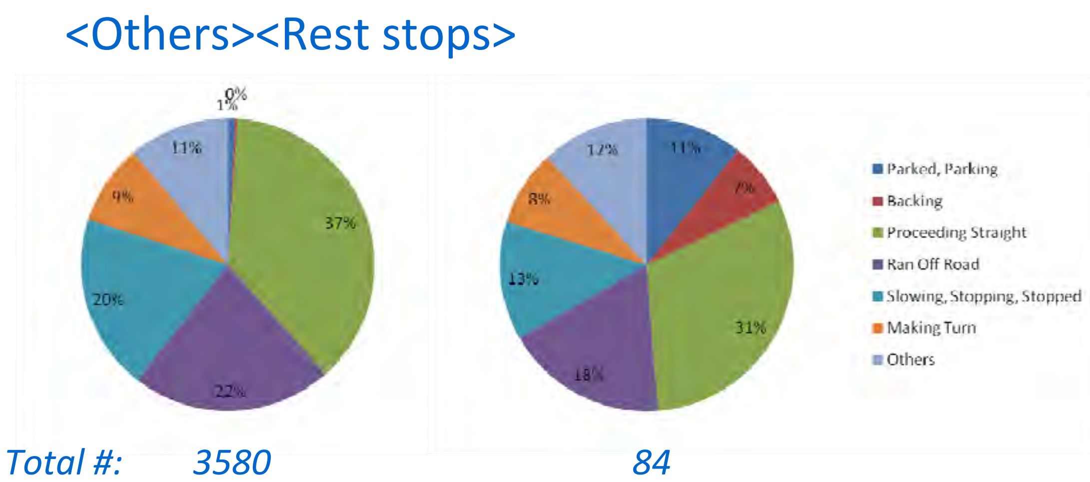
A5.9 Movement



The largest share of rest stop ramp collisions involved ‘parked or parking’ vehicles, as shown in previous figures. This was followed by 21% ‘proceeding straight’ and then 14% ‘making turn’. In the ‘others’ ramp collisions, ‘proceeding straight’ movement contributed a very large share (42%) to all collisions. This was followed by ‘slowing, stopping, or stopped’ (17%) and ‘ran off road’ (16%).

A5.10 Movement Excluding IRL=4

In the rest stop ramp collisions, there was an increase in the percentages of ‘proceeding straight’ (31%), ‘ran off road’ (18%), ‘slowing, stopping, stopped’ (13%) and ‘others’ (12%). There was a reduction in the percentages of ‘parked, parking’ (11%), ‘backing’ (7%), and ‘making turn’ (8%), because IRL=4 indicate parking lots in rest areas. ‘Proceeding straight’ was now the largest category. In the ‘others’ ramp collisions the percentage of ‘proceeding straight’ reduced (37%) although ‘proceeding straight’ remains the largest category. There was also a reduction in the percentages of ‘making turns’ as a contributor to collisions. There was an increase in the percentage of ‘slowing, stopping, stopped’, ‘ran off road’, ‘others’ as a contributor to collisions. Note that collisions in the ramps of rest stops are still highly correlated to parking activities (parked, parking, backing) as compared to collisions in other ramps. This implies that some of rest stops are short of available parking spots, resulting in possible illegal parking activities in connected on/off-ramp areas.



A5.11 Conclusions

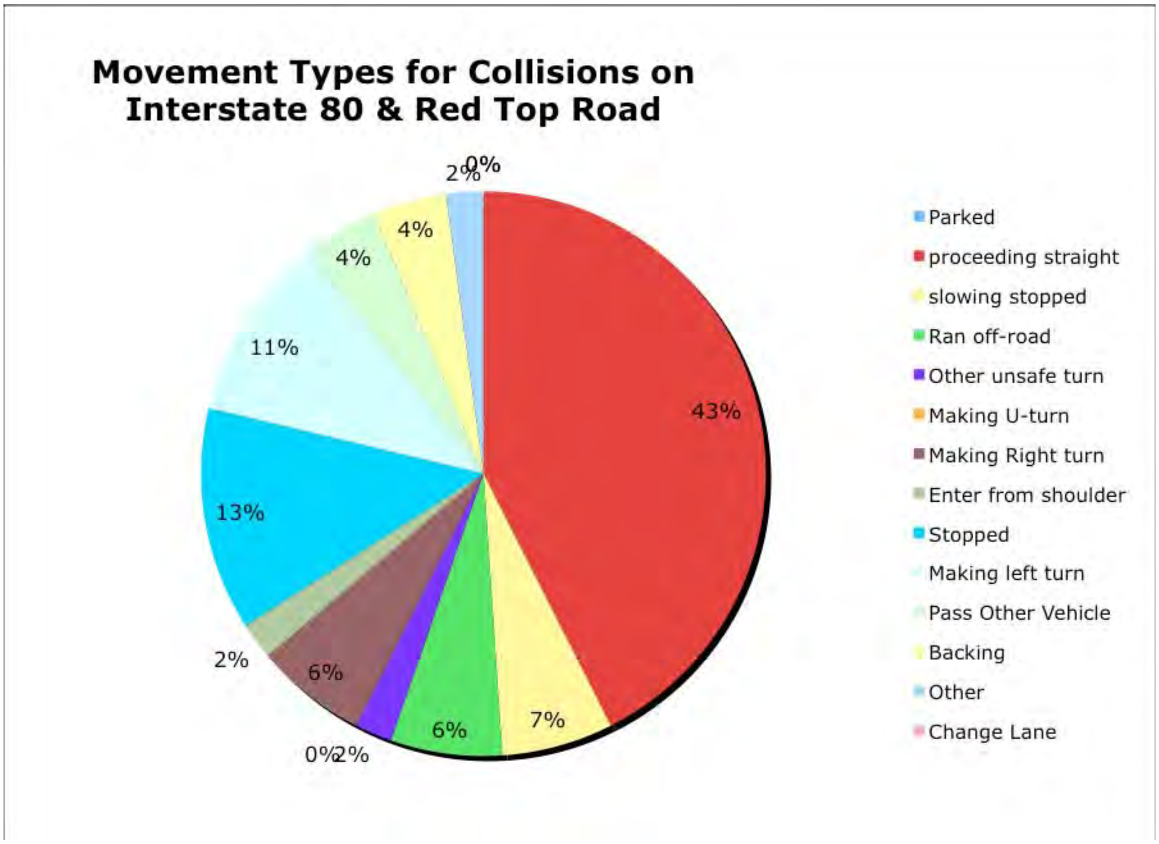
The rate of collisions on rest stop ramps was less as compared to the rate of collisions on other ramps. Ramp area intersection area, IRL=4, was the major location for rest stop ramp collisions and to a lesser extent ‘other’ ramp collisions, because IRL=4 indicate parking lots in case of rest areas. Trucks were the primary vehicle types involved in rest stop ramp collisions. The primary collision factor was ‘other’ violations and ‘improper turns’ were a close second. The primary type of collision was the ‘sideswipe’ collisions followed by the ‘hit object’ collisions. This order of importance was reversed when collisions at IRL=4 were removed from the data. ‘Parked, parking’ movement caused the maximum number of collisions. However, on removal of IRL=4, ‘proceeding straight’ movement causes the most collisions.

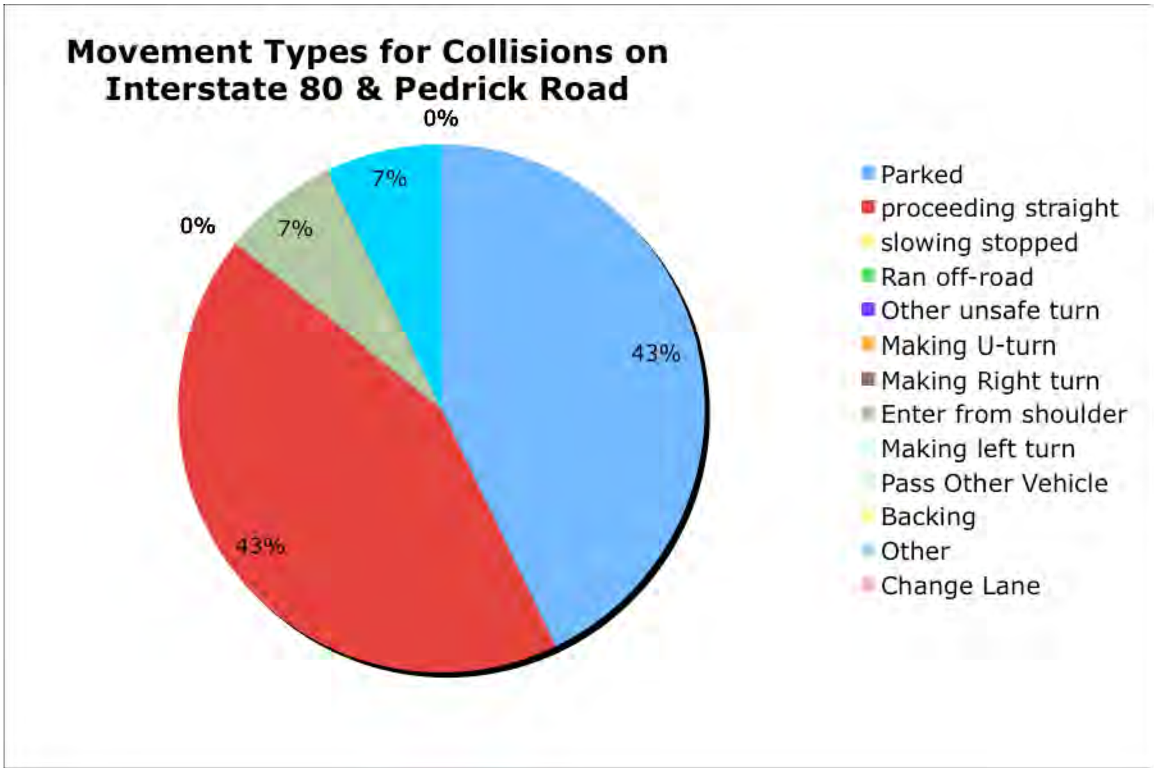
APPENDIX 6: INFORMAL TRUCK STOPS

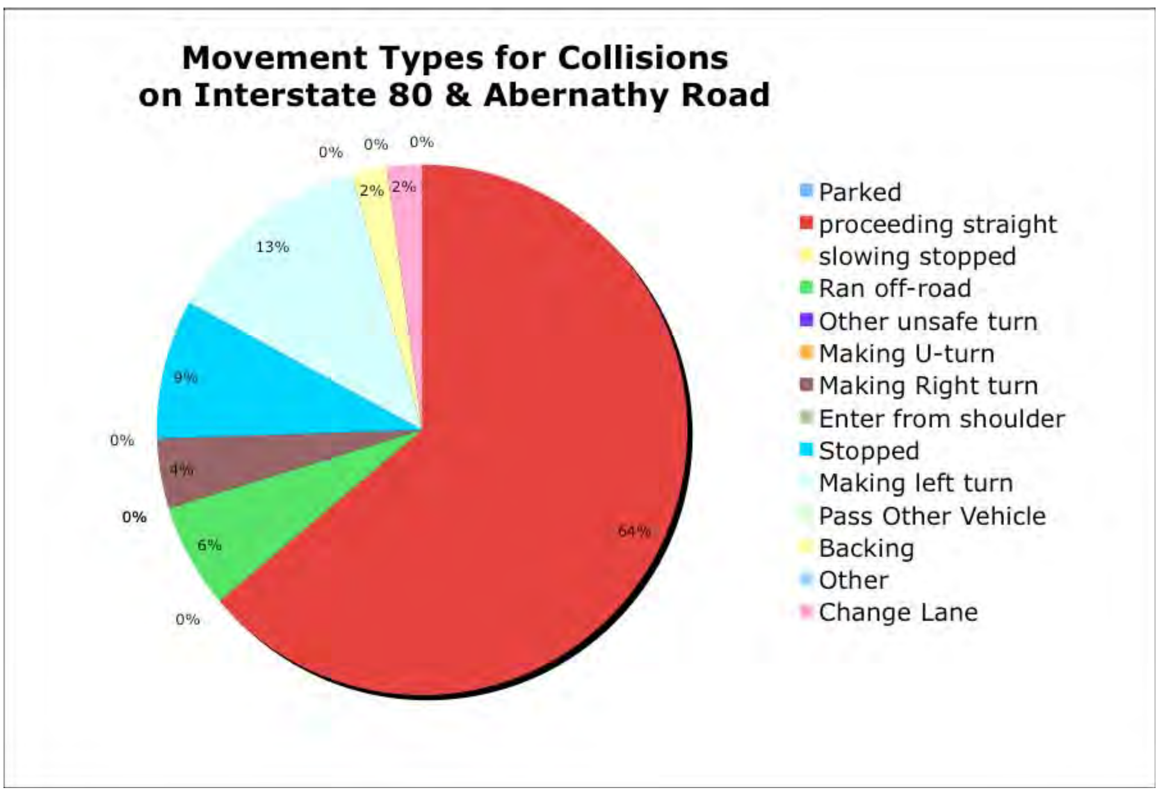
California Highway Patrol has compiled a list of locations, which, although not formally designated as rest stops, are used by truck drivers for that purpose. Large numbers of trucks are parked for extended periods on the ramps at these locations. In this section, the characteristics of ramp collisions and highway truck collisions in the vicinity of these ramps are analyzed.

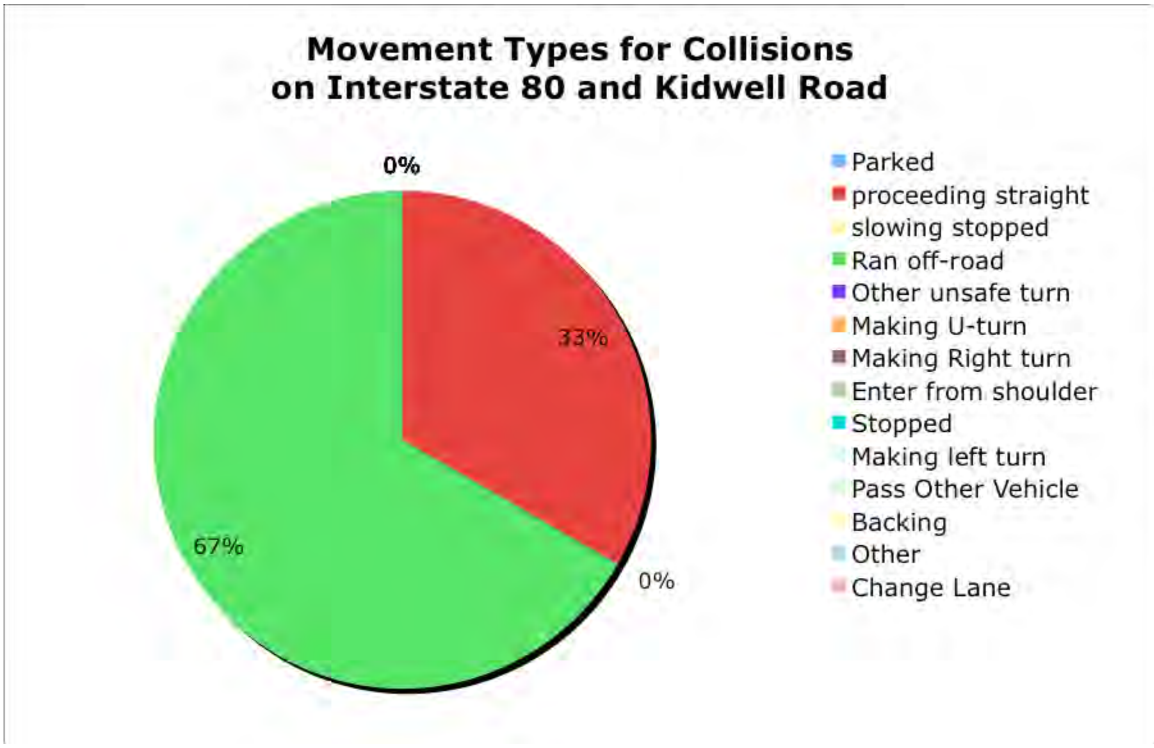
The following graphs in section A10.1 display the percentages of each of the different movement types at the time of collision for all nine ramps analyzed. Section A10.2 presents the distribution of collisions along the postmiles and a table summarizing the strict fatigue definition collision characteristics at the various designated and informal rest stops.

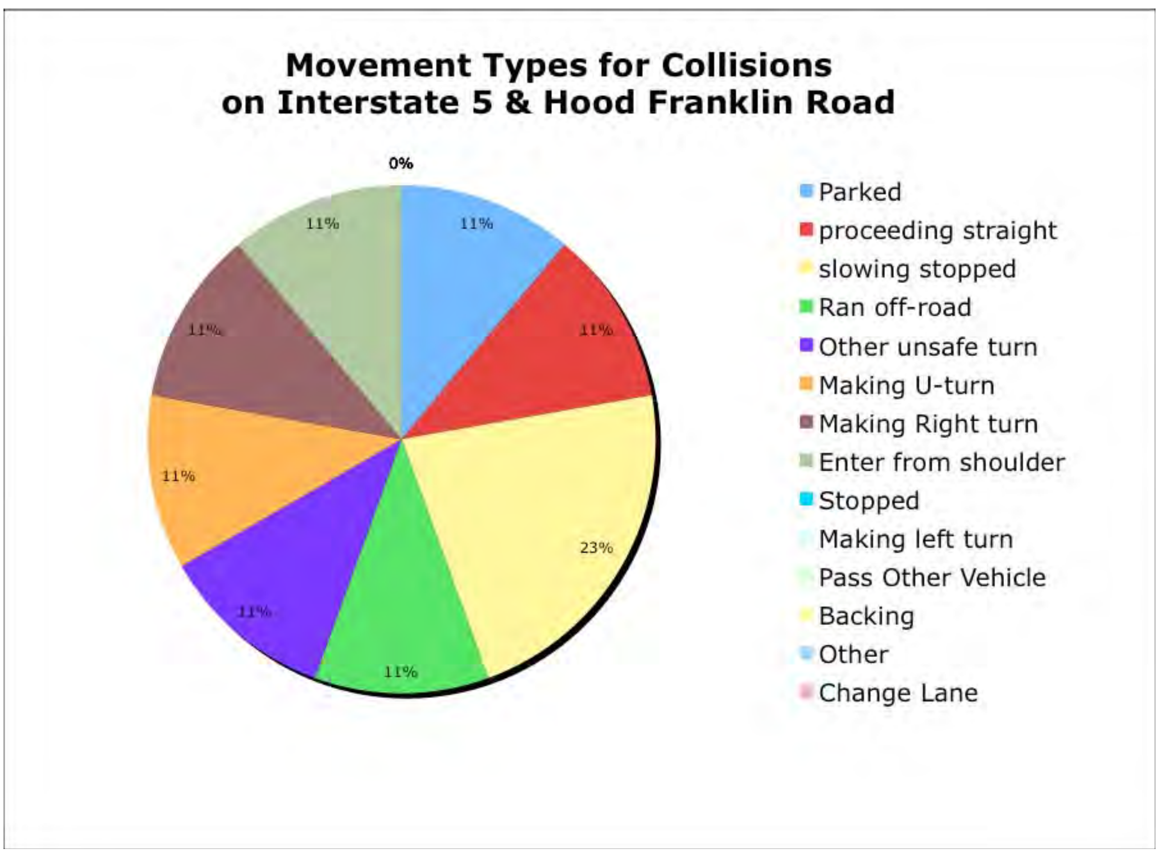
A6.1 Ramp Collisions

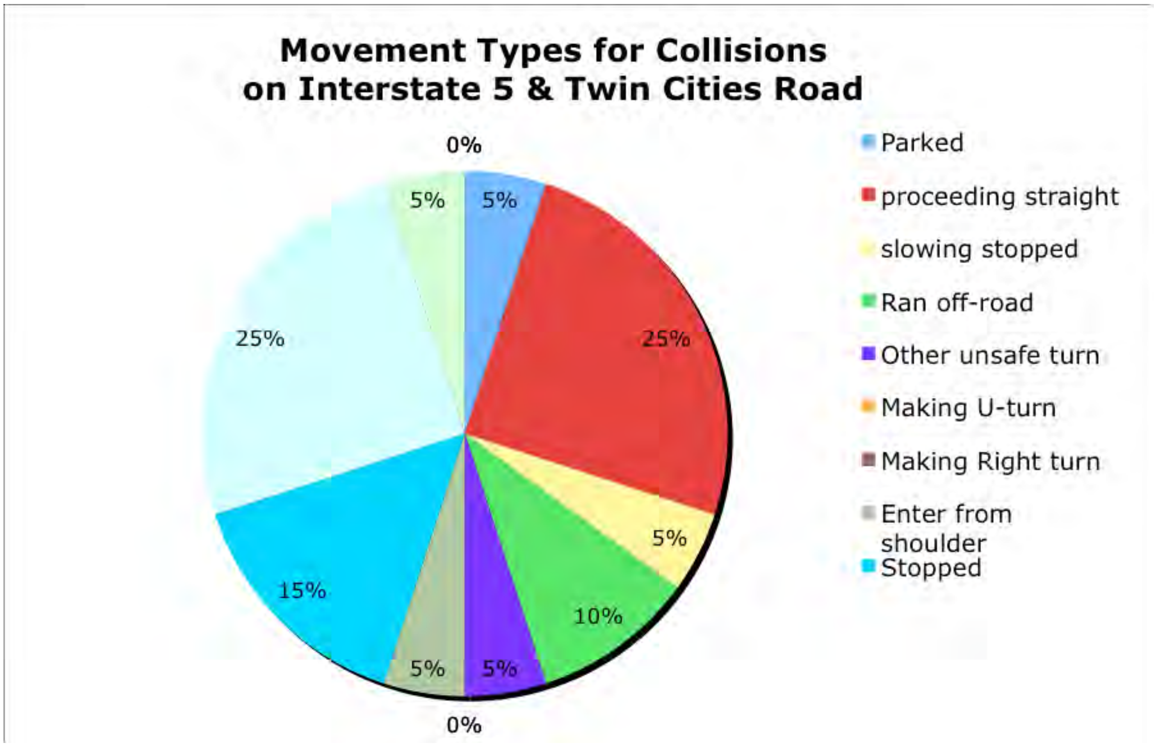


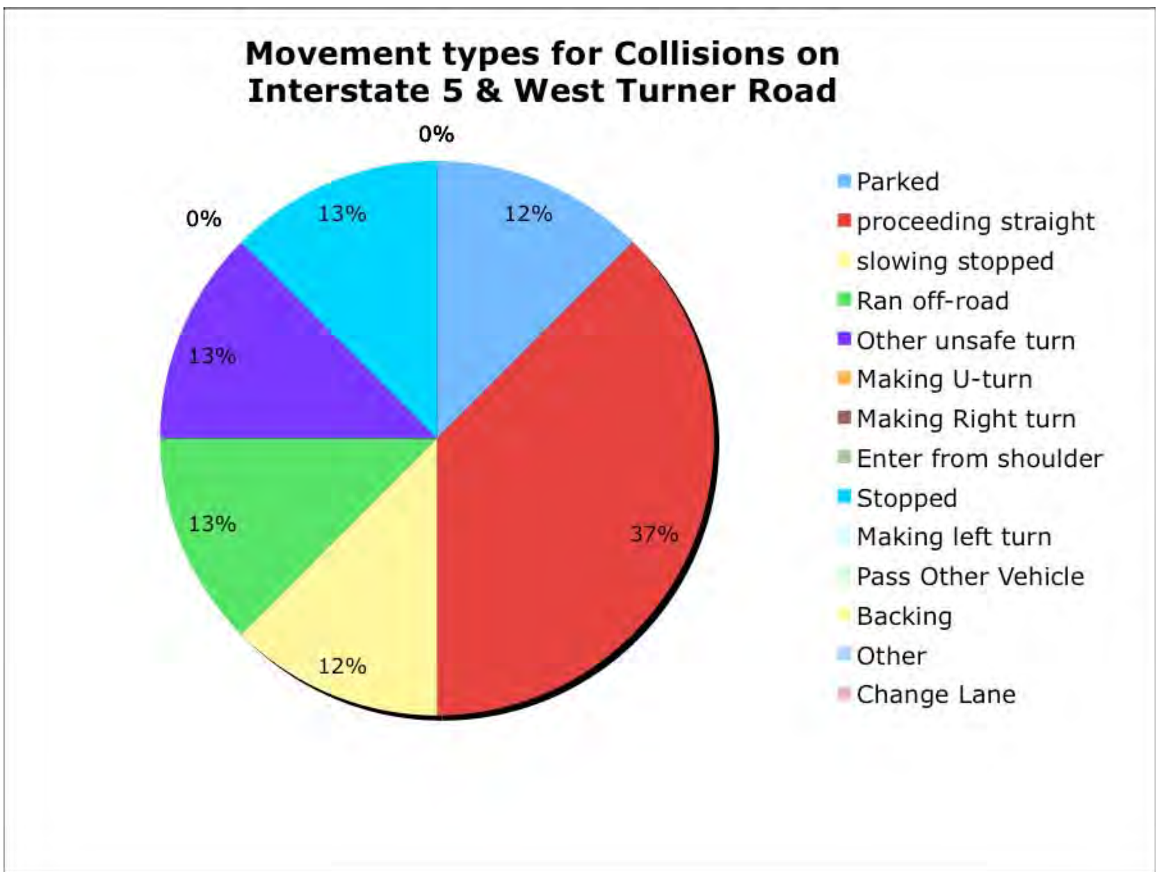

Movement Types for Collisions on Interstate 80 & Pedrick Road
0%
7%
0%
7%
43%
43%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane

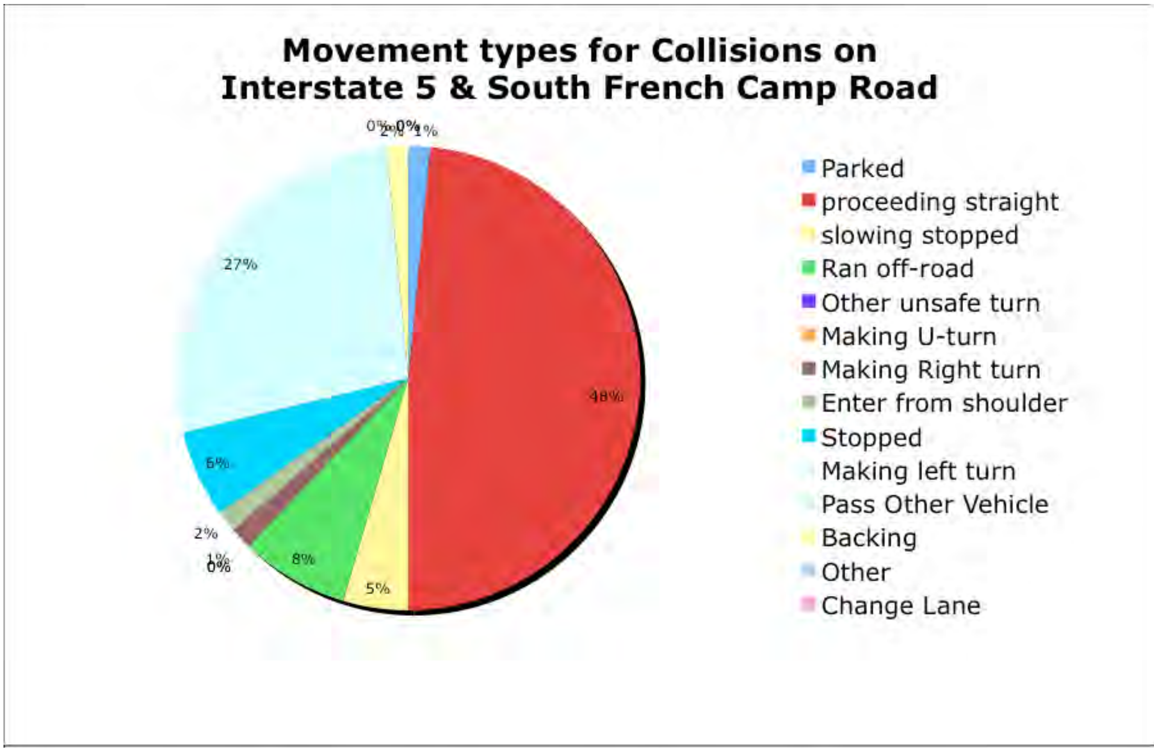

Movement Types for Collisions on Interstate 80 & Abernathy Road
0%
0%
0%
2%
2%
13%
9%
0%
4%
0%
6%
0%
64%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane

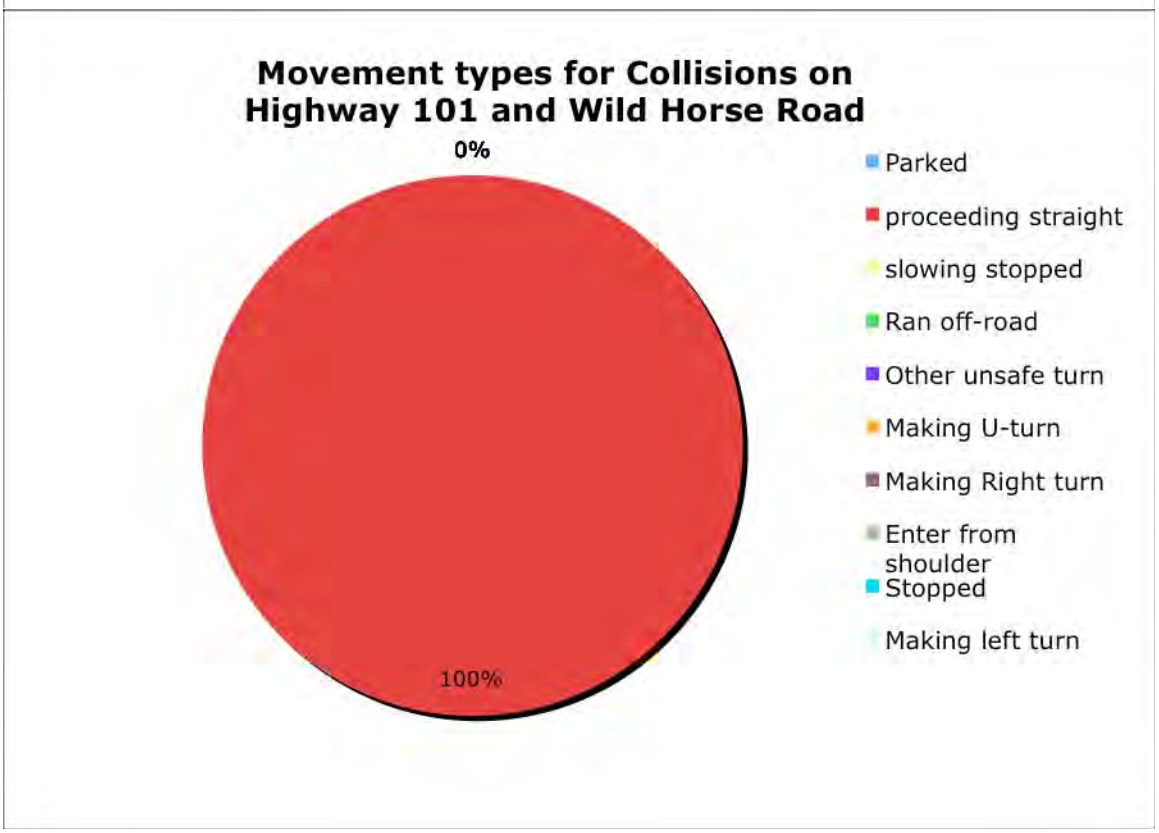

Movement Types for Collisions
on Interstate 80 and Kidwell Road
0%
33%
67%
0%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane


Movement Types for Collisions
on Interstate 5 & Hood Franklin Road
0%
11%
11%
11%
11%
23%
11%
11%
11%
11%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane


Movement Types for Collisions
on Interstate 5 & Twin Cities Road
0%
5%
5%
25%
25%
5%
15%
10%
5%
5%
0%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped


Movement types for Collisions on
Interstate 5 & West Turner Road
0%
0%
13%
12%
13%
13%
37%
12%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane


Movement types for Collisions on
Interstate 5 & South French Camp Road
48%
27%
6%
8%
5%
2%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn
Pass Other Vehicle
Backing
Other
Change Lane


Movement types for Collisions on
Highway 101 and Wild Horse Road
0%
100%
Parked
proceeding straight
slowing stopped
Ran off-road
Other unsafe turn
Making U-turn
Making Right turn
Enter from shoulder
Stopped
Making left turn

A6.2 FATIGUE RELATED COLLISIONS AT INFORMAL REST AREAS, DESIGNATED REST AREAS

Table A6.1:
Fatigue Related Highway Collisions near Informal Rest Stop Locations

	Number of Collisions within a mile stretch of Informal Rest Stop location	Number of Collisions Nearest to Rest Stop (before)	Location of nearest collision (miles before)	Number of Collisions Nearest to Rest Stop (after)	Location of nearest collision (miles after)	
Northbound Highway 101 and Wild Horse Road	0	1	5.7	2	0.1	0 collisions up to 2 mile after except for the 2 collision location 0.1 mile after. 3 collision location 7.8 mile before.
Southbound Highway 101 and Wild Horse Road	0	1	5.3	1	2.4	2 collision location 12 miles before, 15 miles after.
Northbound Interstate 5 and Twin Cities Road	0			1	2	2 collision location 8 miles after
Northbound Interstate 5 and Hood Franklin Road	2	1	0.4	1	1.7	2 collision location 2 miles after
Southbound Interstate 5 and Twin Cities Road	0	1	1	1	1.5	2 collision location 3 miles after
Southbound Interstate 5 and Hood Franklin Road	0	1	2	1	2	2 collision location 2.7 miles before and 10 miles after
Northbound Interstate 5 and South French Camp Road	0	1	3.6	1	0.2	2 collisions location 6.5 miles before and 2.8 miles after

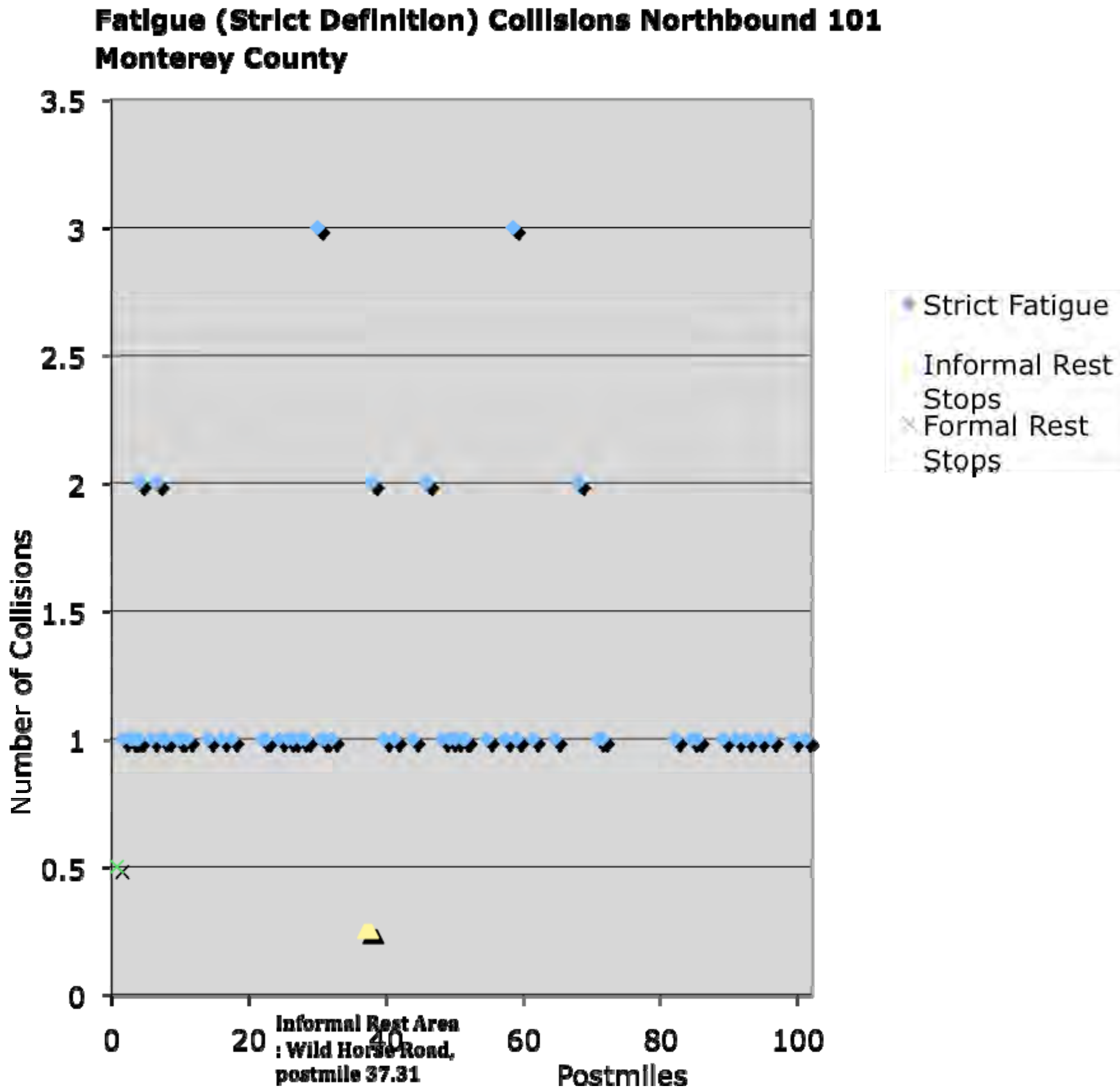
Northbound Interstate 5 and West Turner Road	1	1	1.6	1	1.4	2 collisions location 2 miles before and 3.5 miles after
	Number of Collisions within a mile stretch of Informal Rest Stop location	Number of Collisions Nearest to Rest Stop (before)	Location of nearest collision (miles before)	Number of Collisions Nearest to Rest Stop (after)	Location of nearest collision (miles after)	
Southbound Interstate 5 and South French Camp Road	1	1	1.4	1	1.7	2 collision location 10.9 miles after
Southbound Interstate 5 and West Turner Road	4	1	1	1	1.4	2 collision location 7.2 miles before
Eastbound Interstate 80 and Red Top Road	2	1	1.4	1	0.3	All 4 locations unsafe with a higher number of collisions at rest stops and a number of 2 and 3 collision locations.
Eastbound Interstate 80 and Abernathy Road	0	1	2	1	0.3	Informal rest stop located immediately next to two formal rest stop location. Lack of space or adequate facility at the formal rest stop location? Formal rest stop location unpopular due to some reason? 2 collisions location 3 miles after.
Eastbound Interstate 80 and Pedrick Road	1	1	0.6	1	0.3	3 collision location 6 miles before, 3 collision location 1.3 miles after

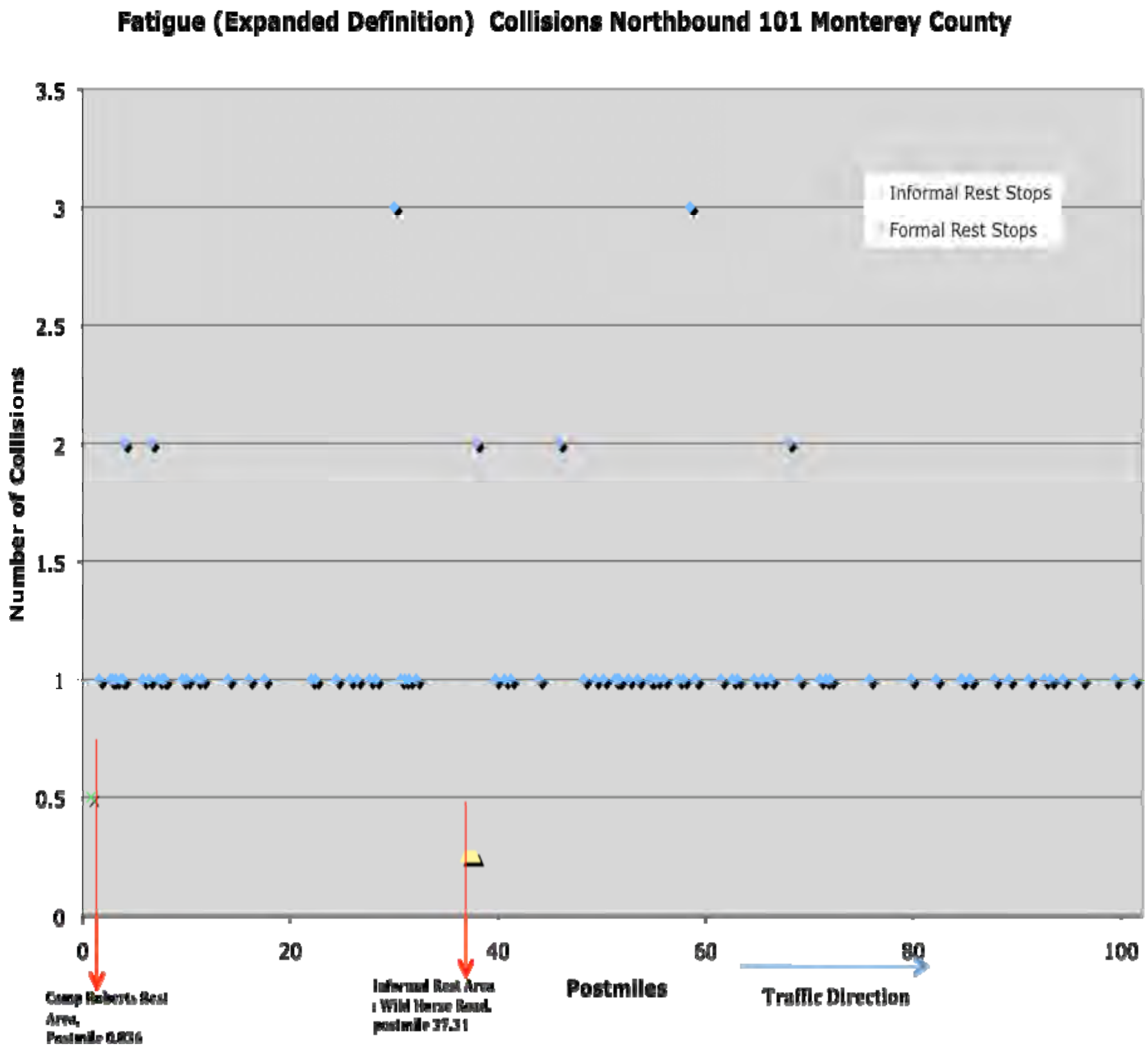
	Number of Collisions within a mile stretch of Informal Rest Stop location	Number of Collisions Nearest to Rest Stop (before)	Location of nearest collision (miles before)	Number of Collisions Nearest to Rest Stop (after)	Location of nearest collision (miles after)	
Eastbound Interstate 80 and Kidwell Road	3+1	1	1	1	1.6	
Westbound Interstate 80 and Red Top Road	0	1	0.1	2	1.8	2 collision location2 miles after
Westbound Interstate 80 and Abernathy Road	0	1	0.6	1	0.4	2 collision location 1.2 miles before
Westbound Interstate 80 and Pedrick Road	1	1	0.2	1	0.2	2-collision location nine miles before. All four locations unsafe in spite of presence of formal rest stops.
Westbound Interstate 80 and Kidwell Road	1	1	0.6	1	1	2 collision location ten miles before

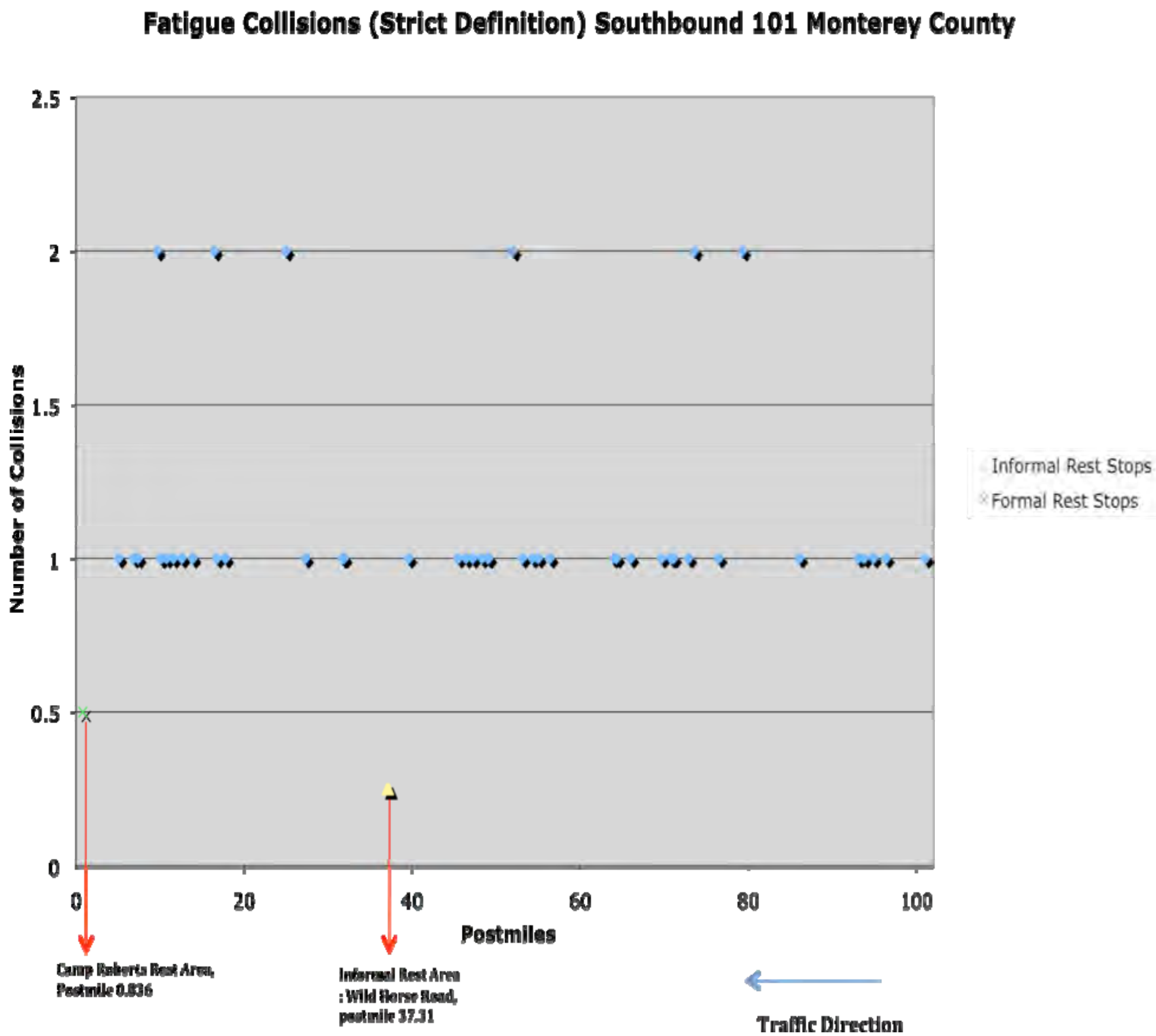
Table A6.2:
Fatigue related Highway Collisions at
Designated Rest Area locations near the informal rest stops

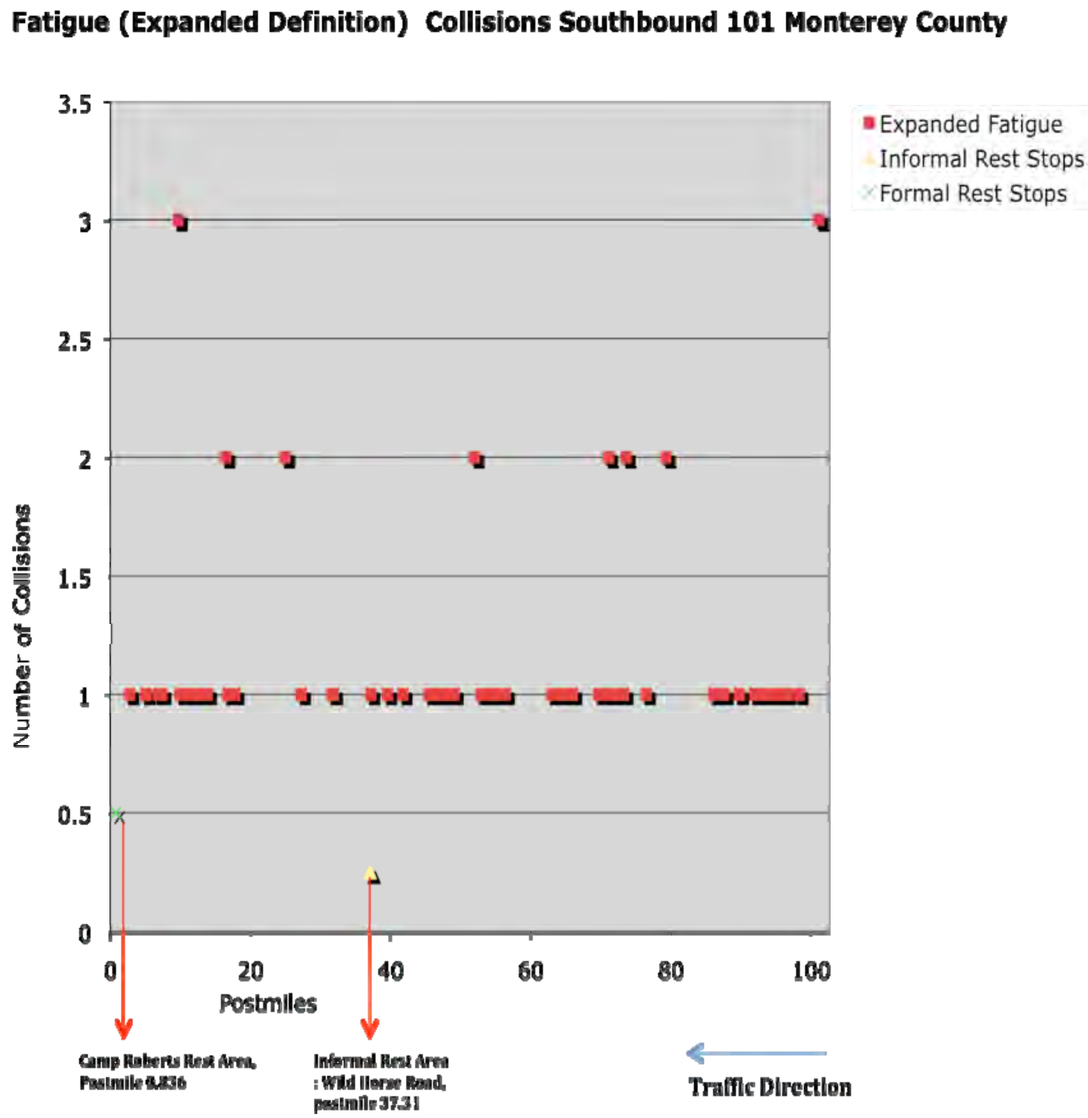
	Number of Collisions at formal Rest Stop location	Number of Collisions at Peak (within 10 miles before)	Location of Peak (miles from formal rest stop)	Number of Collisions at Peak (within 10 miles after)	Location of Peak (miles from formal rest stop)	
Northbound 101 Camp Roberts	0			1	0.8	2 collision location 3.2 mile after
Southbound 101 Camp Roberts	0			1	4.3	2 collision location 9 mile after
Northbound I-5 Elkhorn Rest Area	0	1	2			2 collisions 15 miles after
Eastbound 80 Truck Weigh Station at Postmile 14.3	1	1	0.2	1	0.2	Many collision location. Two collision location 5 miles after. 3 collision location 7 miles after.
Eastbound 80 Truck Weigh Station at postmile 16.03	0	1	1.5	1	0.9	2 collision location 3miles after. 3 collision location 5.2 miles after.
Westbound 80 Hunter Hill Rest Stop	0	1	0.5	1	0.1	2 collision location 7 miles after.
Westbound 80 Truck Weigh Station at Postmile 14.3	1	2	0.7	2	0.5	
Westbound 80 Truck Weigh Station at postmile 16.03	0	1	0.6	1	1	2 collision location 1.2 miles before.

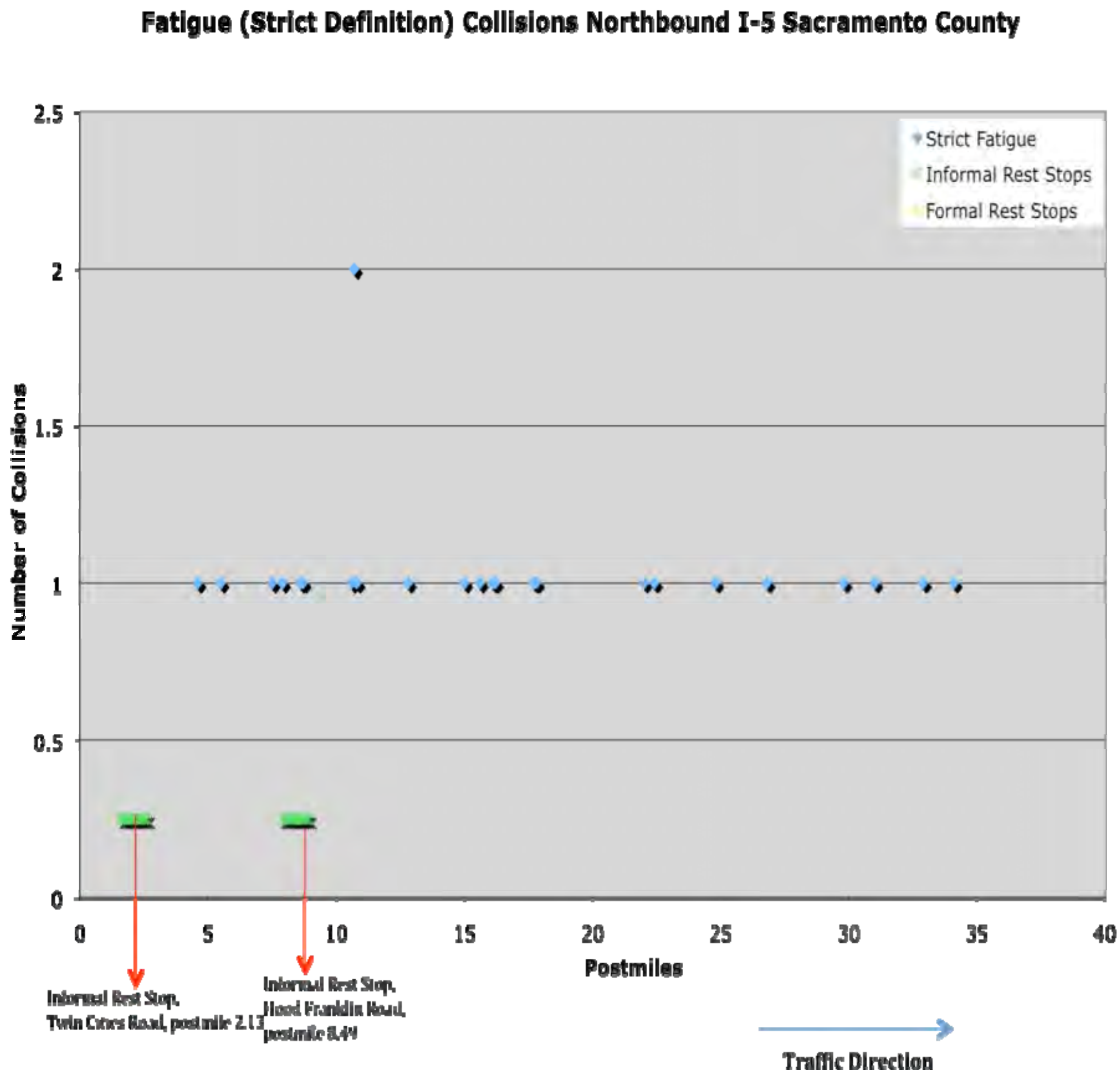
A6.2.1 FATIGUE RELATED COLLISIONS AT INFORMAL REST AREAS, DESIGNATED REST AREAS AND TRUCK SCALES

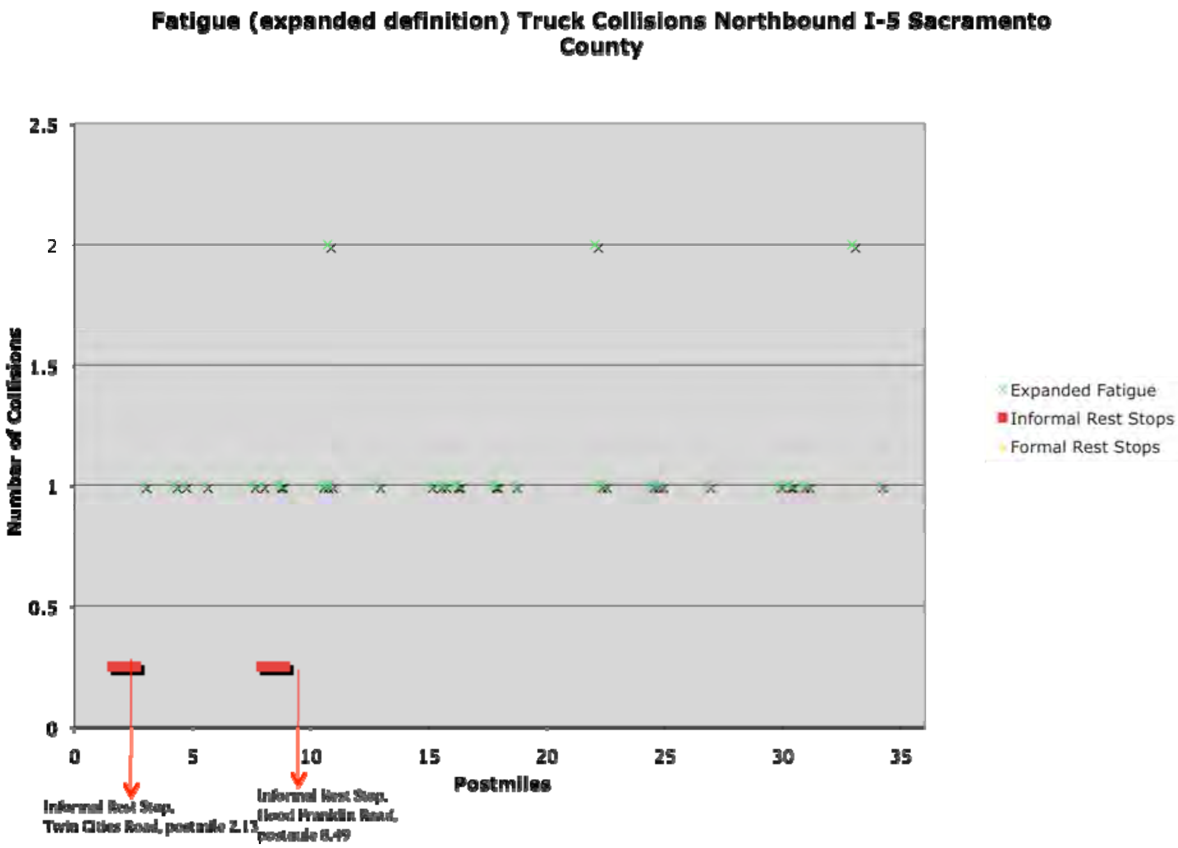


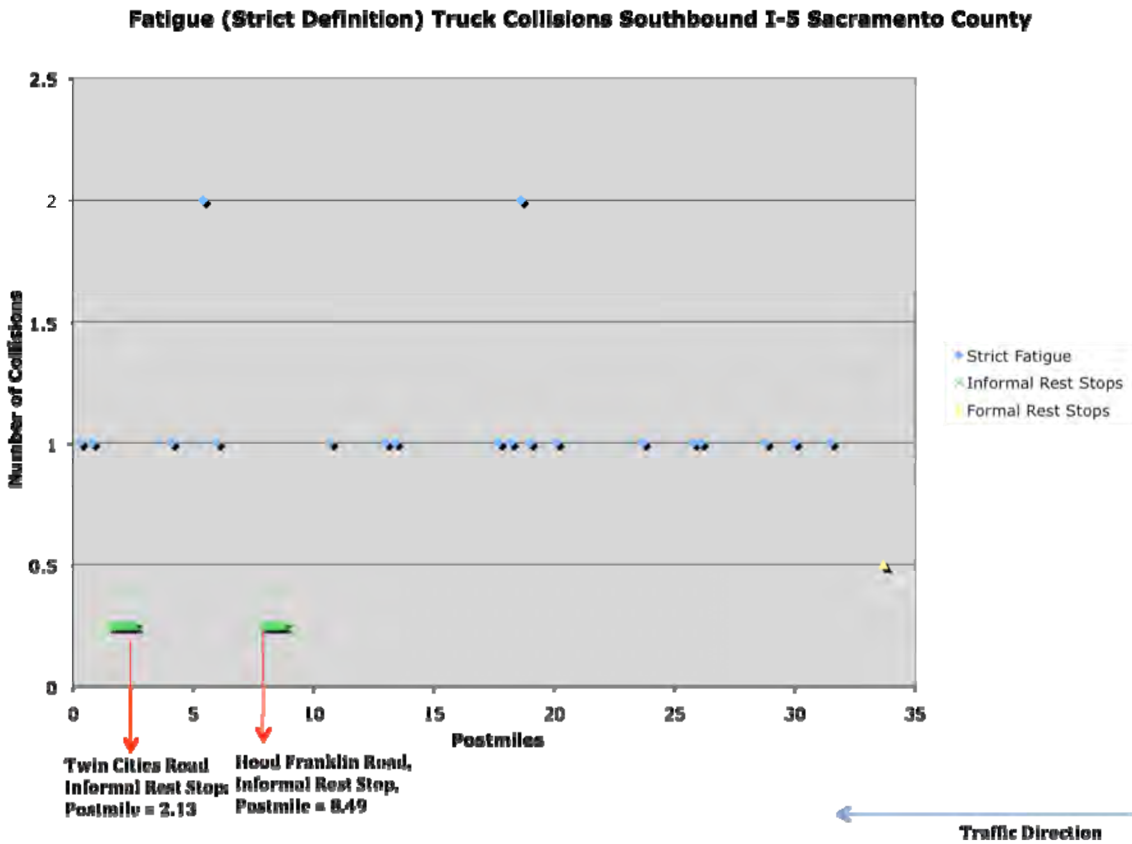

Fatigue (Expanded Definition) Collisions Northbound 101 Monterey County
Informal Rest Stops
Formal Rest Stops
Number of Collisions
0
0.5
1
1.5
2
2.5
3
3.5
0
20
40
60
80
100
Postmiles
Traffic Direction
Camp Roberts Rest Area,
Informal Rest Area : Wild Horse Road, postmile 37.31


Fatigue Collisions (Strict Definition) Southbound 101 Monterey County
Number of Collisions
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
Postmiles
Informal Rest Stops
Formal Rest Stops
Camp Roberts Rest Area, Postmile 0.836
Informal Rest Area : Wild Horse Road, postmile 37.31
Traffic Direction

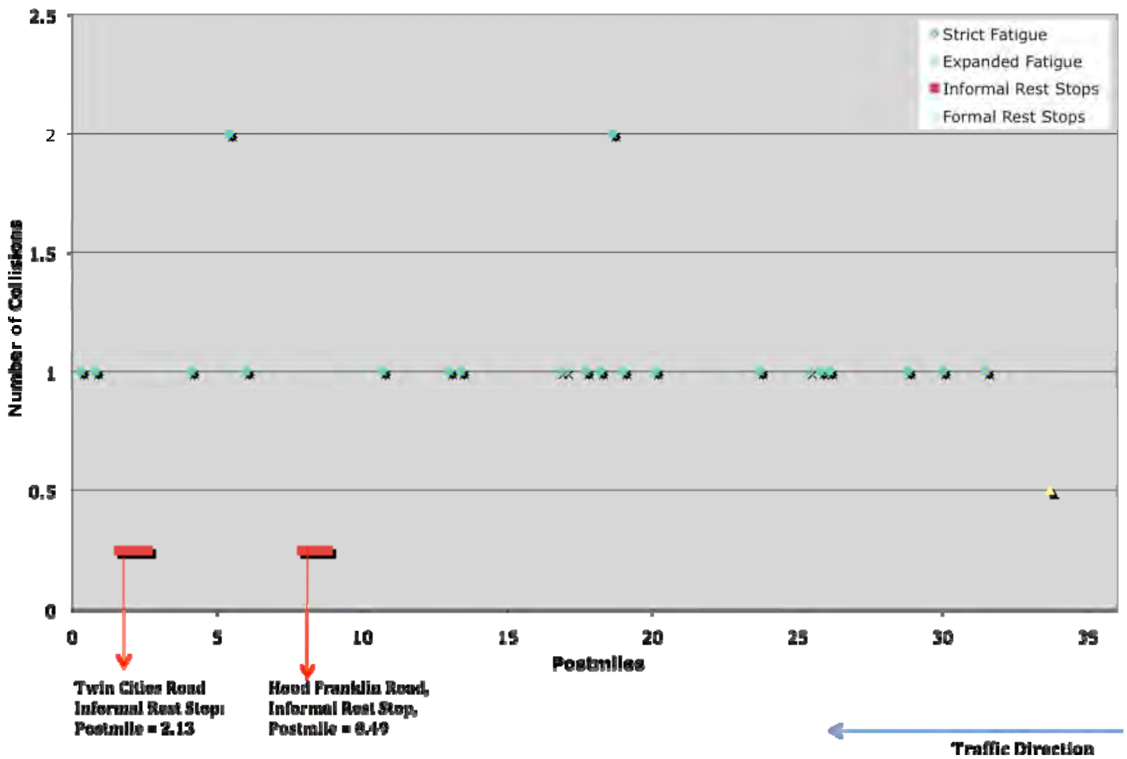

Fatigue (Expanded Definition) Collisions Southbound 101 Monterey County
Number of Collisions
3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
Postmiles
Expanded Fatigue
Informal Rest Stops
Formal Rest Stops
Camp Roberts Rest Area, Postmile 0.836
Informal Rest Area : Wild Horse Road, postmile 37.31
Traffic Direction


Fatigue (Strict Definition) Collisions Northbound I-5 Sacramento County
Strict Fatigue
Informal Rest Stops
Formal Rest Stops
Number of Collisions
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
Postmiles
Informal Rest Stop,
Twin Cities Road, postmile 2.13
Informal Rest Stop,
Hood Franklin Road,
postmile 8.49
Traffic Direction

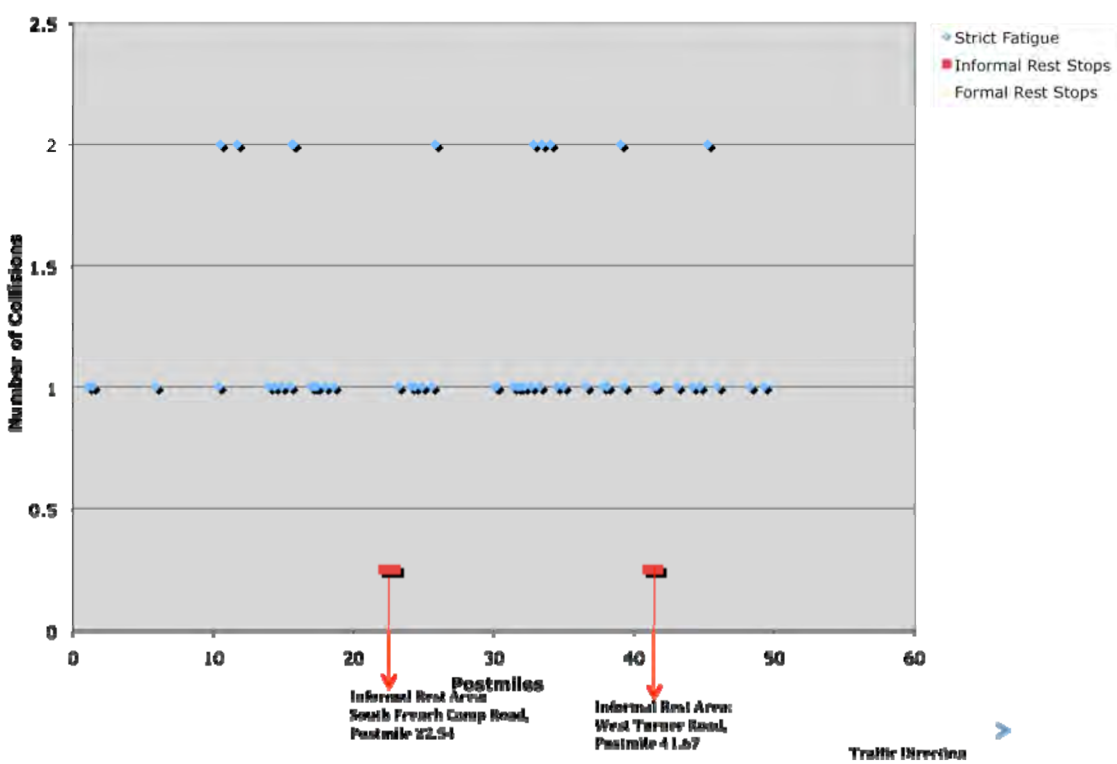

Fatigue (expanded definition) Truck Collisions Northbound I-5 Sacramento County
Number of Collisions
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
Postmiles
Expanded Fatigue
Informal Rest Stops
Formal Rest Stops
Informal Rest Stop,
Twin Cities Road, postmile 2.13
Informal Rest Stop,
Hood Franklin Road,
postmile 8.49


Fatigue (Strict Definition) Truck Collisions Southbound I-5 Sacramento County
Number of Collisions
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
Postmiles
Strict Fatigue
Informal Rest Stops
Formal Rest Stops
Twin Cities Road Informal Rest Stop; Postmile = 2.13
Hood Franklin Road, Informal Rest Stop, Postmile = 8.49
Traffic Direction

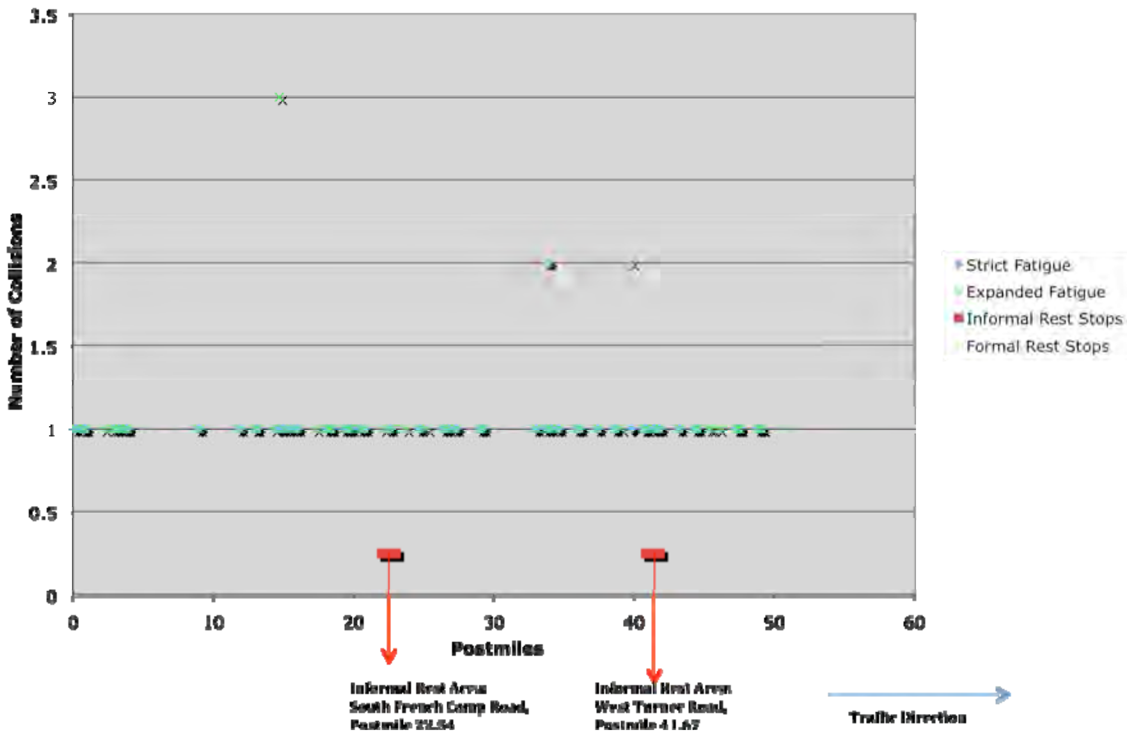
Fatigue (Expanded Definition) Truck Collisions Southbound I-5 Sacramento County



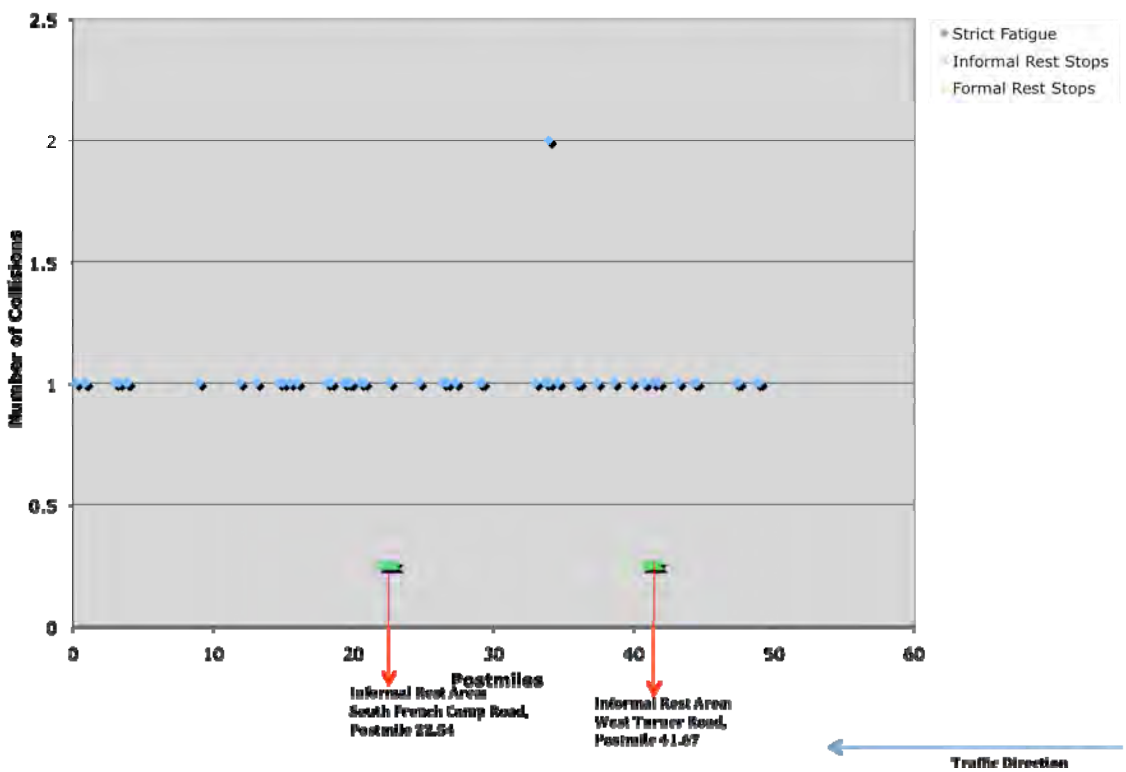
Fatigue (Strict Definition) Collisions Northbound I-5 San Joaquin County

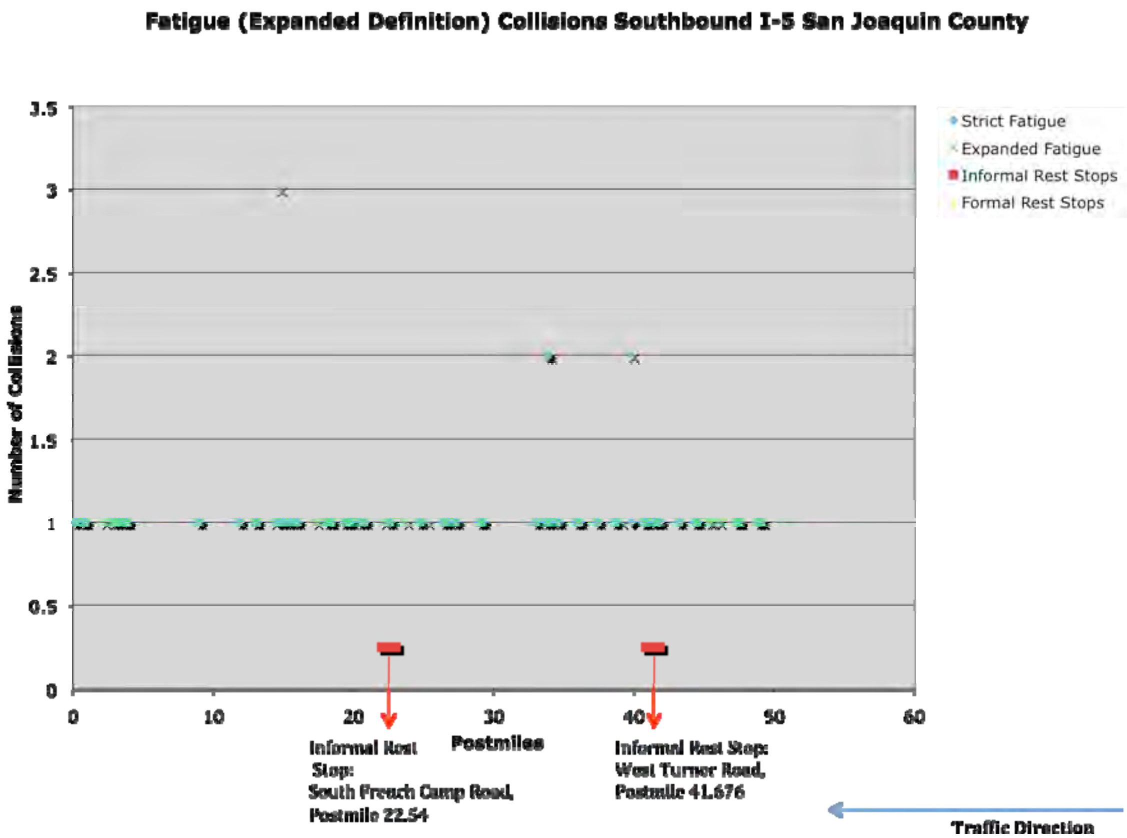


Fatigue (Expanded Definition) Collisions Southbound I-5 San Joaquin County

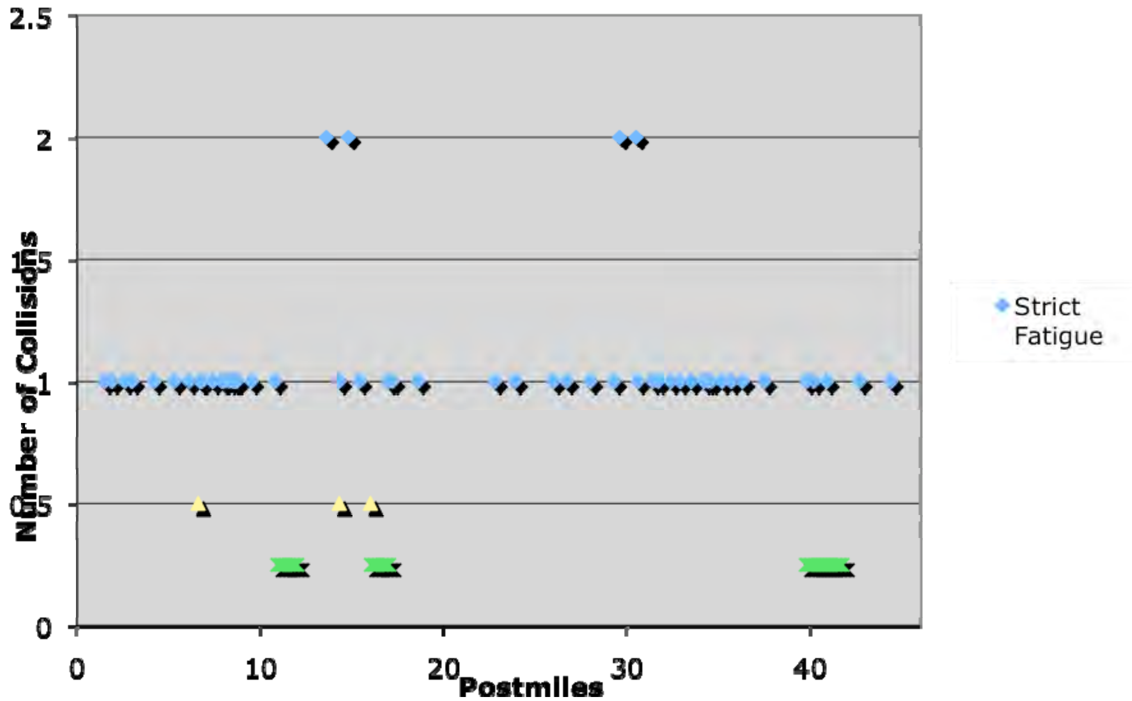


Fatigue (Strict Definition) Collisions Southbound I-5 San Joaquin County

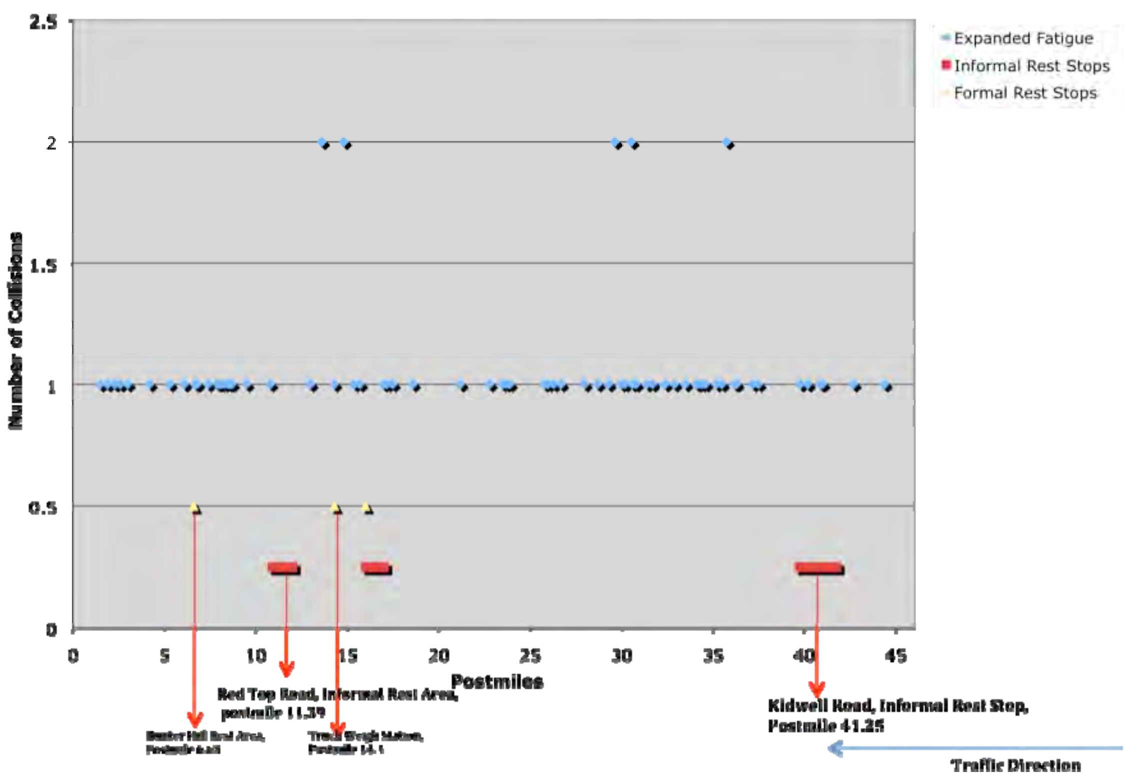


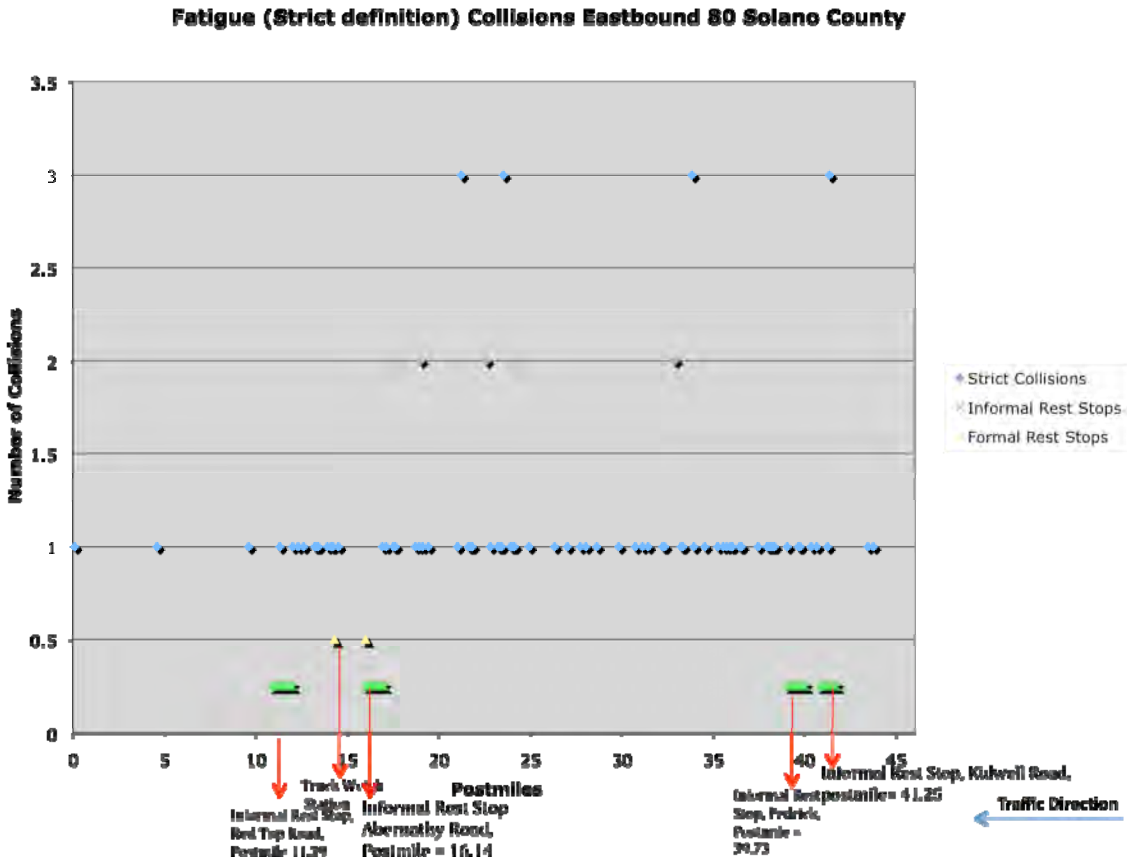

Fatigue (Expanded Definition) Collisions Southbound I-5 San Joaquin County
Number of Collisions
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
Postmiles
Strict Fatigue
Expanded Fatigue
Informal Rest Stops
Formal Rest Stops
Informal Rest Stop: South French Camp Road, Postmile 22.54
Informal Rest Stop: West Turner Road, Postmile 41.676
Traffic Direction

Fatigue (Strict definition) Collisions Westbound 80 Solano County



Fatigue (expanded definition) Collisions Westbound 80 Solano County




Fatigue (Strict definition) Collisions Eastbound 80 Solano County
Number of Collisions
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
45
Postmiles
Strict Collisions
Informal Rest Stops
Formal Rest Stops
Informal Rest Stop
Abernathy Road,
Postmile = 16.14
Traffic Direction