National Cooperative Highway Research Program

NCHRP Synthesis 287

Sleep Deprivation Countermeasures for Motorist Safety

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 2000	3. REPORT TYPE AND DATES COVERED Final Report

4. TITLE AND SUBTITLE NCHRP Synthesis 287: Sleep Deprivation Countermeasures for Motorist Safety	5. FUNDING NUMBERS 20-5
6. AUTHOR(S): Transportation Research Board	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Transportation Research Board National Research Council 2101 Constitution Ave., N.W. Washington, D.C. 20418	8. PERFORMING ORGANIZATION REPORT NUMBER 30-06
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, D.C. 20001	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES Sponsored in cooperation with the Federal Highway Administration	
12a. DISTRIBUTION/AVAILABILITY STATEMENT N	12b. DISTRIBUTION CODE: unlimited

13. ABSTRACT (Maximum 200 words)

This synthesis report will be of interest to highway and other transportation safety specialists and researchers. Considerable attention has been directed at the role of driver sleepiness and fatigue in commercial vehicle crashes; however, 96% of sleep-related crashes do not involve commercial vehicles. This report focuses on the current state of the practice for countermeasures to reduce drowsy driving and the crashes that result from drowsy driving among the general driving public. These countermeasures are presented within the following categories: public education and awareness, new technologies, and roadway (i.e., continuous shoulder rumble strips), environmental (safe stopping areas), and regulatory and judicial (reporting of fatigue-related crashes, sanctions, and licensing) countermeasures. Three examples of effective state practices are also provided. Information was collected by surveying U.S. and Canadian transportation agencies and by conducting a literature search.

14. SUBJECT TERMS Safety and Human Performance			15. NUMBER OF PAGES
17. SECURITY CLASSIFICATION Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

National Cooperative Highway Research Program

Synthesis of Highway Practice 287

Sleep Deprivation Countermeasures for Motorist Safety

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Research Sponsored by the American Association of State Highway and Transportation Officials in Cooperation with the Federal Highway Administration

NATIONAL ACADEMY PRESS
Washington, D.C. 2000

Subject Areas
Safety and Human Performance

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communication and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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Project 20-5 FY 1998 (Topic 30-06)
ISSN 0547-5570
ISBN 0-309-06868-1
Library of Congress Catalog Card No. 00-134393

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the Federal Government. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

Printed in the United States of America

PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis report will be of interest to highway and other transportation safety specialists and researchers. It describes the current state of the practice for countermeasures to reduce drowsy driving and the crashes that result from drowsy driving. Information for the synthesis was collected by surveying U.S. and Canadian transportation agencies and by conducting a literature search to gather additional information.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

This report of the Transportation Research Board provides information on sleep deprivation countermeasures for motorist safety. These countermeasures are presented within five distinct categories: public education and awareness, new technologies, and roadway, environmental, and regulatory and judicial countermeasures. In addition, three examples of noteworthy state department of transportation countermeasure programs are provided.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the available information was assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the author's research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

ACKNOWLEDGMENTS

Jane C. Stutts, Ph.D., Manager, Epidemiology Studies, Highway Safety Research Center, University of North Carolina, Chapel Hill, was responsible for collection of the data and preparation of the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Jesse Blatt, Ph.D., Special Assistant, Office of Research and Traffic Records, National Highway Traffic Safety Administration; Thomas E. Bryer, Director, Bureau of Highway Safety and Traffic Engineering, Pennsylvania Department of Transportation; Ralph L. Carhart, Senior Landscape Architect/Roadside Rest Coordinator, Office of State Landscape Architecture, California Department of Transportation; Robert J. Carroll, Transportation Specialist, Office of Research and Technology, Federal Motor Carrier Safety Administration; Vernon S. Ellingstad, Director, Office of Research and Engineering, National Transportation Safety Board; Anne T. McCartt, Ph.D., Senior Associate, Preusser Research Group, Inc., Trumball, Connecticut; Richard F. Pain, Ph.D., Transportation Safety Coordinator, Transportation Research Board; Paul S. Rau, Ph.D., Engineering Research Psychologist, Office of Vehicle Safety Research, National Highway Traffic Safety Administration; William "Bill" C. Rogers, Director of Research, American Trucking Association Foundation; Alex Vincent, Ph.D., Senior Ergonomist, Transportation Development Center, Transport Canada; and David K. Willis, President and CEO, AAA Foundation for Traffic Safety.

In addition, we extend a special thanks to Ron Knipling, Chief, Research Division, Federal Motor Carrier Safety Administration.

This study was managed by Stephen F. Maher, P.E., Manager, Synthesis Studies, who worked with the consultant, the Topic Panel, and the Project 20-5 Committee in the development and review of the report. Assistance in project scope development was provided by Donna L. Vlasak, Senior Program Officer. Don Tippman was responsible for editing and production. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Crawford F. Jencks, Manager, National Cooperative Highway Research Program, assisted the NCHRP 20-5 Committee and the Synthesis staff.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance are appreciated.

SLEEP DEPRIVATION COUNTERMEASURES FOR MOTORIST SAFETY

SUMMARY

Sleep deprivation is a significant contributor to highway crashes. The National Highway Traffic Safety Administration estimates that driver sleepiness or fatigue is a primary causal factor in 100,000 police-reported crashes each year, which result in 71,000 injuries and 1,500 deaths. These numbers represent about 1.5 percent of all police-reported crashes and 4 percent of fatalities. Sleepiness likely contributes to many more crashes, because in addition to falling asleep at the wheel, sleepy drivers are less attentive, slower to react, and are more impaired by even low levels of alcohol.

Considerable attention has been directed at the role of driver sleepiness and fatigue in commercial vehicle crashes; however, 96 percent of sleep-related crashes do not involve a commercial vehicle. This report focuses on countermeasures to reduce drowsy driving and drowsy driving crashes among the general driving public. Although the only truly effective solution to sleep deprivation is adequate sleep, countermeasures exist or are being investigated that have the potential to make highway travel safer. This report reviews these countermeasures as grouped into the following categories:

- Public education and awareness,
- New technologies,
- Roadway countermeasures,
- Environmental countermeasures, and
- Regulatory and judicial countermeasures.

Integrated into the various chapters are the results of a questionnaire distributed to state and provincial transportation departments in the United States and Canada, as well as state highway department safety offices.

Public education and awareness countermeasures are primarily directed at reducing drowsy driving. Effective program development requires careful attention to identifying (1) the target audience, (2) the themes or messages to be conveyed, and (3) approaches for conveying these messages to the intended audience. Populations known to be at high risk of involvement in sleep-related accidents include young adults (especially young males), shift workers, persons with undiagnosed and/or untreated sleep disorders, and commercial vehicle operators. Within the overall population, the following risk factors for involvement in a sleep-related motor vehicle crash have been identified: excessive daytime sleepiness, acute sleep loss, extended hours of wakefulness, use of sedating medications, alcohol, and driving conditions that do not cause but may unmask sleepiness.

Public education and awareness messages generally have stressed the dangers of drowsy driving, the warning signs of sleepiness, and actions to reduce the risk of involvement in a sleep-related crash. Although there are a limited number of proven countermeasures that can be recommended, short naps, particularly when combined with drinking a caffeinated

beverage, have been shown to increase alertness. Some pharmacological countermeasures, such as the new drug modafinil, also show promise. For persons with sleep disorders, diagnosis and treatment can significantly reduce the risk of crashing.

Educational efforts have also been directed at a number of special populations, including law enforcement personnel, driver educators, school administrators and teachers, physicians, the trucking industry, employers and unions, and state transportation and highway safety personnel. Both the federal government and private organizations such as the National Sleep Foundation and AAA Foundation for Traffic Safety have undertaken efforts to increase public awareness of the dangers of drowsy driving, and an increasing number of state transportation departments and highway safety offices have also become involved.

Technologies are being developed that may further reduce the number of sleep-related crashes occurring on our nation's highways. Although these technologies are directed almost exclusively to commercial vehicle operators and operation, at least some have potential application in noncommercial vehicles. Technologies are being developed and/or validated in the field to (1) monitor or detect drowsy driving, (2) warn drivers of drowsiness, and (3) help drowsy drivers to maintain alertness. Various types of monitoring devices have been examined, including devices that measure eye movements, eye blinks, head movements, brain wave activity, and heart rate. One of the most promising technologies assesses drowsiness based on the percentage of eyelid closure over the pupil (PERCLOS). There is still much research to be carried out, however, before these technologies are ready for implementation in broader commercial and private settings. Particularly challenging is the issue of documenting and validating all of the various devices, since many are being developed as proprietary technologies. Also, before these technologies can be extended to the general driving public, they must be made more cost-effective and more "driver friendly." The public will also need to be educated about the proper—and improper—use of such technologies.

In contrast to these new technologies, continuous shoulder rumble strips (CSRSs) represent a roadway countermeasure that has already proven highly effective in preventing a very common type of fall-asleep crash: a single vehicle running off a high-speed, rural roadway. CSRSs are grooved patterns placed more or less continuously along the shoulder of a roadway, which produce both noise and vibration when a vehicle's tires travel across them. Unlike countermeasures to discourage drowsy driving, CSRSs work by alerting already drowsy drivers and reducing their likelihood of crashing. Because they are 20 to 50 percent effective in preventing run-off-road crashes, and because of their relatively low cost, CSRSs have an extremely high benefit-cost ratio. Their only reported drawbacks center around issues of potential misuse by the driving public, noise pollution, bicyclists' concerns, maintenance, and reduced flexibility in shoulder use during roadway construction or maintenance activities. Almost all states have some experience in the use of CSRSs, and many have adopted guidelines for incorporating them not only on rural interstates, but also on urban interstates and two-lane rural highways. A few states have also experimented with placing rumble strips along the centerline of nondivided roadways to prevent vehicles from crossing into approaching travel lanes.

The primary example of an environmental countermeasure for reducing drowsy driving and drowsy driving crashes is safe stopping areas, often in the form of roadside rest areas. Although the safety benefits of rest areas are difficult to document, they are an established and popular component of our nation's highway system. Recently, safe stopping areas have received increased attention due to a documented shortage of parking spaces for commercial vehicle operators. For motorists, however, the primary concern is not the availability of

parking spaces, but the safety and security of the facility and the amenities available. Recent research has shown that many motorists are reluctant to stop at rest areas at nighttime, even when drowsy, because of concerns about personal safety. Some states report ongoing efforts to upgrade rest area facilities and increase security.

Another category of countermeasures for sleep-related crashes are regulatory and judicial measures. Although a wide range of such measures is potentially available for commercial vehicle operation, possibilities for the general driving public are much more limited. Three areas that have general applicability are reporting of drowsy driving crashes, legal sanctions against drowsy drivers, and driver licensing. Reporting of drowsy driving crashes can be improved by including a checkbox on the accident report form for identifying a crash-involved driver as sleepy or fatigued and by implementing programs to educate and train police officers in how to identify a sleep-related crash. With regard to legal sanctions against drowsy drivers, at least one state has concluded that such actions would be premature pending an increased awareness and appreciation of the problem by both the public and the law enforcement community. And finally, although existing federal regulations might be applied to interstate commerce involving operators with sleep disorders, only a few states currently have regulations in place that govern the licensing of persons with two of the most prominent disorders, narcolepsy and sleep apnea.

There is clearly no single solution to the problem of drowsy driving. However, multifaceted programs that combine public education and awareness with roadway, environmental, and regulatory countermeasures, and that are poised to take advantage of available new driver monitoring and alerting technologies, offer promise.

CHAPTER ONE

INTRODUCTION

This report presents a synthesis of current knowledge and practice pertaining to sleep deprivation countermeasures for motorist safety. Although a well-established risk factor for commercial vehicle crashes, sleep deprivation has only recently been recognized as a significant contributor to crashes involving the general motoring public. This chapter presents background information on the nature of sleep deprivation and its consequences on the roadway, and provides a rationale for the project and overview of the chapters to follow.

THE NATURE OF SLEEP DEPRIVATION

Definition of Terms

Sleep is a basic biological need, and sleepiness the inevitable consequence of failure to satisfy that need. Sleepiness can be succinctly defined as "the inclination to sleep." Studies have linked sleepiness to decrements in vigilance, reaction time, memory, psychomotor coordination, information processing, and decision making—all of which are critical to safe driving [Lyznicki et al. 1998; National Highway Traffic Safety Administration (NHTSA) 1998].

In this report the terms "sleepy" and "drowsy" are used interchangeably. The term "fatigued" is also sometimes used, although technically it has a different meaning than sleepy or drowsy. Fatigue is defined as "a disinclination to continue performing the task at hand" (Brown 1994). Fatigue can result from physical labor as well as from repetitive activities, such as monitoring a display screen or driving a car long distances. A person can be fatigued without being sleepy. The effects of sleepiness and fatigue on driving, however, are very much the same: a progressive withdrawal of attention from the road and traffic demands leading to impaired driving performance (Brown 1994). In the case of sleepy drivers, the ultimate impairment is falling asleep at the wheel.

Causes of Sleepiness

The primary cause of sleepiness is not getting adequate sleep, resulting in a state of sleep deprivation. Sleep deprivation can be either chronic or acute. People who are chronically sleep deprived get too little sleep on a routine basis. On average, people need 8 hours of sleep a night; sleeping less than this leads to a "sleep debt" that accrues over time (Caskadon and Dement 1981; Dement and Vaughan 1999). The greater the sleep debt, the greater the corresponding sleep drive or urge to sleep.

Chronic sleep deprivation can also result from frequent interruptions of sleep, or sleep fragmentation. Sleep fragmentation occurs with certain sleep disorders and can be an unwelcome side effect of chronic illness or pain. It can also have external causes, including a noisy or uncomfortable sleep environment. Thus, both adequate quantity and quality of sleep are needed to avoid sleepiness.

Like chronic sleep deprivation, acute sleep deprivation is also caused by too little sleep, but on a single-night or short-term basis. Even persons who normally get adequate sleep at night can experience bouts of acute sleep deprivation as a result of a late night out, cramming for an exam, caring for a sick child, or preparing for an out-of-town trip.

Sleepiness can also occur in persons who are not sleep deprived. Our bodies' sleep and wake cycles are largely regulated by an internal body clock that programs us to feel sleepy during the middle of our nighttime sleep period, and again 12 hours later, between two and four o'clock in the afternoon. This pattern of sleep and wakefulness is referred to as the circadian sleep cycle, or circadian rhythm. Sedating medications and alcohol can also cause drowsiness in persons who are not sleep deprived. However, soporific circumstances, such as driving alone on a long, monotonous road, can only unmask existing sleepiness.

Prevalence of Sleepiness

Americans have been described as chronically sleep-deprived (Webb and Agnew 1975; National Commission on Sleep Disorders Research 1993; Coren 1996; Johnson 1999). A recent "Omnibus Sleep in America Poll" conducted for the National Sleep Foundation reported that nearly one-third of American adults get fewer than 6 1/2 hours of sleep at night during the week, and two-thirds sleep less than the recommended 8 hours (Johnson 1999). Participants were not asked about episodes of acute sleep loss.

In the same survey, nearly one of five Americans reported that they experience sleepiness during the day so bad that it interferes with their daily activities at least a few days each week (Johnson 1999). Even more alarming, 62 percent said that they had driven while drowsy during the last year, and 27 percent admitted to having dozed off at the wheel. Very similar results were obtained in a survey of licensed New York State drivers (McCartt et al. 1996).

In a recent issue of *The New England Journal of Medicine* focusing on the problem of drowsy driving, noted sleep researcher

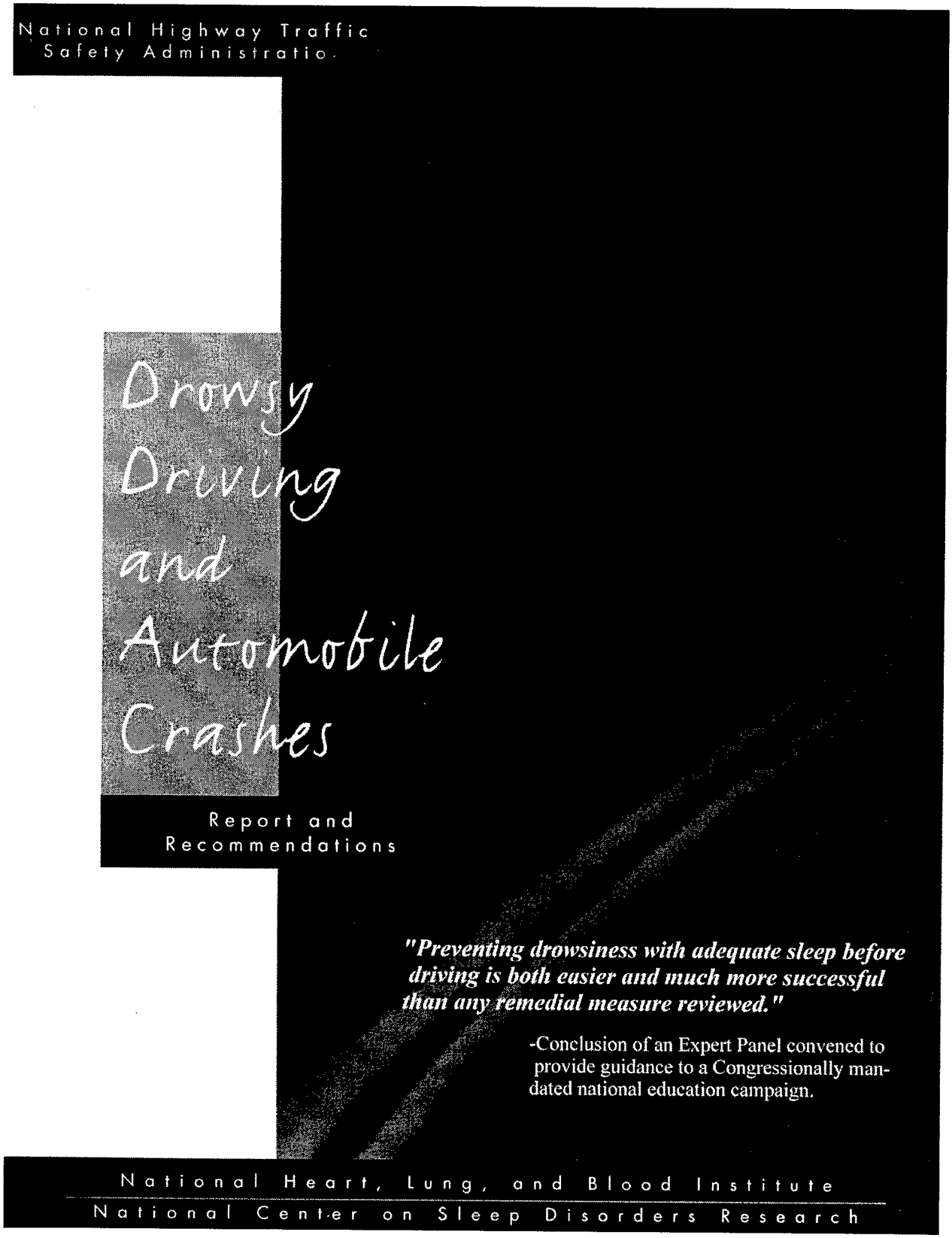


FIGURE 1 National Highway Traffic Safety Administration/National Center for Sleep Disorders Research Expert Panel Report on Drowsy Driving and Automobile Crashes (NHTSA 1998).

William Dement lamented that Americans do not place adequate priority on getting enough sleep. He viewed pervasive drowsy driving as an established fact in the United States, and attributed it at least in part to a "public acquiescence" that society no longer accords drunk drivers (Dement 1997).

CONSEQUENCES OF SLEEPINESS FOR MOTORIST SAFETY

The decrease in physical and cognitive performance experienced by sleepy drivers translates into an increased accident risk on the road. The NHTSA estimates that driver sleepiness or fatigue is a primary causal factor in at least 100,000 police-reported crashes each year, resulting in more than 71,000 injuries and 1,500 deaths. These numbers represent about 1.5 percent of all police-reported crashes and 4 percent of all fatalities [Knipling et al. 1995; Knipling and Wang 1995; National Sleep Foundation (NSF) undated]. Because drivers are more likely to fall asleep on long, monotonous sections of high-speed rural highways, the percentages can be much higher for certain roadways. Prior to installation of rumble strips to help alert drowsy drivers, an estimated 30 percent of all fatal crashes occurring on the New York State Thruway were attributed to drivers who fell asleep (Shafer 1993).

Commercial vehicle operators are at greater risk for involvement in a sleep-related accident than are drivers of passenger vehicles. This is primarily due to their increased mileage and more frequent nighttime driving, although long driving times may also be a factor. On a per-mile-traveled basis, commercial vehicle operators have the same rate of involvement in sleep-related crashes as noncommercial drivers [Federal Motor Carrier Safety Administration (FMCSA) 2000]. An estimated 1 percent of all large truck crashes, 3 to 6 percent of fatal heavy truck crashes, and 15 to 33 percent of fatal-to-the-truck-occupant-only crashes are primarily related to driver fatigue (Knipling and Shelton 1999).

Available data are likely to underestimate the magnitude of the drowsy driving problem, especially for motorists. As outlined by Leger (1995), there are at least three ways in which driver sleepiness contributes to the occurrence of a crash: (1) the driver falls asleep at the wheel, (2) the driver's sleepiness leads to reduced performance and loss of attention, and (3) sleepiness augments the negative effects of even moderate consumption of alcohol. Police accident reports typically capture only the first category of sleep-related crashes. Sleepiness and fatigue may also contribute to the *one million* accidents caused each year by driver inattention (Knipling 1999a; NSF undated).

REPORT FOCUS AND FORMAT

The focus of this report is on countermeasures to reduce drowsy driving and the crashes that result from drowsy driving. Although sleep researchers and highway safety professionals agree that the only truly effective solution to sleep deprivation is adequate sleep (Figure 1), countermeasures exist or are under investigation that have the potential to make highway travel safer. This report reviews available literature and current practice with respect to these countermeasures.

Despite considerable current interest in sleep and fatigue issues affecting commercial vehicle operation, the report primarily addresses the general driving public. Sleep and fatigue are well recognized and clearly identified problems for commercial vehicle operators; however, 96 percent of all sleep-related crashes *do not* involve a commercial motor vehicle (Knipling and Wang 1994).

As part of the preparation of this report, a questionnaire on "Sleep Deprivation Countermeasures for Motorist Safety" was distributed to transportation departments in all 50 United States, the District of Columbia, and Puerto Rico, as well as to 13 Canadian province transportation agencies. Responses were obtained from 37 states and seven provinces. A copy of the survey is contained in Appendix A. In addition, because many of the questions on the survey dealing with public awareness and education activities are more often addressed by state highway safety offices, an abbreviated version of the survey was mailed to a listing of state highway safety officials provided by the National Association of Governor's Highway Safety Representatives. A total of 23 states and the District of Columbia responded to this survey. A copy of the survey is contained in Appendix B.

The results of the literature review and surveys are presented in the remaining chapters of the report. The chapters are organized according to the following major categories:

- Driver countermeasures—public education and awareness (chapter 2),
- New technologies (chapter 3),
- Roadway countermeasures (chapter 4),
- Environmental countermeasures (chapter 5), and
- Regulatory and judicial countermeasures (chapter 6).

In addition, chapter 7 highlights noteworthy activities in several states and chapter 8 summarizes and draws conclusions from the presented results.

CHAPTER TWO

DRIVER COUNTERMEASURES—PUBLIC EDUCATION AND AWARENESS

Public education and awareness countermeasures are primarily directed at *preventing* drowsy driving and the crashes and injuries that result from drowsy driving. There are three steps involved in the development of effective educational/awareness countermeasures: (1) identification of the target audience, (2) identification of themes or messages, and (3) identification of approaches for conveying messages to the intended audience. In other words, an effective public education and awareness program requires careful attention to who, what, and how. The following review is organized around these three topic areas and concludes with examples of public education and awareness efforts at the national and state/provincial levels.

TARGET POPULATIONS

High-Risk Populations

Public education and awareness programs designed to prevent drowsy driving have often targeted specific high-risk populations. These populations have been identified from analyses of crash data and from studies examining the driving and crash experiences of certain populations suspected or known to obtain inadequate sleep. The following high-risk populations have been identified in the literature:

- Young adults (especially young males),
- Shift workers,
- Persons with undiagnosed and/or untreated sleep disorders, and
- Commercial vehicle operators.

Young Adult and Male Drivers

Analyses of police-reported motor vehicle crash data have consistently shown young persons, and in particular young males, to be overrepresented in drowsy driving accidents (NHTSA 1998). The reasons have not been clearly identified, but likely involve a combination of chronic sleep loss and increased nighttime driving [National Center on Sleep Disorders Research (NCSDR) 1998]. In their examination of 1990–1992 North Carolina crash data, Pack et al. (1995) reported that 55 percent of fall-asleep crashes involved drivers 25 years old or younger, with age 20 being the peak age of occurrence. Three-fourths of the crash-involved drivers were males. In New York State, one-third of drivers in fall-asleep crashes were from 18 to 34 years of age, even though this age group was involved in less than 20 percent of all crashes (New York State Task Force 1996). Males were involved in three-fourths of the fall-asleep crashes, compared with two-thirds of all crashes in the state.

At the national level, Wang et al. (1996) observed that drivers between the ages of 25 and 34 accounted for 40 percent of sleepy drivers identified in the 1995 Crashworthiness Data System, a national database of towaway passenger vehicle crashes. Eighty-seven percent of the sleepy drivers were male. Outside of the United States, Horne and Reyner (1995b) reported that 45 percent of drivers in sleep-related crashes in two regions of Great Britain were under 30 years of age, and 82 percent were male.

In addition to their greater involvement in sleep-related crashes, young persons and males are also more likely to report a history of driving while drowsy. Seventy-two percent of males responding to a recent poll by the NSF said that they had driven while drowsy at least once in the past year, compared with 54 percent of females. Within age groups, percentages dropped from 73 percent for 18 to 29 year-olds, to 62 percent for 30 to 64 year-olds, and to 32 percent for persons 65 and older (Johnson 1999) (see Table 1).

In a New York State survey, 21 percent of males reported that they sometimes or often drove while drowsy, compared with 12 percent of females. Also, 26 percent of 25 to 34 year-olds reported sometimes or often driving drowsy, compared with less than 20 percent for other age groups (McCartt et al. 1996).

Shift Workers

Shift workers are another group that has been identified at high risk for involvement in sleep-related crashes (Akerstedt 1988). An estimated 20 percent of men and 15 percent of women in the U.S. workforce have "non-standard" work hours, including evening or night shifts, rotating shifts, split shifts, or irregular work schedules (Kessler 1992). These workers often suffer from both reduced sleep quantity and quality. Kessler (1992) reports that shift workers average 1.5 fewer hours of sleep a night than non-shift workers. The work schedules of shift workers also conflict with circadian rhythms, forcing them to work when they would naturally be asleep, and sleep when they would naturally be awake.

Richardson et al. (1990) surveyed shift workers and day workers at a manufacturing plant and found that the shift workers reported poorer quality sleep, experienced greater fatigue

TABLE 1
RESULTS OF NATIONAL SLEEP FOUNDATION POLL: DRIVING DROWSY (Johnson 1999)

	Sex		Age			
	Men (%)	Women (%)	18–29 (%)	30–64 (%)	65+ (%)	Overall
In the past year, have you ever driven a car or other vehicle while feeling drowsy?	71.6	54.0	72.9	61.9	32.1	61.9
In the past year, have you ever dozed off, even if just for a brief moment, while at the wheel of a car or other vehicle?	36.3	19.6	30.8	27.2	15.4	27.1
Do you know someone personally who has crashed due to falling asleep at the wheel?	27.4	19.7	31.7	21.4	12.8	23.2
Have you ever had an accident because you dozed off or were too tired while driving?	2.1	1.0	1.8	1.4	1.3	1.5
Number of respondents	430	526	221	646	78	956

during waking hours, drank more caffeine and alcohol, and had experienced more crashes during the previous year because of sleepiness. Similar studies carried out on special populations engaged in shift work—house staff in large teaching hospitals (Marcus and Loughlin 1996), nurses (Gold 1992), cab drivers (Corfitsen 1993; Dalziel and Job 1997), firefighters (Paley and Tepas 1994), and aviation pilots (Rosekind et al. 1994)—have generally confirmed these results.

In the New York State survey referenced earlier, working rotating shifts, and in particular shifts that included day, evening, and nighttime hours, was associated with a greater frequency of driving drowsy in the previous year (McCartt et al. 1996). Recent research has also linked work schedules to accident involvement. Drivers involved in sleep-related versus non-sleep-related crashes in North Carolina were four to five times as likely to work night shift jobs (Stutts et al. 1999).

Persons with Sleep Disorders

Persons with undiagnosed and/or untreated sleep disorders are also at increased risk for involvement in a sleep-related crash. Two such disorders have been frequently studied and reported in the scientific literature. One is sleep apnea, a condition in which a person's airway collapses and closes during sleep, stopping breathing and eventually causing the person to awaken in order to resume breathing. The individual is usually unaware of these awakenings, even though they may occur hundreds of times during a night. The result, however, is increased sleepiness during the daytime. An estimated 4 to 5 percent of men and 2 percent of women have clinical sleep apnea (Haraldsson et al. 1992; Pakola et al. 1995), although only a fraction of these have been diagnosed. In addition to males, individuals who are older, who are overweight, and who snore during sleep are at especially high risk of developing the disorder. Once sleep apnea is diagnosed, treatments including surgery or continuous positive airway pressure can generally alleviate its symptoms, often producing dramatic increases in daytime alertness and functioning (Findley et al. 1992; Engleman et al. 1994).

Studies of persons with sleep apnea have shown them to have two to seven times more crashes than persons without sleep apnea (George et al. 1987; Findley et al. 1988; Wu and Yan-Go 1996; Teran-Santos et al. 1999). Not surprisingly, the risk of crash involvement increases with the severity of the disorder (Aldrich 1989; Findley et al. 1989). Once diagnosed and treated, the risk of crashing diminishes (Haraldsson et al. 1995; Cassel et al. 1996; Wu and Yan-Go 1996).

Narcolepsy is a much less common disorder, affecting an estimated one-tenth of one percent of the population (Dement et al. 1973; Cohen 1988). In addition to experiencing excessive daytime sleepiness, persons with narcolepsy fall asleep with little or no warning. Such "sleep attacks" can have serious consequences if driving, and research has generally shown narcoleptic drivers to have an even higher crash rate than persons with sleep apnea (Aldrich 1989; Cohen et al. 1992). Although some states have adopted regulations and guidelines for drivers with narcolepsy as well as sleep apnea (Pakola et al. 1995), a major drawback continues to be that the vast majority of these individuals have never been properly diagnosed.

Commercial Vehicle Operators

Commercial vehicle operators are at increased risk for involvement in a sleep-related crash because of their greater exposure to high-risk driving times and situations. This is especially true for long distance truckers, who tend to work long hours, at irregular schedules, and to drive alone, at night, under monotonous driving conditions. Identified risk factors for drowsy driving among truckers include driving during circadian low points; obtaining inadequate sleep prior to driving; working long, irregular, or unreasonable schedules; the hypnotic effect of monotonous driving; economic and schedule-driven pressures that influence levels of risk acceptance; potential impairment due to medications; and the physical demands of having to load and unload freight (Filliatrault et al. 1996; Lyznicki et al. 1998). The predominantly male, middle-aged, and often sedentary population of truckers may also be more likely to

experience chronic daytime sleepiness due to sleep apnea and other sleep disorders (Stoohs et al. 1993, 1994).

A large-scale study carried out as a joint project of the FMCSA [formerly the Federal Highway Administration's (FHWA's) Office of Motor Carriers], American Trucking Associations, and Transport Canada revealed that the amount of time spent driving was a less important contributor to driver fatigue than was the time of day during which the driving took place. The study also concluded that truck drivers were not good judges of their own level of fatigue (Wylie et al. 1996). In a follow-up survey of 511 tractor-trailer operators stopped at inspection sites, irregular work schedules, less restful daytime sleep, pressure to maintain schedules, and the lack of availability of suitable parking areas for napping and sleeping were identified as factors that might contribute to operator fatigue (Abrams et al. 1997).

A recent survey of long distance truck drivers traveling on New York's interstate roadways also examined factors associated with fatigue. Results of multivariate analyses revealed the following six factors to be independently associated with drivers' self-reports of having fallen asleep at the wheel: (1) greater daytime sleepiness, (2) more arduous work schedules with more hours of work and fewer hours off-duty, (3) older and more experienced drivers, (4) shorter and poorer sleep on the road, (5) symptoms of sleep disorder, and (6) greater tendency to nighttime drowsy driving (McCartt et al. 2000)

A 1995 National Truck and Bus Safety Summit identified fatigue as the highest-priority issue affecting the safety of motor carriers. Although the focus of the current synthesis document is on countermeasures to prevent drowsy driving crashes by the general driving public, much can be learned from activities directed at commercial vehicle operators.

The General Driving Population

Not all sleep-related crashes involve young males, shift workers, persons with sleep disorders, or commercial vehicle operators; "average" drivers are also involved in such crashes and have been targeted in public education and awareness campaigns. Risk factors for drowsy driving in the general population include chronic daytime sleepiness, acute sleepiness, use of medications that can cause drowsiness, and alcohol consumption. These are each briefly discussed here.

Chronic Daytime Sleepiness

The same "chronic daytime sleepiness" experienced by shift workers and persons with sleep disorders can be experienced by anyone who gets less sleep on a daily basis than their body requires. Young adults often fall into this category. Teenagers are at especially high risk for chronic daytime sleepiness, both because of physical changes that accompany puberty and changes in their circadian clocks that make it difficult for them to fall asleep until later at night (Carskadon 1990).

As noted in chapter 1, many Americans are sleep deprived. Although sleep experts agree that most adults need an average of 8 hours of sleep a night for optimal alertness and functioning during the daytime, recent polls conducted by the NSF reveal that the average adult sleeps fewer than 7 hours a night during the week, and one-third sleep fewer than 6 1/2 hours (Johnson 1999; NSF 2000). Not surprisingly, many of these adults report feeling sleepy during the day.

Reasons for such chronic daytime sleepiness in the general population are many and varied. Working long hours, working multiple jobs, and caring for young children are possible explanations. For many persons, however, chronic daytime sleepiness likely results simply from trying to fit too many activities into a 24-hour day and not valuing the importance of adequate sleep.

Acute Daytime Sleepiness

In addition to chronic daytime sleepiness, the general driving public can also experience acute episodes of sleepiness. Although they may get adequate sleep on a routine basis, individuals can have occasional nights when they stay up late, have difficulty falling asleep, or for some other reason get less than their usual amount of sleep. As a result, they also experience increased sleepiness the next day and a greater risk for involvement in a sleep-related crash. In their survey of North Carolina drivers involved in recent sleep-related accidents, Stutts et al. (1999) found that half had slept for fewer than 6 hours the night before their crash, and nearly one in five had slept for fewer than 4 hours.

Sometimes acute sleepiness occurs in addition to underlying chronic sleepiness. Coren (1996) examined Canadian crash data and found a significant increase in accidents the Monday following the change to daylight saving time and the loss of 1 hour of sleep time. The author suggested that even small additional losses of sleep in an already chronically deprived society could have consequences for public health and safety. Other researchers, however, have failed to substantiate an increase in crashes (Stewart 1985; Vincent 1998) and, overall, daylight saving time has been found to have a lowering effect on crashes due to increased daylight driving (Ferguson et al. 1995).

Sedating Medications

Taking medications that cause drowsiness also increases crash risk. Common medications that can cause drowsiness include benzodiazepine anxiolytics (used for treating anxiety and other stress-related disorders, as well as muscle spasms), tricyclic antidepressants (for depression), long-acting hypnotics (also for

depression and problems sleeping), and sedating antihistamines (for allergic reactions and cold symptoms) (Gengo and Manning 1990; Ray et al. 1992; Ceutel 1995; O'Hanlon et al. 1995; Van Laar et al. 1995; Barbone et al. 1998; Weiler et al. 2000). Risk is generally highest during the initial weeks of taking a new drug, and for higher dosages and drug combinations (Ray et al. 1992; Ceutel 1995; Neutel 1995).

Alcohol

Analysis of crash data reveals that alcohol is a factor in 15 to 20 percent of sleep-related crashes (Pack et al. 1995; Wang et al. 1996). Research has shown that alcohol and sleep loss interact synergistically to increase levels of sleepiness (Lumley et al. 1987; Zwyghuizen-Doorenbos et al. 1988; Dement and Vaughan 1999). Even modest sleep loss, when accompanied by alcohol, can result in significant decreases in performance and alertness (Lumley et al. 1987; Dement and Vaughan 1999). In driving simulator studies, the combination of low doses of alcohol and sleep loss produced performance decrements greater than their combined individual effects (Roehrs et al. 1994).

It has also been suggested that low levels of alcohol may interact with circadian factors to enhance drowsiness (Horne and Baumber 1991; Horne and Gibbons 1991; NHTSA 1998). Alcohol consumed in the afternoon, during the circadian nadir, produced greater performance impairments than the same amount consumed during evening hours (Horne and Gibbons 1991).

Driving Conditions

The effects of all of the above—chronic daytime sleepiness, acute sleepiness, sedating medications, and alcohol—can be exacerbated by driving conditions that encourage sleepiness. Such conditions include warm vehicles, long-distance driving, monotonous roadways, glare from the sun, driving alone, and driving at nighttime or in mid-afternoon when our bodies' circadian rhythms make us more inclined toward sleep. Only the last of these conditions has a physiological link to sleepiness; the rest are all situations that simply encourage underlying sleepiness to assert itself. As described in one sleep medicine text, "Heavy meals, warm rooms, boring lectures, and the monotony of long-distance automobile driving unmask the presence of physiological sleepiness but do not cause it" (Roth et al. 1994).

Special Populations

In addition to targeting populations at high risk for involvement in a sleep-related crash and the broader population of "average" drivers, education and awareness countermeasures designed to reduce sleep-related crashes can also be directed toward a variety of "special population" groups. A number of these are identified here:

- *Law enforcement personnel*—Educating police officers about the importance of identifying sleep-related crashes, and indicators for a sleep-related crash, can contribute to better data for understanding the nature and extent of the drowsy driving problem. It can also sensitize them to the need for public education and awareness activities, and may in some cases enlighten them to their own vulnerability.
- *Driver educators*—Most driver education curricula contain a great deal of information about the dangers of driving drunk, but little or nothing about the dangers of driving drowsy.
- *School administrators and teachers*—Recent federal legislation (the "Z's to A's Act") was introduced to encourage high schools to experiment with a later start time, allowing students to sleep longer in the mornings to increase their alertness and performance during the daytime. A side effect of the legislation might also be decreased crash involvement. Although the federal legislation was not passed, some individual school systems have already adopted a later high school start time in response to educational efforts by the medical community.
- *Physicians*—The American Medical Association recently adopted a policy encouraging physicians to become more knowledgeable about the diagnosis and management of sleep disorders; investigate patient symptoms of sleepiness; inform patients about the risks of driving or working while sleepy; advise patients about possible medication side effects that may impair driving; and inquire about sleepiness as a possible contributing factor to any motor-vehicle-related or other unintended injuries (Lyznicki et al. 1998).
- *Trucking industry*—The trucking industry is actively involved in efforts to reduce drowsy driving and drowsy driving accidents. Industry, government, and the private sector have developed educational campaigns and materials that directly target trucking companies and individual truckers.
- *Employers/unions*—Similarly, educational programs and materials aimed at workplace environments, especially those that employ shift workers, can be a particularly efficient approach for reaching large numbers of at-risk drivers.
- *State transportation and highway safety offices*—Ultimately, many countermeasures to reduce sleep-related crashes must be initiated by state transportation departments and offices of highway safety. Educating state officials about the importance of the problem and ways it can be effectively addressed are crucial.

PUBLIC EDUCATION AND AWARENESS MESSAGES

The specific message(s) to be conveyed by an educational program or campaign to reduce drowsy driving depends to a great extent on its intended audience. However, a comprehensive

education and public awareness program generally will include (1) information about the dangers of drowsy driving, (2) warning signs for drowsiness, and (3) appropriate actions to reduce the risk of a drowsy driving crash. Each of these program components is briefly highlighted in the following sections.

Dangers of Drowsy Driving

Statistics gleaned from crash as well as survey data can be used to underscore the risks associated with drowsy driving. In its "Drive Alert . . . Arrive Alive" campaign, for example, the NSF points out that each year at least 100,000 accidents involve driver drowsiness or fatigue as a principal causal factor. It also points to a recent Gallup Poll survey revealing that 52 percent of respondents reported driving while drowsy at least once in the previous year (Gallup Organization 1997; NSF undated). A brochure for the AAA Foundation for Traffic Safety's "Wake UP!" campaign begins with the statement that "Sleepiness slows reaction time, decreases awareness, and impairs judgement." This kind of information provides the foundation for the specific prevention messages to follow.

A number of researchers have suggested that drowsy driving educational campaigns should have as a goal changing the public mindset about fatigued or drowsy driving. Nelson (1997), for example, states that "Education and public awareness campaigns need to emphasize that 'immoderate indulgence of driving' is as dangerous to safety as 'immoderate indulgence of alcohol'." A goal of the AAA Foundation for Traffic Safety's drowsy driving educational efforts is "to make drowsy driving as socially unacceptable as drunk driving is today" (Willis 1996). Activist groups such as Parents Against Tired Truckers and Victims of Irresponsible Drowsy Drivers are helping to bring about these changes.

Convincing the target population that it is dangerous and wrong to drive while drowsy is critical, because all other education program components are rendered ineffective in its absence. Nilsson et al. (1997), discussing the subjective nature of fatigue, observe that "most readers may recall deliberately willing themselves to continue driving, overestimating their endurance, and ignoring various sensations that they would otherwise have heeded as signals to stop and rest." Itoi et al. (1993) note that "the fact that we are able to control our sleep-impulse to *some* extent and in *some* situations can easily be mistaken as an ability to control sleep indefinitely and in all situations." The willingness to respond appropriately to warnings of drowsiness—whether drooping eyelids, in-vehicle alarms, or the rumble of shoulder pavement markings—is key to preventing drowsy driving crashes.

Warning Signs of Sleepiness

There is some debate over whether drivers have adequate warning to prevent falling asleep at the wheel. Some argue that it is "almost impossible for a normal, sober person to fall asleep at the wheel without warning" (Mitler 1989; Horne and Reyner 1998). Others contend that drivers may not recognize their impending sleep in time to react (Brown 1993, 1994). When drivers involved in recent sleep-related crashes in North Carolina were interviewed, 23 percent reported that they had felt "not at all drowsy" immediately prior to their crash (Stutts et al. 1999). Among drivers of heavy trucks who admitted to having dozed off at the wheel, 10 percent said that they were never aware of pending problems, and 28 percent that they were only sometimes aware (Abrams et al. 1997).

A related issue is whether drivers can accurately assess how drowsy they actually are, and how likely they are to fall asleep. Several studies suggest that drivers have varied and limited abilities to predict the onset of sleep (Itoi et al. 1993; Filliatrault et al. 1996). A key conclusion of FMCSA's in-depth study of 80 long distance truck drivers was that drivers are *not* good judges of their levels of fatigue (Wylie et al. 1996).

These findings point to a need to better educate drivers about warning signs that they should recognize and heed. The following warning signs of fatigue were identified for the NSF's "Drive Alert . . . Arrive Alive" campaign (NSF undated). Drivers who:

- Can't remember the last few miles driven,
- Experience wandering or disconnected thoughts,
- Have difficulty focusing or keeping their eyes open,
- Have trouble keeping their head up,
- Drift from their lanes or hit a rumble strip,
- Yawn repeatedly,
- Tailgate or miss traffic signs, and
- Keep jerking their vehicles back into the lane.

Others have come up with slight variations on this list. Itoi et al. (1993), for example, concluded that yawning was not a good indicator of falling asleep; better indicators in this study were eye closure, head nodding, and hallucination/wandering thoughts. The "top five" indicators of sleepiness as reported by a survey of nearly 300 sleep experts were eyelid closures, inattention, yawning, inability to stay in lane, and disengagement from the environment (Nguyen et al. 1998). Regardless of the precise symptoms, it is important that drivers be educated to try to recognize these warnings and to take appropriate actions when they experience them.

Actions to Reduce the Risk of a Crash

Preventive Actions

Actions that drivers can take to reduce their risk of a sleep-related crash include both preventive and reactive measures. As noted in the NCSDR/NHTSA Expert Panel report on driver fatigue and sleepiness (NHTSA 1998), "preventing drowsiness

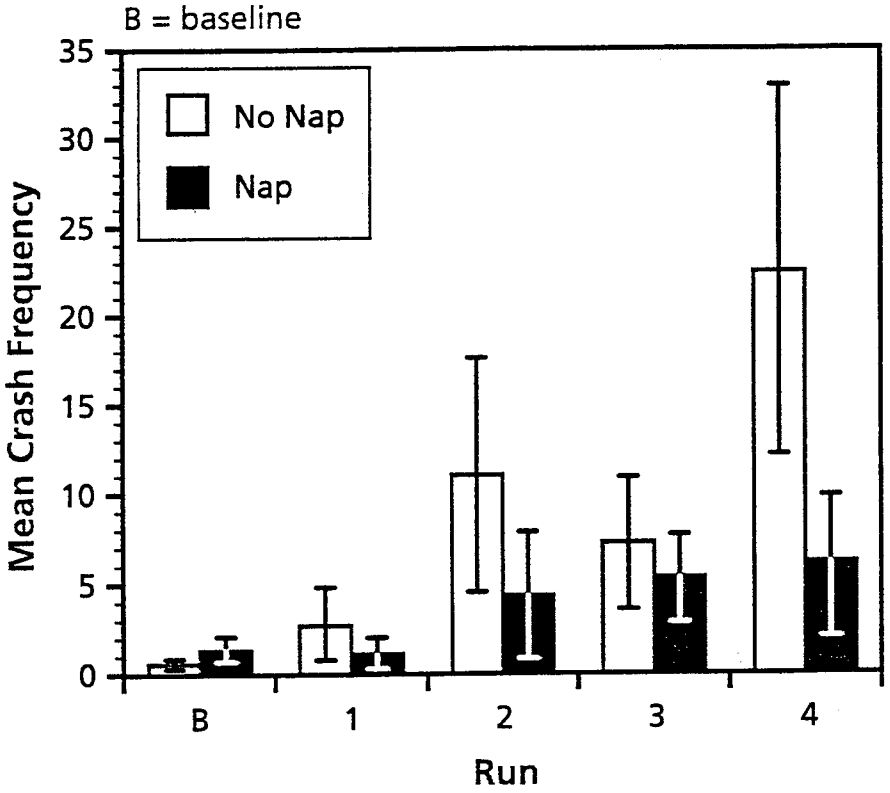


FIGURE 2 Results from Trucking Research Institute study showing positive effects of napping on driver simulator performance across increased periods of sustained wakefulness (TRI 1999).

with adequate sleep before driving is both easier and much more successful than any remedial measure reviewed." Although the panel recommended that all drivers practice good "sleep hygiene," they admitted that this recommendation was based more on intuition than sound scientific evidence.

Beyond practicing good sleep hygiene and making sure that one is adequately rested, a preventive measure that has been validated in the scientific literature is prophylactic napping (Dinges et al. 1987). Essentially, prophylactic napping involves taking a scheduled or planned nap in order to prevent becoming drowsy later on. In a recent laboratory study involving truck/bus drivers, a 3-hour afternoon nap was shown to increase subjects' nighttime alertness as well as driving performance [Trucking Research Institute (TRI) 1999] (Figure 2). Alertness was assessed using a variety of behavioral and physiological measures, while driving performance was assessed on a driving simulator. Results confirmed that prophylactic naps taken early within a long period of sustained wakefulness were more restorative than recuperative naps taken later, after onset of drowsiness (TRI 1999).

Similarly positive results have been reported in a number of National Aeronautics and Space Administration (NASA)/Federal Aviation Administration (FAA) studies (Rosekind et al. 1994b, 1995). In one recent study, pilots who took scheduled naps (lasting on average 26 minutes) on overnight flights were able to maintain higher levels of alertness and more consistent performance levels throughout their flights, when compared with pilots who had not napped (Rosekind et al. 1994b). In response to these and other studies, the FAA convened an industry/government working group "to draft advisory material to sanction controlled rest on the flight deck" (Rosekind et al. 1995).

In addition to prophylactic napping, another measure for preventing drowsy driving crashes is to schedule trips so that they do not involve nighttime driving (Mitler et al. 1988; Brown 1994). Although this measure has not been specifically validated in the scientific literature, it has a firm basis in known circadian periods of sleepiness. The majority of drowsy driving crashes are reported to occur between midnight and 8 a.m. (Knipling and Wang 1994; Pack et al. 1995).

Other preventive measures are recommended in the NSF's "Drive Alert... Arrive Alive" campaign. Beyond getting a good night's sleep, these include:

- Planning to drive long trips with a companion,
- Scheduling regular stops (every 100 miles or 2 hours),
- Avoiding alcohol and medications that may impair performance, and

- Consulting a physician if experiencing excessive daytime sleepiness, frequent difficulty sleeping at night, or loud snoring (NSF undated).

Given the relatively high prevalence of sleep disorders in the general population, and the fact that only a fraction of cases are ever diagnosed and treated, the last educational message is especially important. As noted earlier, effective treatments are available for many sleep disorders and these have been shown to dramatically lower the risk of crash involvement (Findley et al. 1992; Engleman et al. 1994; Haraldsson et al. 1995; Cassel et al. 1996; Wu and Yan-go 1996).

Actions for the Drowsy Driver

Once in a drowsy driving situation, the only certain approach for preventing a sleep-related crash is to stop driving. Drivers should be encouraged to stop driving and sleep before continuing their trip or to let a more alert passenger take over the driving.

If stopping driving is not a viable option, then two actions that can help on a short-term basis are to consume caffeine and to take a short nap. The NCSDR/NHTSA Expert Panel on Driver Fatigue and Sleepiness recommended drinking the equivalent of two cups of coffee, followed by a 15- to 20-minute nap (NHTSA 1998). Caffeine has been shown to significantly increase alertness in people who are sleepy (Lumley et al. 1987; Rosenthal et al. 1991; Kelly et al. 1997), but needs some time to take effect in the body. Napping has also been shown to be an effective intervention for sleepiness (Dinges et al. 1987; Gillberg et al. 1996; Horne and Reyner 1996). By drinking coffee first, then napping, the alerting effects of both can be combined for maximal impact (Reyner and Horne 1997).

In addition to caffeine, two other drugs also show promise for helping to combat drowsy driving. One is the drug melatonin, which may help reset the body's internal clock (e.g., following a cross-country flight), as well as facilitate the body's ability to sleep when it would normally remain awake (Arendt et al. 1987; Hughes et al. 1994; Sack et al. 1994). Another potential pharmacologic aid to sleepy drivers is the drug modafinil, a new stimulant compound with no known side effects. A recent French study showed the drug to be effective over longer periods of sleep deprivation, when recovery sleep was not an option. The drug was especially effective when combined with napping (Batéjat and Lagarde 1999). Additional research is needed to confirm the benefits of these or other pharmacologic aids to alertness.

A few other remedial measures have some limited support in the scientific literature. These include physical discomfort, such as might result from reducing the temperature inside the vehicle or sitting in an uncomfortable position, and nicotine use (NHTSA 1998). Other behavioral measures available to drowsy drivers—including listening to the radio, rolling down car windows, chewing gum, and stopping for light exercise—have not been confirmed in the scientific literature and at best have only short-term benefits (Lisper et al. 1986; NHTSA 1998; Horne and Reyner 1999).

There is ample evidence that the driving public, including commercial vehicle operators, is largely unaware of strategies that are, and are not, effective to combat drowsiness. Although drinking caffeinated beverages and napping are two strategies that are frequently cited, a large percentage of drivers also report relying on unproven strategies. When asked what they did when they found themselves in a drowsy driving situation, 49 percent of drivers in a recent North Carolina survey said that they rolled down the car windows or adjusted the air conditioner or heat and 32 percent said that they listened to the radio (Stutts et al. 1999). Similarly, heavy truck operators surveyed said that they cooled the truck cab, stretched or changed sitting positions, listened to the radio, talked on the citizen's band radio, chewed gum or ate candy, and sang (Abrams et al. 1997). A survey of Australian bus and coach drivers yielded similar responses (Feyer et al. 1993). Clearly, the driving public needs to be educated both about what works and what does not work to reduce their risk of falling asleep at the wheel.

APPROACHES TO PUBLIC EDUCATION AND AWARENESS

The approach that driver education and awareness programs take to convey messages about preventing drowsy driving and drowsy driving crashes reflects their identified target audience: programs directed at the general driving public can be quite different from those directed at specific subpopulations of interest, such as shift workers, persons with sleep disorders, or law enforcement officials. Frequently used approaches for the general driving public include public service announcements (PSAs); informational brochures and pamphlets for distribution by insurance companies, at driver licensing offices, or at highway rest areas; stories in the national and local media; and print ads (Figure 3). More focused campaigns might include these as well as individual mailings, assemblies, videos, conference presentations, and other targeted efforts. The important point here is that educational activities must be appropriate for their intended audience: young males need to be approached differently than truck drivers, and truck drivers differently than persons with sleep disorders.

It is also important that educational efforts are based on an understanding and appreciation of their target audience. In its cooperative program with the NCSDR to combat drowsy driving, the NHTSA has adopted a "social marketing approach" that seeks to establish "a thorough understanding of the target populations' level of knowledge, concerns about the issue, and desires for change" (NCSDR 1993; NHTSA website 1999).

FIGURE 3 Sample educational materials.

The summary of national and state/local education and public awareness activities that follows illustrates a wide variety of approaches.

PUBLIC EDUCATION AND AWARENESS ACTIVITIES AT THE NATIONAL LEVEL

Public education and awareness activities designed to combat drowsy driving at the national level have involved a high level of cooperation not only among department of transportation (DOT) agencies, but also between the public and private sectors. Most of these efforts are relatively new; reflecting that drowsy driving has only recently been recognized as a significant highway safety and public health problem. Many of the programs are "acts in progress." Following are highlights of those activities that specifically address public education and awareness. Program activities in other areas (e.g., technological countermeasures, roadway countermeasures) are reviewed in their respective chapters.

NHTSA/NCSDR Program to Combat Drowsy Driving

In 1996, the NHTSA teamed with the NCSDR of the National Heart, Lung and Blood Institute, National Institutes of Health, to respond to a Congressional mandate "to develop educational countermeasures to the effects of fatigue, sleep disorders, and inattention on highway safety" (NHTSA website 1999). The program has three major components: (1) workplace education for shift workers, (2) school-based programs, and (3) in-vehicle data-collection efforts to obtain performance measures related to driver inattention. A large number of individual projects have been undertaken as a result of this collaborative effort, including the convening of a panel of experts to produce the report "Drowsy Driving and Automobile Crashes," frequently cited in the current review (NHTSA 1998).

One of the recommendations of the Expert Panel report was to develop educational programs targeting young adults and shift workers. In response to this recommendation, the NHTSA conducted a series of focus groups with these two high-risk populations (Harvard School of Public Health 1997). The NHTSA ultimately opted to focus its attention on shift workers, whereas the NCSDR undertook the challenge of educating high school and middle school age students. (Efforts to address the needs of young males were put on hold, because this population appeared especially resistant to educational interventions.) Educational materials and implementation strategies for shift workers and their employers have been developed. The program is currently being evaluated at selected sites, with results anticipated by the spring of 2000.

In addition, the NCSDR and NHTSA have collaborated with Scholastic Magazine, Inc., to develop and distribute educational materials specifically for young audiences. These include materials for both students and teachers at the high school and middle school levels. Additional activities are planned in response to a workshop held to develop a national strategy for educating youth about sleep and drowsy driving that was hosted by the NCSDR in the fall of 1998 (NCSDR 1998).

Other planned activities include development of a program to address long-distance driving by young males, work with the FHWA to educate the public regarding the function of rumble strips and the appropriate response that drivers should take when they encounter these roadway features, and continued work on in-car devices to detect and warn drowsy drivers.

National Sleep Foundation Activities

The NSF operates as a nonprofit organization "dedicated to both the prevention of catastrophic accidents caused by sleep deprivation and excessive sleepiness and to enhanced quality of life for the millions of Americans who suffer from sleep disorders" (NSF website 1999). It creates and distributes educational brochures and newsletters, works to educate health care

professionals, sponsors special symposia, maintains a speakers' bureau and up-to-date website, promotes National Sleep Awareness Week, and engages in a wealth of other public outreach activities. The Foundation's "Omnibus Sleep in America" polls (The Gallup Organization 1997; Johnson 1998, 1999; NSF 2000), published annually since 1997, are tangible examples of its efforts to increase public awareness of the importance of sleep to a safe and healthy life.

The goal of the NSF's "Drive Alert . . . Arrive Alive" program is to increase public awareness of the dangers of driving while drowsy and reduce the number of accidents attributable to drowsy driving. Initial efforts were a cooperative venture between NSF and various agencies and organizations in New York, including the Institute for Traffic Safety Management and Research and the Governor's Traffic Safety Committee. After its inaugural launching in New York in 1993, the campaign was introduced at a national forum in Washington, D.C., in December 1994, and expanded nationwide in 1995. The NSF's goal is to increase public awareness and reach at-risk groups with programs in every state. It aims to accomplish this by creating working partnerships and collaborating with national, state, and local traffic safety organizations and agencies. Efforts have also been made to establish an international forum for addressing the problem of drowsy driving.

AAA Foundation for Traffic Safety

The AAA Foundation for Traffic Safety's "Wake UP!" brochure and accompanying audio tape takes a light approach to discussing such important topics as biological clocks, sleep debt, sleep disorders, and danger signals that someone should not be driving. The brochure provides a "sleep test" to dispel some common misperceptions about sleep and offers tips for driving alert and remaining alive. The brochure has been widely distributed to the general motoring public through state and local AAA offices and state highway safety offices. In addition, in collaboration with the NSF and American Trucking Associations, a version of the brochure, titled "Awake at the Wheel," has been made available to commercial vehicle operators.

The AAA Foundation also funded a research study to identify risk factors for driver involvement in a sleep-related motor vehicle crash, and to examine the issue of underreporting of sleep- and fatigue-related crashes in state motor vehicle crash files. The results of this research are documented in a final report available on the AAA Foundation website (www.aaafoundation.org) (Stutts et al. 1999).

Federal Highway Administration/Federal Motor Carrier Safety Administration

Most of the FHWA's/FMCSA's activities in the area of drowsy driving are directed at the development and testing of new technologies and regulatory measures to reduce drowsy driving, with a focus on commercial vehicle operation. Several recent activities, however, have relevance to education and awareness countermeasures for the general driving public. The recently completed "Driver Fatigue and Alertness Study" (Wylie et al. 1998) produced a number of intriguing findings about the causes of fatigue among truckers, the ability of drivers to recognize their fatigue, and individual differences in responses to fatiguing situations.

The FMCSA has also joined with the American Trucking Associations, the National Private Truck Council, and other industry partners to conduct a multi-faceted campaign to educate motor carriers, professional truck driver associations, truckers, and the general public about the hazards of driving while fatigued. The campaign is a comprehensive effort that seeks to reach all seven million of the nation's commercial driver's license holders. As part of the campaign, the FMCSA has provided funding to the TRI for several major public information and education (PI&E) initiatives. These have included "Awake at the Wheel" PSAs and print brochures distributed nationwide, and a video for educating truckers and their families about fatigue and the importance of adequate sleep. A train-the-trainer instructional program has also been developed for fleet safety managers and truck driver training personnel. These and other materials can be obtained by calling a toll-free number (1-800-ATA-LINE). The FMCSA is also working with the TRI and the NPTC to develop a model wellness program that can be used by both large and small companies to educate truckers and their families about the importance of sleep, diet, exercise, and lifestyle to work performance and to an overall state of wellness.

PUBLIC EDUCATION AND AWARENESS ACTIVITIES AT THE STATE LEVEL

To learn about public education and awareness activities at the state level, a series of questions (numbered 4–10) was included in a survey sent to all state transportation departments and provincial transportation agencies (see Appendix A). In addition, because activities of this nature are frequently carried out by state highway safety offices, a smaller survey focusing primarily on these questions was also sent to state highway safety offices (see Appendix B). A total of 43 states plus the District of Columbia responded to the surveys. This number includes 20 states that responded to the larger DOT survey only, 17 that responded to both the DOT and highway safety office surveys, and 7 that responded only to the highway safety office survey. In addition, survey responses were obtained from seven Canadian provinces. Detailed results from the survey are contained in Appendix C. The following is a summary of key findings.

State Activities

Of the 44 states (including the District of Columbia) responding, 26 (59 percent) reported engaging in some level of activity

over the past 5 years to raise public awareness and concern about drowsy driving. A number of states reported using materials and brochures developed by the AAA Foundation for Traffic Safety as part of its "Wake UP!" campaign, as well as materials from the NSF, Parents Against Tired Truckers, and the FHWA. Activities have ranged from focused, short-term events (television PSAs over a holiday period, an educational campaign tied to the spring shift to daylight saving time) to more comprehensive, long-term educational campaigns. Sample activities are highlighted here:

- Utah conducted a "You Snooze, You Lose!" campaign at Brigham Young University during the 1997–98 school year. The campaign built upon an earlier media-based effort, but also challenged students to communicate directly with one another about drowsy driving. Each residence hall president was asked to talk with five students on their floor about drowsy driving, and these students were in turn asked to talk with five more students, etc.
- Washington sponsored "The Western States Forum on Driver Fatigue" in November 1996. The goal of the forum was to increase awareness within the region about the issue of driver fatigue and to begin to develop effective intervention strategies. The forum laid the groundwork for continuing research and educational activities in the state.
- Vermont has developed extensive materials addressing sleep deprivation and drowsy driving for use in its driver education and traffic safety programs.
- South Carolina developed a PSA for television entitled "Nodding Off," which dramatically depicts what can happen when a driver chooses to continue driving while drowsy.
- Wyoming developed scripts for radio PSAs that could be recorded by Wyoming Highway Patrol officers and played on local radio stations.
- Pennsylvania partnered with the Schering Corporation, a pharmaceutical company, to develop a brochure, "Driving While Drowsy Can Be Hazardous to Your Health." The brochure has been widely distributed to drugstores.
- In Massachusetts, signs have been erected encouraging drivers to use rest areas.

By far the most comprehensive drowsy driving PI&E program has been undertaken by New York State. Beginning with the launching of the national "Drive Alert . . . Arrive Alive" campaign in the fall of 1993, followed by a statewide Highway Safety Forum on Fatigue, Sleep Disorders and Traffic Safety (Institute for Traffic Safety Management and Research 1993), New York has partnered with a broad array of state and Federal government agencies and private sector organizations to address the problem of drowsy driving (McCartt et al. 1998). Focus groups and several statewide surveys carried out in 1994 helped to identify key educational messages, target populations, and communication strategies. Two feature campaigns include the "Break for Safety" campaign implemented over the 1995 Thanksgiving and Christmas holiday weekends, targeting drivers traveling on the New York Thruway, and the "Choice is Yours" campaign targeting the general driving public. Other activities have involved wide distribution of a variety of informational materials, coupled with presentations at numerous local, state, and national conferences to reach highway safety professionals and members of the enforcement community. In addition to these statewide PI&E activities, several communities are conducting their own local programs to increase public awareness of the dangers of drowsy driving.

Overall, two-thirds of the states that reported engaging in drowsy driving public education and awareness activities indicated that they had developed and/or distributed brochures, posters, or other print materials. About one-half also reported each of the following:

- Developing/distributing PSAs for radio or TV;
- Developing press releases, holding news conferences, etc.;
- Making presentations, conducting conferences, holding training sessions, etc.;
- Working with trucking companies or commercial vehicle operators;
- Working with businesses, industry, etc.;
- Working with state/local government offices; and
- Working with state/local law enforcement personnel.

The majority of the activities attempted to convey some if not all of the following messages:

- Causes of drowsy driving,
- Individuals or groups at high risk for involvement in drowsy driving crashes,
- Dangers associated with drowsy driving,
- Countermeasures to reduce drowsiness while driving.

The targeted audience was most often the general driving public or the general driving public along with commercial vehicle operators. None of the identified programs targeted commercial vehicle operators only.

Key participants and sponsors of these various state PI&E activities have included state highway safety offices, health departments, state and local law enforcement agencies, AAA clubs, state trucking associations, medical centers, and numerous other public and private agencies and organizations. A key funding source has been Federal 402 funds, although again a variety of state and local government and private sources have been tapped.

It should be noted that although the states generally expressed enthusiasm for their activities, only New York indicated that it had collected any information on the effectiveness of its efforts.

Canadian Provincial Activities

Four of the seven Canadian provinces responding to the survey indicated that they had engaged in activities to raise public awareness and concern about drowsy driving over the past 5 years. These activities have primarily targeted commercial vehicle operators. Key participants in the activities have been Transport Canada, provincial branches of the Canadian Trucking Association, and provincial government and insurance companies. Some documentation of program effectiveness is available from Transport Canada. The province of Alberta is also joining with the Canadian Sleep Institute in a planned pilot project that will incorporate identified performance measures and evaluation criteria.

CHAPTER THREE

NEW TECHNOLOGIES FOR PREVENTING DROWSY DRIVING CRASHES

Education can help persuade drivers not to operate a motor vehicle when drowsy. However, research has shown that many drivers are unaware of their drowsiness, are not good judges of their likelihood of falling asleep, and/or do not make good judgments about their ability to continue driving safely (Brown 1993; Itoi et al. 1993; Filliatrault et al. 1996; Dinges and Mallis 1998). For these drivers technology offers other possible solutions. Although technology cannot reduce or eliminate fatigue, it can "defend the driver from the adverse consequences that fatigue can induce" (Hancock and Verwey 1997). New technologies also offer other potential benefits, including earlier detection and objective data-driven feedback. This chapter presents an overview of the types of technologies being developed and their future for preventing drowsy driving crashes.

AN OVERVIEW OF DROWSY DRIVING TECHNOLOGIES

Types of Technologies

There are many ways that technologies used to prevent fatigue- or sleep-related crashes can be categorized. One way is to categorize them by their purpose. Technologies have been developed to:

- *Monitor* or *detect* drowsy driving,
- *Alert* or *warn* drowsy drivers, and
- Help drowsy drivers *maintain alertness.*

Another approach to categorizing drowsy driving technologies is in terms of how they operate. Technologies can be

- Driver-based,
- Vehicle-based, or
- Roadway/environment-based.

In practice there is considerable overlap among these categories, because technologies tend to be conceived and developed as part of a larger fatigue management system. Also, an operator-oriented system can be either driver- or vehicle-based, or a combination of both.

Basis in Commercial Vehicle Operation

The development of new technologies to help manage driver fatigue has occurred largely in the realm of commercial vehicle operation. Although less than 4 percent of drowsy driver crashes involve heavy trucks, heavy truck crashes are more likely than passenger car crashes to involve driver fatigue, and they tend to be especially severe (Rau 1999; FMCSA 2000). In addition, operators of commercial vehicles have a greater absolute likelihood of being involved in a drowsy driving crash because of their increased exposure.

Economics is also a factor in the focus on commercial vehicle operation. Many of the new technologies are expensive, and although their costs can be expected to decline, at least for now the challenge is first to make them economically viable in the commercial market. Government regulation may also play a role, as technologies for detecting and monitoring drowsy driving are seen by some as a supplement, or even an alternative, to current commercial vehicle operator hours-of-service regulations.

The focus of this document is on countermeasures designed to reduce drowsy driving crashes among the general driving public. The assumption being made is that at least some of the technologies currently being developed and marketed for the commercial vehicle fleet have potential application in the non-commercial vehicle fleet (Knipling 1998).

Dinges and Mallis (1998) list four major types of fatigue-monitoring technologies that have been developed for use with commercial vehicle operators. They include:

- *Readiness to perform/fitness for duty technologies*—This might include, for example, a short computer-based test of functional abilities that a driver must complete before initiating a trip.
- *Mathematical models for predicting alertness*—These typically involve computer algorithms that take into account hours on duty, hours slept the previous night, time of day, and other variables known to influence operator alertness.
- *Vehicle-based driver monitoring systems*—These typically collect continuous real-time data pertaining to operator behavior (eye blinks, head nods, facial expressions, etc.) or physiology (heart rate, brain activity, etc.).
- *Vehicle-based driving performance technologies*—These measure the status of the operator's vehicle. Example measurements include lane departures, vehicle speed, and steering wheel movements.

All four of these categories of fatigue-monitoring technologies have potential application in workplace settings other than commercial vehicle operation, and among the general driving public as well.

TABLE 2

SCIENTIFIC, PRACTICAL, AND LEGAL CRITERIA AND QUESTIONS REGARDING THE DEVELOPMENT AND USE OF TECHNOLOGIES FOR MONITORING OPERATOR VIGILANCE OR IMPAIRMENT (Dinges 1997)

Criteria	Development Questions
Scientific/Engineering	
Validity	Does it measure what it purports to measure, both operationally (e.g., eye blinks) and conceptually (e.g., hypovigilance)?
Reliability	Does it measure the same thing consistently?
Generalizability	Will it measure the same event (operationally and conceptually) in everyone?
Sensitivity	What proportion of the persons (or times within a given person) does it detect when reduced vigilance is actually present? (Does it miss some hypovigilance or some hypovigilant persons?)
Specificity	What proportion of the persons (or times within a given person) does it correctly identify safe vigilance when it is actually present? (How often does it false alarm?)
Practical/Implementation	
Ease of use	Can nearly everyone use it correctly?
Acceptance	Will the target population use the technology?
Unobtrusiveness	Is the technology "transparent" or convenient for the user?
Robustness	Can the technology withstand heavy use and/or abuse?
Economical	Is the technology cost-effective?
Implementation	Operationally, how is the technology to be used? (For example, does it only detect reduced vigilance conditions? Does it also alert the operator? If it alerts the operator, what is the nature of the alert? Does it trigger a broader countermeasure response?)
Legal/Policy	
Purpose	What is the goal of implementing the technology? Is the use of the technology mandatory? If so, who mandates it and for what purpose?
Privacy	Who has access to any data acquired by the technology?
Enforcement	Is the technology to be used for enforcement, compliance, or advancement/demotion? If so, how is this to be accomplished?
Misuse potential	Can use of the technology lead to misuse (1) by the person being monitored (e.g., continuing to operate while impaired); (2) by the mandating entity (e.g., requiring an operation to continue when impairment is present).
Liability	Who is liable if the technology fails to detect impairment or if it is misused in association with an adverse event?

The Technology Development Process

In discussing the potential for technological solutions to problems of fatigue management, Dinges (1997; also Dinges and Mallis 1998) makes a strong case for adhering to rigid standards for development. Table 2 summarizes some of the criteria that technologies must meet before they are ready for commercial application, and certainly before they should be considered for public promotion. (The table specifically addresses operator-monitoring technologies in a commercial setting, but the same basic criteria could be applied to other technologies, such as driver warning and alertness maintenance devices, used in other settings.) Currently, most technologies are in the prototypical development, validation testing, or early implementation stages. For all technologies, however, there should be a clear progression from the scientific/engineering validation phase, through the practical implementation phase, to the public policy phase (Dinges and Mallis 1998).

One of the problems in trying to document available technologies is that many of the technologies are being developed in a proprietary context, and scientific data to support their claims are either unavailable or lacking. As expressed by one researcher:

> Given the growing federal support for technology development in fatigue management (the facilitators), the entrepreneurial zeal currently overtaking technology companies in the area (the vendors), and the escalating attractiveness of fatigue management technologies to transportation industries (the buyers), there is a risk of a rush toward widespread use of technologies that do not reliably detect fatigue. At this time, more proactive and coordinated efforts are urgently needed among relevant governmental agencies, transportation industries, and the scientific and engineering communities to ensure that promising technologies for fatigue management meet minimum standards for the criteria outlined [in Table 2] (Dinges and Mallis 1998).

The technologies discussed in the current chapter have all been subject to a rigorous development process that has been documented in the published literature.

REVIEW OF EXISTING TECHNOLOGIES

Within the three categories of technologies designed to prevent drowsy driving crashes, the greatest attention has been given to technologies for detecting drowsy driving. Technologies for warning the driver and for helping to maintain alertness are less well developed. This reflects the natural progression in the development of an overall fatigue management system—detection must precede efforts to alert or awaken. Questions of how best to alert and awaken drowsy drivers are typically dealt with as part of the larger issue of how monitoring systems should

interface with the driver. Clearly, however, detecting, warning, and maintaining wakefulness are each important components in managing driver fatigue.

Technologies to Detect Drowsy Driving

Many different technologies have been examined to detect drowsy driving. These technologies typically involve some level of real-time monitoring of the driver, the vehicle, or some combination of both. Technologies that focus on the driver will be reviewed first.

Driver Monitoring Technologies

Technologies designed to detect declines in driver alertness due to drowsiness or fatigue have involved monitoring the driver's physiological state (heart rate, brain activity, etc.), as well as behavior (head movements, eye movements, yawning, etc.) or performance (lane deviations, speed variability, etc.). In simulator studies there has been a high correlation between physiological and behavioral deterioration in the fatigued or drowsy driver (Knipling 1998). However, analyses of over-the-road performance data from commercial vehicle drivers have shown much lower correlations between biobehavioral and performance measures, because deliberate or strategic driving in the real world is a large component in the variability seen in performance measures such as lane keeping (Rau 1999).

Monitoring alertness through physiological or behavioral measures is not a new phenomenon; eyeblink frequency, for example, was studied in relation to visual alertness as early as the 1920s, and was studied in the context of simulated truck driving in the 1970s (Stern et al. 1994). What is new, however, is the potential for applying such technology to a real-life, everyday problem, such as fatigued or drowsy driving. This is possible because of the tremendous advances that have been made in recent years to make driver monitoring technologies smaller, more affordable, and generally more practical to implement.

Dinges and Mallis (1998) give examples of biobehavioral measures that have been used alone or with other measures for on-line monitoring of alertness. The types of measurements identified include:

- videos of the face (may include eyelid position, eye blinks, eye movements, pupillary activity, facial tone, direction of gaze, head movements),
- eye trackers,
- wearable eyelid monitors,
- head movement detectors,
- EEGs (electroencephalograms, for tracking brain waves), and
- ECGs (electrooculograms, for tracking eye movements).

The example technologies identified for each of these types of measurements include many that were privately developed, but which have been documented in the published literature and in various conference proceedings (such as the 1996 Technological Conference on Enhancing Commercial Motor Vehicle Driver Vigilance, jointly sponsored by the American Trucking Associations Foundation, the FHWA, and the NHTSA).

One technology that appears particularly promising is PERCLOS, a measure of the *per*centage of eyelid *clos*ure over the pupil, over time. Initial research leading to this methodology was carried out by Wierwille and colleagues at the Virginia Institute of Technology (Wierwille et al. 1994). A follow-on study, carried out at the University of Pennsylvania, evaluated the validity, sensitivity, and reliability of PERCLOS and five other technologies: two electroencephalogram algorithms for detecting changes in brain wave activity, two eye blink monitors, and a head-position monitoring device (Dinges et al. 1998; Mallis 1999). Subjects were required to perform a computerized psychomotor vigilance task after various periods of wakefulness. Only PERCLOS correlated highly with attention lapses both within and between subjects. Based on this research, the percentage of time that eyes are at least 80 percent shut is considered by the FHWA and the NHTSA to be the most promising real-time measure of driver alertness for in-vehicle monitoring systems.

In a related study, an "eye tracker system" was used to examine a variety of ocular measurements (including partial eye closure) that might be used singly or in combination to predict driver alertness (FMCSA 1999; Stern and Ranney 1999; TRI 1999). The following six parameters were all shown to be potential candidates for detecting drowsiness:

- Blink duration,
- Blink frequency,
- Partial eye closures (measured here as the ratio of vertical to horizontal pupil diameter),
- Full eye closures,
- Saccade frequency (rapid eye movements), and
- Larger scale head and body movements.

Again, partial eye closure appeared the most promising. Not only was it associated with decreased alertness, but clear changes could be detected 2 to 3 minutes before subjects incurred an "accident" on the truck driving simulator, and likely changes were present 10 to 12 minutes before such "accidents." This finding makes partial eyelid closures (i.e., PERCLOS) an especially valuable early indicator of driver fatigue.

Research on PERCLOS has continued, with the Intelligent Vehicle Initiative joining with the NHTSA and the FHWA to fund a project at the University of Pennsylvania and Carnegie Mellon Research Institute to develop the driver–vehicle interface system for PERCLOS and similar commercial vehicle driver alertness monitors. Efforts are also underway to develop a non-

video-based technology as a very low-cost front-end PERCLOS sensor, and to develop a "second-generation" PERCLOS camera that will be able to provide real-time driver feedback (P. Rau, NHTSA Office of Human Centered Research, personal communication, February 2000).

Vehicle Monitoring Technologies

In addition to monitoring the driver to detect drowsy driving, a second option is to monitor the vehicle that is being controlled by the driver. Candidate measures include:

- Vehicle speed
- Accelerator/pedal angle
- Steering wheel movements
- Lane position
- Lane excursions
- Following distance

Vehicle measurements have several advantages over driver measurements, which may also lead to their more rapid assimilation into the noncommercial vehicle fleet. They have greater face validity, are less obtrusive, and are likely to meet with less resistance from the public (commercial as well as noncommercial operators). They also are a natural extension of our nation's ongoing efforts to create more "intelligent" vehicle and highway systems.

Again, a fairly extensive body of literature exists on the potential usefulness of particular technologies or measures for detecting impaired driver performance (see, for example, Filliatrault et al. 1996 and Wylie et al. 1996 for reviews). A 1994 study carried out using a high-fidelity, fully interactive driving simulator showed that drivers tested after being awake for 36 hours and again after being awake for 60 hours recorded more crashes, greater lateral placement variance, more lane excursions, and higher average speeds (Peters et al. 1994). The authors concluded that lane excursions occur too late and have too significant safety implications to be useful measurements for avoiding fatigue-related crashes. Instead, they recommended that lateral lane variance form the basis for an early detection system. Measurements of lane deviation have been explored extensively as a direct performance indicator of drowsiness, in combination with PERCLOS, in the development of the NHTSA's drowsy driver detection system (Wierwille et al. 1996; Wierwille 1999).

Steering wheel movements have also shown promise as an early indicator of impaired performance (Bishop et al. 1985; Petit et al. 1990; Filliatrault et al. 1996). In a study that involved long-haul truck drivers operating an instrumented truck on a closed-circuit track (Siegmund et al. 1995; Filliatrault et al. 1996), micromovements of the steering wheel provided the best advance indication of lane departure. Several other vehicle-based measures, including vehicle speed, accelerator angular velocity, and car-following distance, were not significantly associated with lane deviation. The authors noted that "relatively high and long duration [steering wheel] deviations followed by rapid corrections seemed most indicative of control problems" (Filliatrault et al. 1996).

In general, it is believed that some combination of biobehavior and performance measures are important components of an overall drowsy driver monitoring and detection system (Grace et al. 1999; Wierwille 1999). However, a performance measure alone is not sufficient to predict drowsiness (P. Rau, NHTSA Office of Human Centered Research, personal communication, April 2000).

Technologies to Alert or Warn the Driver

Once driver drowsiness or other performance impairment has been detected, the logical follow-on is to emit some message or warning to the driver, with the assumption that the driver can then take appropriate corrective actions to avoid a crash. Just what this warning message should entail and how it should be delivered is still a matter requiring considerable research and debate (Knipling 1998). It is also one that needs to be addressed within the much broader context of overall system–driver interface. Following are some of the questions that need to be answered:

- How should messages be displayed or presented? Which are more effective, visual or auditory messages? Which interfere least with other driving tasks?
- How often should messages be displayed or presented? Continuously? Intermittently? Only when warranted by dangerous driving behavior?
- What should be the function of the message? Should it simply provide information (e.g., current level of alertness) or should it also advise or warn the driver?
- Should all drivers receive the same messages or should messages be tailored to "norms" set by the individual driver?

Field research has recently been completed to help guide the driver–vehicle interface for a PERCLOS-based monitoring system within the commercial vehicle environment. As part of this project, actual monitoring systems were put into place in test vehicles and their real-time performance evaluated (Grace et al. 1999). Additional work has been carried out using driver simulators to evaluate various interface systems. The system will be further refined based on input from overnight express drivers who have the systems installed in their cabs.

In developing its own answers to how drowsy drivers can best be alerted to potentially dangerous situations, the United States can take advantage of research that has been carried out in other countries. For example, in Europe, the Generic Intelligent Driver Support project, involving a partnership of six

European Union countries, has tried to address the problem of driver overload, which could result from trying to attend to an increasing number of support/communication/entertainment and other applications that will soon be available in personal vehicles. The Generic Intelligent Driver Support system tries to prevent driver overload by presenting messages via different sensory mechanisms (e.g., a slight torque at the steering wheel) and by scheduling the timing of the message (Hancock and Verwey 1997).

Another driver monitoring and warning system referred to as DAISY (Driver Assisting System) under development in Germany is able to adapt its warning messages to thresholds that have been determined acceptable to the driver, thereby increasing driver acceptance of the system (Onken and Feraric 1997). More recently, a European consortium was formed with the specific goal of developing a centralized vocal management system to improve automotive safety. The system will take into account the immediate complexity of the driving task and demands on the driver in determining when and how to safely relay information (INRETS 1998).

Technologies to Maintain Alertness

A variety of technologies have been examined as possible aids in maintaining or reestablishing alertness. Most of these have met with limited success; a finding that reflects the inherent biological difficulty in overcoming the body's physiological need for sleep with anything other than sleep itself.

In the study by Peters et al. (1994) described earlier, in which subjects were deprived of sleep for up to 60 hours and tested on a driving simulator, subjects who "crashed" their simulator vehicles were alerted or awakened by a loud "crashing" noise. However, this noise was not found to be effective in preventing subsequent crashes. The authors conclude that "highway design aids that use noise or motion to alert/awaken drivers (such as rumble strips), although sufficient to instantaneously alert or awaken the driver, might not be sufficient to maintain continuing alertness in those with further distance to drive" (Peters et al. 1994).

When evaluating PERCLOS along with several other driver drowsiness-detection measures, researchers also examined whether two alerting stimuli—three recorded messages received through headsets or vibrotactile stimuli delivered through a hand-held box—improved performance on their psychomotor vigilance test (Dinges et al. 1998; FMCSA 1998). The stimuli were delivered systematically and were not contingent upon test performance. Results of the experiment showed that the stimuli did not improve performance "beyond the minute in which the alert occurred, suggesting only a narrow window of opportunity for a drowsy driver to safely leave the roadway."

As with warning devices and driver–vehicle interface systems in general, much of the work to produce a more "intelligent transportation system" (ITS) has carryover to the development of fatigue management systems. Desmond and Matthews (1997), for example, suggested that the reason fatigued drivers had more lateral control errors on straight rather than curved sections of road was because they did not match their level of effort to the demand of the task. The authors contend that having drivers perform a secondary task, such as monitoring an in-car navigation system, may lessen driver fatigue when driving task demands are low. ITS developments may also by-pass the "driver alerting" stage altogether, for example, by producing vehicles that safely stop themselves on the shoulder of the roadway if the driver experiences a critical loss of performance (Hancock and Verwey 1997).

Overall, the literature suggests that alerting technologies that operate for only a short-time (e.g., a loud noise, seat vibration, blinking light) are unlikely to have anything more than a short-term effect on a driver's level of alertness. Also, although longer duration interventions (e.g., piquant aromas, cooled air, supplemental task performance) may be somewhat more effective, one might argue that the goal should only be to keep drivers awake long enough to get them safely to a place where they can stop driving, pull off the road, and sleep.

Beyond the specific stimulus to be administered, there are many issues that must be addressed within the overall framework of a driver fatigue management system. Knipling (1999b) notes that although alarms and alerting stimuli may well be employed effectively in future years

> at present there are fundamental, unanswered ergonomic issues relating to their use. Major questions relating to the design of alarm and alerting stimuli, and even whether such stimuli are advisable, include decision/contingency issues relevant to thresholds (e.g., false alarms, hits, misses), possible inducement of compensatory risk-taking (e.g., drivers persisting in driving until alarms and alerts are triggered), and the potential distracting effects of alarms and alerting stimuli.

Given these constraints, Knipling advocates that the current focus of alertness monitoring system development should be limited to providing drivers an "alertometer gauge," or real-time in-vehicle display of their level of alertness (Knipling 1999b). With this information, it would be left to individual drivers to decide whether, and how, they should increase their alertness. The overall concept is one of "Behavior-Based Safety" that seeks to engage individuals in the overall process of monitoring and modifying their behaviors (see also Krause 1999). The same principle applies to another alerting device, termed an "actigraph." Actigraphs can be worn on the wrist and provide feedback on how well rested one is based on generated rest/activity data and performance prediction models (Rogers 1999).

TABLE 3
MONETARY ESTIMATES OF THE U.S. DROWSY DRIVING/FATIGUED CRASH PROBLEM (Source: Knipling 1998)

Monetary Statistical Metric		Vehicle Type Category ($)		
		All Vehicles	Combo-Unit Trucks	Single-Unit Trucks
Total annual U.S. monetary cost*	E	3.8 B	280 M	32 M
	C	12.5 B	765 M	87 M
Per police-reported crash cost	E	34 K	87 K	48 K
	C	120 K	234 K	127 K
Crash cost per registered vehicle annually*	E	20	170	10
	C	68	470	20
Crash costs per vehicle operational life cycle*	E	220	2,060	90
	C	730	5,600	240

*Inflated by 50% for presumed undercounting in the General Estimates System (GES). E, economic value of crash consequences; C, comprehensive value of crash consequences (includes valuation of human consequences beyond economic loss, i.e., loss of life, pain, and suffering); B, billion; M, million; and K, thousand.

CHALLENGES AND ISSUES FOR TECHNOLOGICAL COUNTERMEASURES

Although considerable work has been carried out in developing technologies for preventing drowsy driving crashes, clearly much remains to be accomplished, especially before these technologies can be implemented in the general driving population. The last few years have witnessed tremendous progress, however, and this progress can be expected to continue in the near future. Some of the challenges and issues that will need to be addressed are presented here.

Challenges for "Practical Implementation"

There are many challenges to developing technological countermeasures for preventing drowsy driving crashes. Beyond the challenges of devising measures for the prevention of drowsiness that are valid and reliable and that have acceptable levels of sensitivity and specificity, one must also consider what is needed for that technology to "work" in the real world. These are the "practical/implementation" concerns identified previously in Table 2. To be practically useful a technology must be easy to use, acceptable to the driver, unobtrusive, robust (i.e., not prone to breakdown or malfunction), and economical. These are where the greatest challenges lie, both with respect to commercial vehicle operators and drivers of private vehicles. Real-world data, such as that collected as part of the FHWA's recent "Driver Fatigue and Alertness Study" (Wylie et al. 1996), is critical to the continued development and evaluation of driver monitoring and fatigue management systems.

To a great extent these are marketing challenges. Simply put, there will be no market for a system that the public does not perceive as beneficial, reliable, and cost-effective. The cost issue is especially challenging. Knipling (1998) analyzed General Estimates System crash data and found that even though combination trucks represent a relatively small portion of vehicles involved in drowsy or fatigued driver crashes, their per-vehicle crash costs were many times higher than such costs for other types of vehicles. This was true both when calculated on the basis of crash costs per registered vehicle annually and crash costs per vehicle operational life (Table 3). Knipling concluded that "a positive benefit/cost ratio will be much easier to achieve for combination-unit trucks than for any other vehicle type." He projected that a cost of about $1,000 per vehicle lifetime "seems to be a reasonable target price for these devices" (Knipling 1998).

The question remains as to whether fatigue management technologies will find a market in the general driving population. The greatest potential likely lies in simpler devices, such as the alertometer or actigraph described earlier. If these types of systems were available at a reasonable cost, they might initially be marketed to certain high-risk populations, such as persons with sleep disorders, military personnel, or those engaged in shift work.

Concerns for Misuse

One of the greatest concerns in making these technologies available—either to commercial vehicle operators or to the general driving public—is that they will be misused. Rather than responding to an alarm by stopping to get some rest or letting someone else take over the driving, there is concern that some drivers may rely on the system to keep them awake while they continue driving (see e.g., Summala and Mikkola 1994; Brown 1997; Dinges and Mallis 1998; Knipling 1998). (The same concern exists with respect to rumble strips, as discussed in chapter 4.) This is not a new concern in the highway safety field: issues of risk taking and risk compensation have been raised with respect to many other countermeasures, including seat belts, motorcycle safety helmets, and even larger and heavier vehicles (Wilde 1994; Vincent et al. 1998).

Although potential for misuse is a concern, Dinges and Mallis (1998) argue that it is not a reason for prejudging a technology "that can potentially enhance safety and save lives."

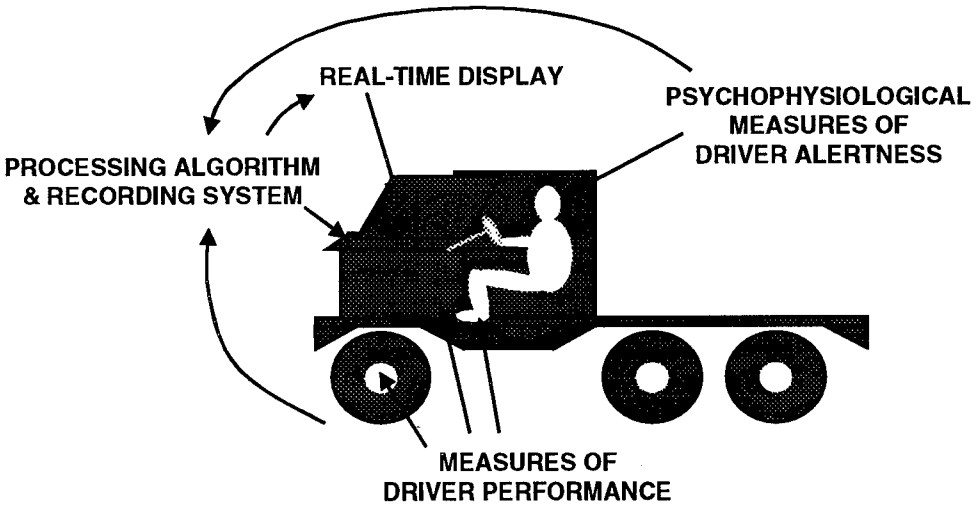


FIGURE 4 Schematic of FHWA/FMCSA's system concept for continuous in-vehicle monitoring (adapted from Knipling 1998).

The authors argue that "education, legal, and policy standards for implementing fatigue-monitoring technologies be developed in parallel with the engineering and scientific development of the devices" (Dinges 1997; Dinges and Mallis 1998). Indeed, the assumption guiding the FHWA/FMCSA's drowsy driver fatigue research program is that "driver behavioral adaptation to in-vehicle alertness monitoring will be markedly positive, especially over the long term" (Knipling 1998). They plan to test this hypothesis with commercial vehicle operators, evaluating the effects of a combined program of performance measurement and feedback, incentives, and education and training (Knipling 1998) (Figure 4).

A Final Caution . . . and Challenge

David Dinges offered a final caution in a presentation at the 1997 Managing Fatigue in Transportation conference. In his concluding remarks, he urges that technological development not be used as a substitute for setting standards for the functional capability of the vehicle operator. He stated:

> This point is perhaps best made with an analogy to another risk factor. Imagine a technology was developed that could absolutely prevent 98 percent of all alcohol-related crashes, and that it was to be installed in all modes of transportation. With this super device in place, would we, as a culture, accept the premise that henceforth it was acceptable for people to drive drunk? This is the ultimate issue we face in the fatigue area as well. Technologies may eventually prevent or limit certain catastrophic outcomes due to fatigued performance, but technologies are not substitutes for setting societal standards for the functional capability of an operator. On the other hand, technologies can help establish and maintain adherence to that standard if they are developed and used in a valid and responsible manner (Dinges 1997).

The challenge is both clear and compelling.

CHAPTER FOUR

ROADWAY COUNTERMEASURES TO PREVENT DROWSY DRIVING CRASHES

A common type of drowsy driving crash involves a single-vehicle traveling on a high speed, rural roadway; the vehicle runs off the roadway, usually without any evasive action being taken by the driver (Knipling and Wang 1994; Pack et al. 1995). Roadway countermeasures to prevent drowsy driving crashes are primarily oriented toward reducing these types of run-off-road events. By far the most successfully employed of these roadway countermeasures is the continuous shoulder rumble strip (CSRS). This chapter reviews what is known about the current use and effectiveness of CSRSs, along with other roadway-oriented countermeasures for preventing drowsy driving crashes. A final section summarizes current U.S. and Canadian practice, drawing from the results of the survey carried out as part of the current synthesis project.

CONTINUOUS SHOULDER RUMBLE STRIPS

What They Are and How They Work

Rumble strips are raised or grooved patterns placed in the paved surface of a roadway that produce both noise and vibration when a vehicle's tires travel across them. When placed in a travel lane—for example, at the approach to an intersection, a dangerous curve, a narrow bridge, a toll plaza, or a work zone—they warn the driver to slow down and use caution. When placed on the shoulder of a roadway, they alert drivers that they have drifted off the roadway, hopefully in time to recover and return safely to the travel lane. The focus of this chapter is on this latter type of rumble strip, placed more or less continuously along the shoulder of a roadway to alert drivers who are in danger of a run-off-road crash.

Several good descriptions and design guidelines exist for the construction and placement of shoulder rumble strips [see, for example, *NCHRP Synthesis 191: Use of Rumble Strips to Enhance Safety* (Harwood 1993) and information on the FHWA rumble strip web page at http://safety.fhwa.dot.gov/rumblestrips/]. In addition, in conjunction with the development of its guidelines, New York State conducted a survey of standards and practices in the United States and Canada. Results of this survey are summarized in a report by Morgan and McAuliffe (1997).

There are four basic types of rumble strips: rolled, milled, formed, and raised. Most shoulder varieties are grooved patterns that are either rolled into the hot pavement during initial construction or resurfacing, or milled (cut) into an existing shoulder (Garder and Alexander 1994; New York State Task Force 1994). Rumble strips can vary across any number of dimensions, including the length and width of the groove, depth of the groove, spacing between grooves, and distance that the grooves are offset from the edge of the roadway. Common dimensions for rolled-in rumble strips are: length, 600 to 1000 mm (2 to 3 ft); width, 38 to 100 mm (1 1/2 to 4 in.); depth, 13 to 25 mm (1/2 to 1 in.); spacing between grooves, 200 to 300 mm (8 to 12 in.); and distance offset from roadway, 0 to 750 mm (most often 12 in.) (Morgan and McAuliffe 1997). Milled-in rumble strip grooves are generally not as long but are wider. Common dimensions are: length, 400 mm (16 in.); width, 175 mm (7 in.); depth, 13 mm (1/2 in.); spacing between grooves, 300 mm (12 in.); and distance offset from roadway, 100 to 450 mm (4 to 18 in.) (Morgan and McAuliffe 1997). Figure 5 shows examples of rumble strips in place on the roadway and Figure 6 provides example guidelines for the milled-in and rolled-in rumble strips.

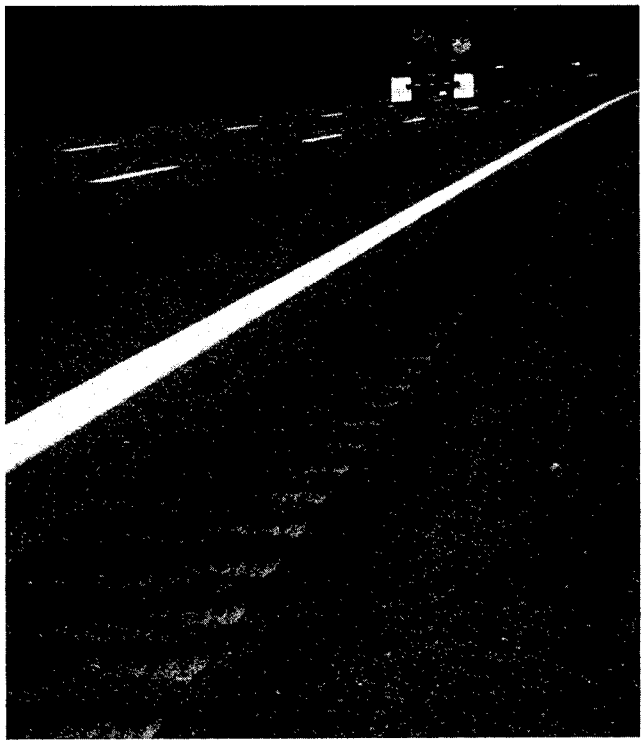
Rumble strips were first installed on the Garden State Parkway in New Jersey in 1955 (Harwood 1993). However, it is only in the past decade that the majority of states have adopted policies that require or encourage their use, primarily on rural interstate and interstate-like roadways. Earlier rumble strips were generally of the rolled variety, but milled strips have become more common because of their greater flexibility and ease of installation.

Effectiveness of the CSRSs

Some of the earliest evaluations of the effectiveness of CSRSs were carried out by the California Department of Transportation (Caltrans). In the early 1970s, the department installed three different types of CSRSs—parallel strips of aggregate, raised circular pavement markers, and parallel slots cut into the shoulder surface—onto the shoulder of a segment of highway and had volunteer drivers travel over them in an instrumented van for periods of up to 5 hours (O'Hanlon and Kelley 1974). The results of this early test showed the parallel aggregate strips to be the most effective in arousing drivers when they ran off the road. None of the configurations, however, proved effective in preventing run-off-road crashes when tested along a 36-mile segment of actual roadway (Tye 1976).

In the two decades since this early evaluation, a number of changes have been made in the design and placement of

(a)



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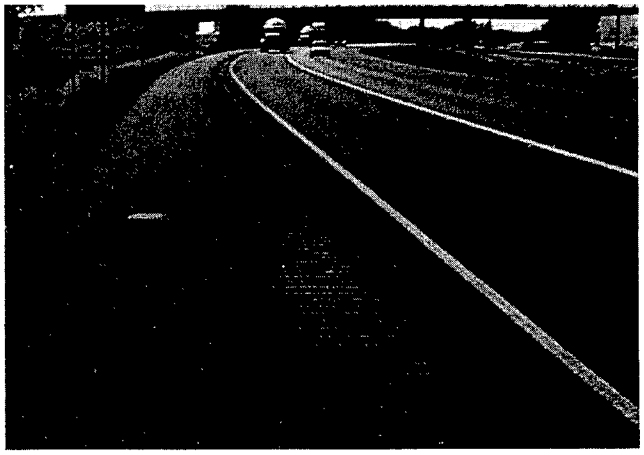


FIGURE 5 *(a)* Milled-in rumble strips on roadway shoulders *(courtesy Jim Growney, FHWA); (b)* rolled-in rumble strips on roadway shoulders *(courtesy Troy Bucko, California DOT).*

CSRSs, and numerous studies now confirm their effectiveness in preventing run-off-road crashes. These studies are briefly summarized here:

- *California*—Examination of before/after data for sections of Interstates 14 and 40 in San Bernardino County where rumble strips were installed showed a 49 percent reduction in single-vehicle run-off-road crashes. Overall crashes declined 19 percent (Chaudoin and Nelson 1985). A recent follow-up evaluation conducted by Caltrans for freeway segments where shoulder rumble strips had been in place for 3 or more years indicated an average statewide reduction in run-off-road crashes of 33 percent (FHWA rumblestrip website).

- *Multistate analysis*—Ligon et al. (1985) analyzed before/after data from 10 sites in 5 states (Arizona, California, Mississippi, Nebraska, and North Carolina), where CSRSs had been installed. The authors found an overall 20 to 30 percent reduction in single-vehicle crashes attributable to CSRSs (a 20 percent decrease at the test sites compared with a 9 percent increase at control sites).

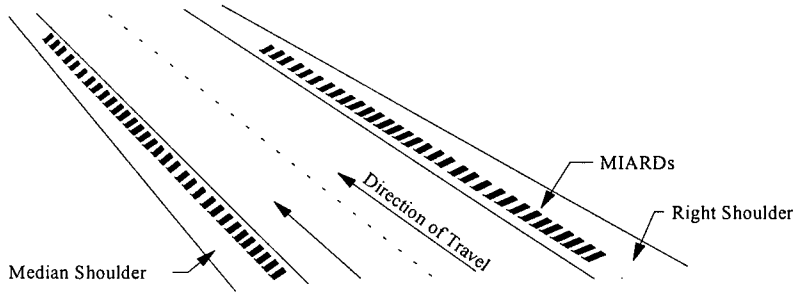
- *Pennsylvania Turnpike*—CSRSs, known in Pennsylvania as "SNAP" for Sonic Nap Alert Pattern, were first installed on the Pennsylvania Turnpike in 1985. Full-scale testing began in 1989 and included roadway segments with both rolled and milled SNAP. Results showed an average 70 percent reduction in drift-off-road crashes (Wood 1994). Follow-up analyses using additional crash data revealed a 57 to 60 percent reduction in relevant crash types (Hickey 1997).

- *New York State*—Installation of CSRSs along the entire 996 km (641 mi) New York State Thruway system began in 1992 and was completed in the fall of 1996. Using data provided by the New York State Thruway Authority on single-vehicle run-off-road crashes, Perrillo (1998) showed a 74 percent reduction in crashes in 1996 compared with 1991, and an 88 percent reduction in 1997 compared with 1991. Analysis in the study was limited to crashes occurring on the Thruway "that could be mitigated" by the use of CSRSs, including those attributed to driver fatigue or drowsiness, inattention, distraction, or medication use. Other studies based on New York Thruway and State DOT data have shown reductions of 65 to 70 percent (McCartt et al. 1998; NYDOT 1998).

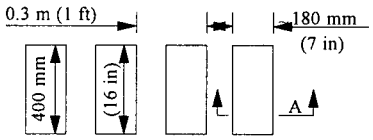
- *California and Illinois*—Highway Safety Information System data were analyzed for two states, California and Illinois, using a before/after study design with two types of comparison populations. The evaluation included 64 sites in Illinois and 28 in California, where rolled-in CSRSs had been installed. Results of the analyses showed that the rolled-in CSRSs reduced single-vehicle run-off-road crashes by 18 percent on all freeways and by 21 percent on rural freeways (Griffith 1999).

- *Utah*—Crash rates per million vehicle miles were calculated for 186 total miles of roadway with rolled-in CSRSs and 110 miles of roadway without CSRSs. The overall accident rate for roadway segments without rumble strips was found to be 33 percent higher than the overall accident rate for roadway segments with rumble strips, whereas the corresponding accident rate for run-off-road crashes was 27 percent higher (Cheng et al. 1994).

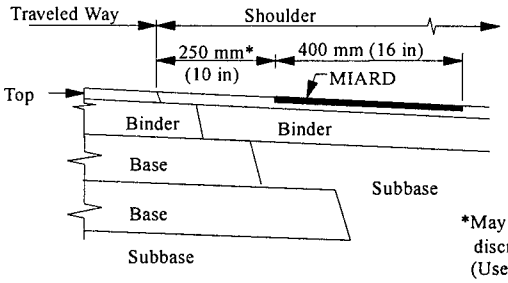
Milled-In Audible Roadway Delineators (MIARDs)



GENERAL ISOMETRIC VIEW

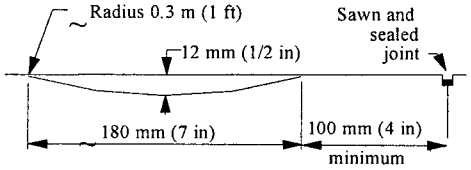


TYPICAL SPACING PLAN

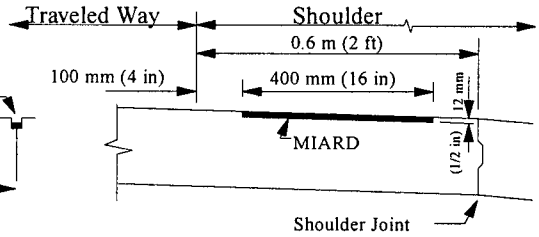


Location on Asphalt Shoulders (Conventional Shoulder Shown)

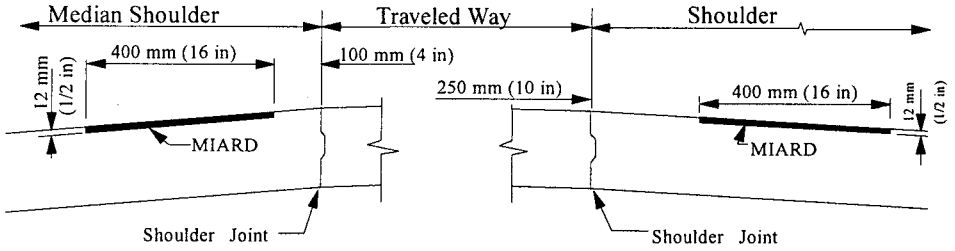
*May be increased at discretion of EIC. (Use 100 mm (4 in) min. offset on left shoulder)



SECTION A



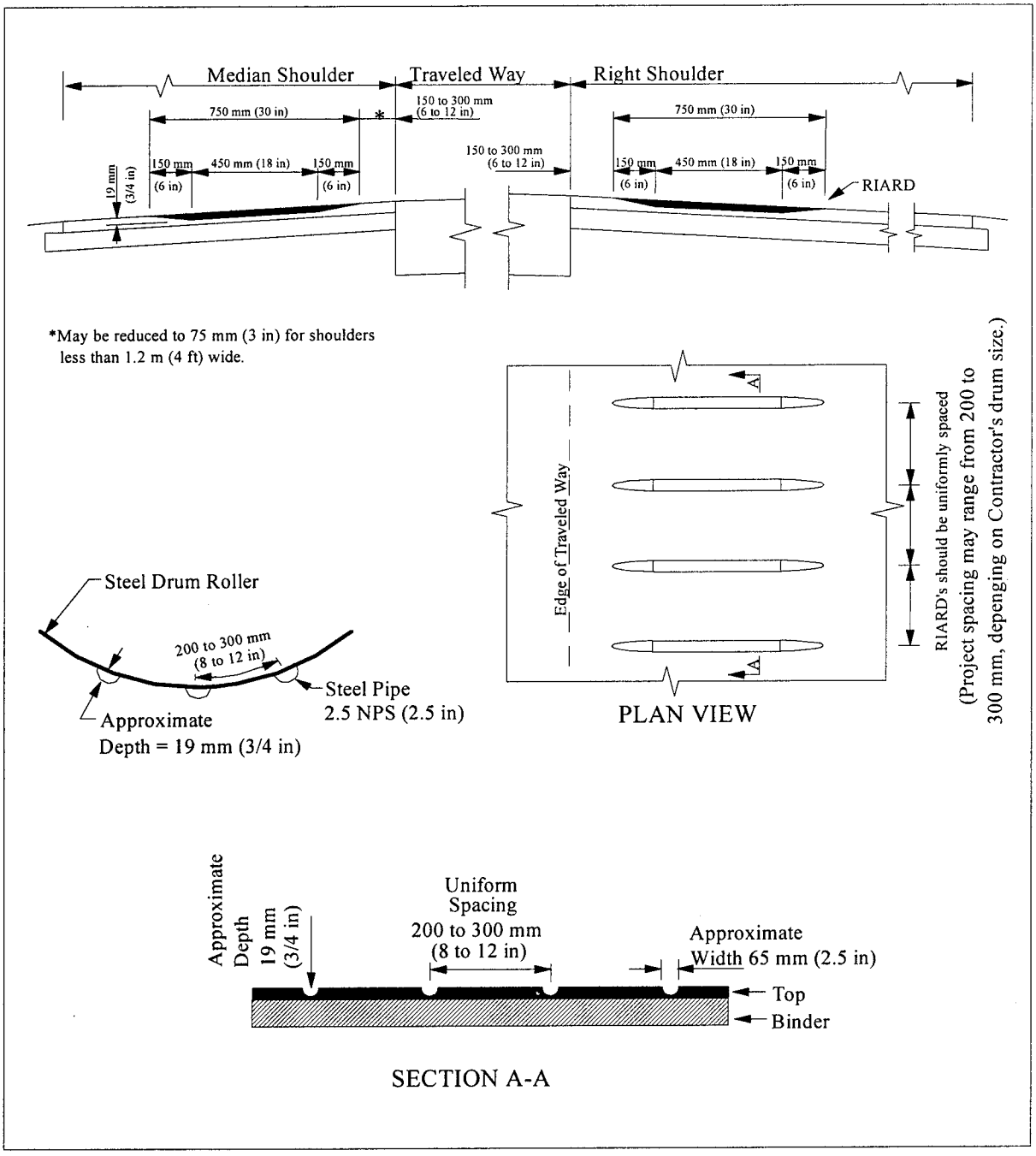
Location on ESAL-Based Concrete Pavement Design



Location on Concrete Shoulders Designed with Conventional Joint Location

(a)

Rolled-In Audible Roadway Delineators (RIARDs)



(b)

FIGURE 6 *(a)* Sample design specifications for milled-in CSRSs (New York State DOT 1997); *(b)* Sample design specifications for rolled-in CSRSs (New York State DOT 1997).

- In addition to these referenced studies, the FHWA rumble strip website also notes several unpublished evaluations that show the following reductions in run-off-road crashes in locations where CSRSs have been installed: a 34 percent reduction on the New Jersey Turnpike, a 42 percent reduction on the Massachusetts Turnpike, an 18 percent reduction for six locations in Washington State, and a 34 percent reduction on the Kansas Turnpike.

These evaluations have targeted a variety of types of CSRSs installed in a variety of settings and have employed a variety of criteria, study designs, and statistical methodologies; thus, it is not possible to arrive at a single best estimate of the effectiveness of CSRSs in reducing run-off-road crashes. The FHWA sets an effectiveness range of from 20 to 50 percent (Harwood 1993; National Sleep Foundation 1997). It is worth noting, however, that not all fatigue-related crashes involve running off the roadway. The FHWA estimates that about one-third of all crashes involve a single vehicle leaving the roadway and that 40 to 60 percent of such crashes involve drowsy, fatigued, or inattentive drivers (FHWA website 1999). CSRSs will not help the drowsy driver who rear-ends the vehicle in front of him, sideswipes the car traveling in the lane beside him, or crosses the centerline and strikes an approaching vehicle head-on. Other countermeasures are needed to prevent these types of drowsy driving crashes.

The 20 to 50 percent effectiveness estimate is for CSRSs placed on rural freeways (interstate or interstate-like roadways). Insufficient data exist for the effectiveness of CSRSs on other types of roadways and, in particular, on two-lane rural roadways (National Sleep Foundation 1997). Results of a survey reported by Garder and Alexander (1995) showed that 35 states had no experience in using CSRSs on two-lane rural highways, and the remaining 15 states had only very limited experience. The authors note that the effectiveness of CSRSs on these types of roadways depends on many factors including traffic volume, speed limit, side slopes, and roadside conditions.

In addition to evaluations of the effectiveness of CSRSs based on crash data analyses, one can also consider what drivers themselves have to say about rumble strips. When a random sample of New York State drivers was surveyed in 1994, 59 percent said that they had driven over rumble strips and 93 percent of these drivers said that they thought rumble strips were helpful in keeping drivers alert and on the road (Fact Finders, Inc. 1994). In 1997, long distance truck drivers in New York State were surveyed when stopped at rest areas and inspection sites. More than three-fourths (77%) of the truck drivers said that they believed rumble strips were very effective in preventing run-off-road crashes due to drowsiness or falling asleep, and an additional 15 percent said they believed rumble strips were somewhat effective. More than one-half (56%) of the drivers said that rumble strips had alerted them when they had been drowsy and run off the road (McCartt et al. 1997, 1998).

CSRS Benefits and Costs

In contrast to many of the educational and technological countermeasures discussed in earlier chapters, the cost effectiveness of CSRSs for preventing drowsy driving crashes is indisputable. Installation costs for rolled rumble strips are difficult to determine, because these are often incidental to resurfacing. Costs for milled rumble strips, although higher, have steadily fallen over the past decade. Recent estimates place installation costs at $0.65 to $1.15 per meter, with some states reporting costs as low as $0.39 per meter (National Sleep Foundation 1997). Perillo (1998) cites a figure of $0.62 per meter for milled rumble strips added to the New York Thruway; this cost includes the addition of rumble strips on each of four roadway shoulders, sweeping and discarding excess asphalt, and maintenance and protection of traffic. In addition to their low installation costs, rumble strips have been shown to be virtually maintenance free and to have a lifespan equal to that of the shoulder itself (Harwood 1993; Perrillo 1998; FHWA website 1999).

A number of studies have estimated the actual benefits and costs of installing CSRSs on sections of roadway. In the 1985 multi-state FHWA analysis, a benefit-cost ratio of 50:1 was estimated for rolled-in rumble strips (Ligon 1985). Perrillo (1998) estimated a benefit-cost ratio of 182:1 (but based on a higher 88 percent crash reduction effectiveness). Garder and Alexander (1994) produced benefit-cost estimates for installing CSRSs on all rural sections of interstate highways; their figures were 200:1 for rolled-in rumble strips and 50:1 for the more expensive milled-in rumble strips. The following quote from the NSF's "Drive Alert . . . Arrive Alive" Fact Sheet summarizes the cost-effectiveness of CSRSs as a highway safety countermeasure:

> From a cost-benefit standpoint, if 40% of crashes on rural interstate highways are sleep- or inattention-related, and rumble strips are 50% effective, the benefit-to-cost ratio is 200 to 1. If only 10% of crashes are sleep- or inattention-related, and rumble strips are only 20% effective, the ratio is 20 to 1 (NSF undated).

Concerns about CSRSs

The primary concerns raised with regard to the use of CSRSs center on their potential for misuse; leading to possible crash migration rather than crash avoidance, the noise generated outside of a vehicle traversing rumble strips, interference with the safe travel of bicyclists on roadway shoulders, maintenance issues, and reduced flexibility in vehicle use of roadway shoulders. These are each briefly addressed here.

Potential for Misuse

Just as with certain vehicle and driver technologies intended to alert drivers when they are drowsy and in danger of falling asleep at the wheel, rumble strips have the potential for misuse

if, instead of responding to the noise and vibration by immediately looking for a safe place to pull over and stop, drivers rely on rumble strips as an "alarm clock" to help keep them awake until reaching their ultimate destination. This problem was recognized by the expert panel convened by the NCSDR and the NHTSA to make recommendations for reducing drowsy driving crashes. Along with their recommendation to promote shoulder rumble strips as an effective countermeasure for drowsy driving, the panel recommended that a public education campaign be conducted to educate motorists about what rumble strips are and what to do if awakened by driving over them (NHTSA 1998). A similar recommendation had been included in the NSF's *Use of Continuous Shoulder Rumble Strips: A Consensus Report* (NSF 1997).

Given that drivers who have momentarily fallen asleep are very likely to do so again within a relatively short period of time (Lisper et al. 1986), the real concern here is that accidents that have been avoided along roadside segments with CSRSs will simply be postponed until later locations without CSRSs; that is, crashes will still occur, but in different locations. This phenomenon, referred to as "crash migration," could be especially dangerous if the displaced crash occurs on a less safe roadway, such as a two-lane highway with narrower shoulders and less roadside clearance. Although the NSF panel cited some evidence from the 1985 California evaluation of CSRSs that seemed to support such a theory, Griffith et al. (1998) concluded that any such effects were "insignificant."

Noise Pollution

A second concern is noise pollution, specifically, noise generated outside the vehicle when tires cross over rumble strips. This external noise is less of a problem when rumble strips are placed on shoulders than when they are placed in travel lanes, and less when used on rural freeways than on other roadways in more built-up areas. However, shoulder rumble strips can still be a source of annoyance to people living or working nearby. Data collected by Garder and Alexander (1995) showed that driving over CSRSs increased the peak noise level for cars by 11 dBA (from 72 to 83 dBA) and for full-size trucks by 9 dBA (from 82 to 91 dBA). Measurements were taken 20 m (66 ft) from the roadway. Although the authors report that residents living nearby this particular section of treated roadway nevertheless supported the rumble strip installation, noise levels continue to be a concern in Maine as well as other states. In addition to not placing rumble strips along roadways in built-up areas, offsetting them further from the edge of the travel lane can reduce the likelihood that vehicles (and in particular large trucks) will traverse them unintentionally. Noise buffers can also be constructed (Hargrave 1993; Garder and Alexander 1995).

Bicyclist Safety and Comfort

A third area of concern is the safety and comfort of bicyclists wanting to travel on the shoulders of roadways with CSRSs. This is generally not a problem on interstate and interstate-like roadways where the vast majority of CSRSs are installed. Even if a state allows bicyclists to travel on these roadways, the shoulders are generally wide enough to safely accommodate both rumble strip and bicyclist. The concern arises when CSRSs are placed on other types of roadways with narrower shoulders. In this situation, bicyclists may be forced to choose between riding outside of the rumble strip—in a space that may be too narrow, not well-maintained, and cluttered by debris—or riding in whatever space may exist between the rumble strip and the edge of the travel lane, placing them much closer to motor vehicle traffic. There is also a concern among cyclists that if they ride over rumble strips they may lose control of their bicycle.

These concerns first surfaced in the mid-1980s, after the FHWA had issued a notice encouraging use of textured shouldered treatments as a countermeasure for reducing run-off-road crashes (FHWA 1986). An article published in *Bicycle Forum* magazine the following year (Williams 1987) questioned the safety implications of rumble strips for bicyclists. When states were surveyed for *NCHRP Synthesis 191: Use of Rumble Strips to Enhance Safety* (Harwood 1993), several highway agencies reported bicyclist complaints about rumble strips.

Recently updated American Association of State Highway and Transportation Officials (AASHTO) guidelines for the construction of bicycle facilities (AASHTO 1999) state that

> Rumble strips or raised pavement markers . . . are not recommended where shoulders are used by bicyclists unless there is a minimum clear path of 0.3 m (1 foot) from the rumble strip to the traveled way, 1.2 m (4 feet) from the rumble strip to the outside edge of paved shoulder, or 1.5 m (5 feet) to adjacent guardrail, curb or other obstacle. If the existing conditions preclude achieving the minimum desirable clearance, the width of the rumble strip may be decreased or other appropriate alternative solutions should be considered (AASHTO 1999, p. 17).

However, the two concerns noted above—adequate remaining space on roadway shoulders and bicycle stability when crossing a rumble strip—persist and have been publicly documented in newsletters of the Human Powered Transportation Committee of ASCE (American Society of Civil Engineers). The first issue arises from rumble strips being used on non-interstate roadways, and especially two-lane rural roadways, with shoulder widths of less than 8 ft. In some cases, the remaining space has been so narrow as to effectively preclude safe bicycle travel. The other issue is the increasing popularity of milled-in rumble strips. Although some sources contend that this design poses no significant handling problems for bicyclists (New York State Task Force 1994; Garder and Alexander 1995), many bicyclists claim that the milled rumble strips are particularly jarring and dangerous. The Pennsylvania DOT recently tested various specifications of milled rumble strips and confirmed severe bicycle jarring with the standard profiles (Figure 7) (D. Bachman, Pennsylvania DOT, personal communication, 2000). In California, a moratorium has been placed on additional rumble

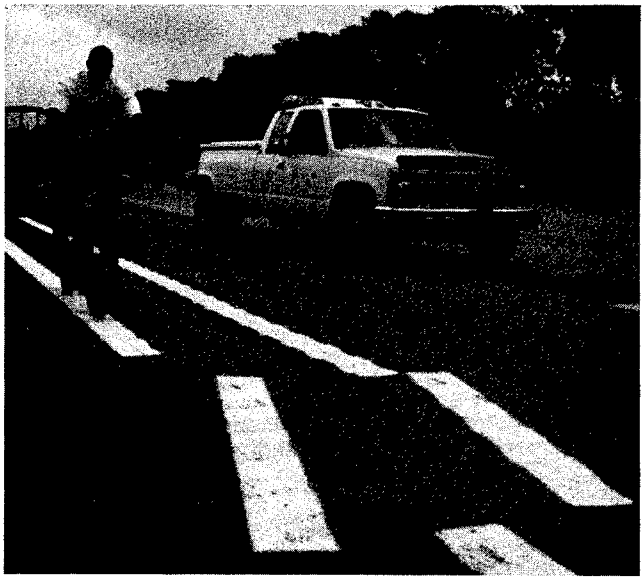


FIGURE 7 Testing rumble strips for bicyclists in Pennsylvania *(courtesy David Bachman, Pennsylvania DOT).*

strip placements pending the results of similar tests (T. Bucko, Caltrans, personal communication, 2000). Studies are underway in both states to evaluate the effectiveness of various types and configurations of rumble strips to determine which are most effective for motor vehicles and at the same time least intrusive on bicyclists.

Meanwhile, there are also studies that suggest that rumble strips may provide a potential safety benefit to bicyclists (Ligon et al. 1985; Garder 1995; Garder and Alexander 1995; Kahn and Bacchus 1995). By helping to keep errant motorists off roadway shoulders, rumble strips may reduce the occurrence of one of the most serious of bicycle collisions—being struck by an overtaking vehicle. Rumble strips also maintain a buffer space between bicyclists and higher speed motor vehicle traffic.

Maintenance Issues

Milled-in rumble strips have generally not been found to adversely affect the lifespan of roadway shoulders; however, some problems have been noted with use of the rolled-in rumble strips (Perillo 1998). When these strips are indented with steel pipes attached to a steel drum roller, it is often difficult to get adequate compaction of the asphalt in between the rolled-in grooves, leading in some instances to a premature deterioration of the shoulder near the edge of the travel lane (Perillo 1998).

States have generally not reported problems with the grooved rumble strips collecting debris or "filling in" with dirt or sand, because windblast from passing motor vehicles usually takes care of this potential problem. Although raised rumble strips can be damaged by snowplows, they typically are not used in climates where snow removal is needed, and newer configurations are more resistant to damage. In general, once installed, CSRSs are a maintenance-free countermeasure for protecting drowsy drivers (Harwood 1993; Garder and Alexander 1994).

Reduced Shoulder Use Flexibility

A final concern is that once in place, rumble strips limit the use of roadway shoulders as temporary travel lanes during construction or maintenance activities. They also hinder conversion of a shoulder to a travel lane to alleviate traffic congestion (e.g., on crowded urban freeways) or to accommodate an emergency evacuation (Harwood 1993; Perrillo 1998). In the case of planned roadway construction or maintenance, the usual approach is simply to fill in the rumble strips with asphalt and then to mill in new rumble strips after the road work has been completed (Perrillo 1998).

The Future of CSRSs

Although the FHWA does not require states to install CSRSs on highways, it does actively encourage and support its use. In addition to the 1986 memorandum cited above, the agency issued a Technical Advisory in 1990 (T 5040.29) that identified textured shoulder treatments (rumble strips) as "a recommended practice for keeping motorists from using the shoulder as a travel lane and warning errant drivers that they are straying from the travel lane." The FHWA has asked each state not already using textured shoulder treatments to implement such a treatment at a minimum of one test site. A 1997 FHWA Memorandum estimated that 85 percent of all states use CSRSs on at least some portion of their roadways (FHWA 1997).

The FHWA has also become actively involved in gathering data to assist states in developing CSRS programs. This information is being made widely available on the FHWA rumble strip website (http://safety.fhwa.dot.gov/rumblestrips/) and includes basic information on what rumble strips are and how they work, copies of research reports, summaries of policies and guidelines provided by individual states, and lists of resources and contacts. Transportation agencies have been encouraged to use the information from the website and the experiences of others to develop and implement shoulder rumble strip use policies that best meet the needs of their jurisdiction.

One of the remaining areas of debate is whether CSRSs should be recommended on roadways other than rural interstates and interstate-like roadways. The 1997 NSF study, *Use of Continuous Shoulder Rumble Strips: A Consensus Report,* concluded that insufficient data were available for recommending CSRSs on other roadway types, and in particular roads that comprise the National Highway System. These roads represent only 4 percent of all roads, but carry more than 40

percent of the nation's traffic and 70 percent of its heavy truck traffic (National Sleep Foundation 1997).

To date, the FHWA's rumble strip program has primarily focused on rural freeway facilities. However, run-off-road crashes are a significant problem on other parts of the National Highway System, such as rural two-lane and multi-lane roadways. The FHWA and others are looking for ways to implement this crash-reduction measure on non-freeway facilities that exhibit a high incident of run-off-road crashes and that would be receptive to such a treatment. As suggested previously in the section on bicyclist concerns, an issue of significant importance is the assurance that such treatment be considerate of the safe and convenient travel of bicyclists who may use the shoulders of these roadways. Efforts are underway by various agencies and groups to develop policies, design standards, and implementation techniques that meet the safety needs of all roadway users (J. Growney, FHWA, personal communication, 1999).

OTHER ROADWAY COUNTERMEASURES

Centerline Rumble Strips

Shoulder rumble strips help to prevent drowsy driving crashes by alerting drivers before they have left the roadway. Another use of rumble strips, however, is along the *centerline* of undivided roadways, to help prevent head-on collisions with approaching traffic. Figure 8 shows an example of a centerline rumble strip in place in Maryland. Only a few states have installed such roadway treatments. Perrillo (1998) identified Maryland, Delaware, and Pennsylvania, and Fitzpatrick et al. (1999, 2000) recently reported on a test treatment installed in California. Generally, the rumble strips are milled into the roadway surface, and then center striping is added to either side of the rumble strip using either paint or thermoplastic traffic striping. In the California application, yellow reflective pavement makers were also installed in between the rumble strip and the raised profile thermoplastic (Fitzpatrick et al. 1999). The Pennsylvania DOT has developed detailed guidelines for installation of milled centerline rumble strips. Garder and Alexander (1995) note that in addition to awakening drowsy drivers, the centerline rumble strips may also help reinforce no passing zones.

Evaluation data are limited. Perrillo (1998) reported a large reduction in head-on crashes in Pennsylvania following installation of centerline rumble strips, but noted that many other roadway improvements were made at the same time that the rumble strips were installed. The author also cited a Delaware study showing a large decrease in crashes over the two-year period following installation of centerline rumble strips on a section of two-lane undivided rural highway. However, regression to the mean could have factored into these results. The California application described above resulted in an overall

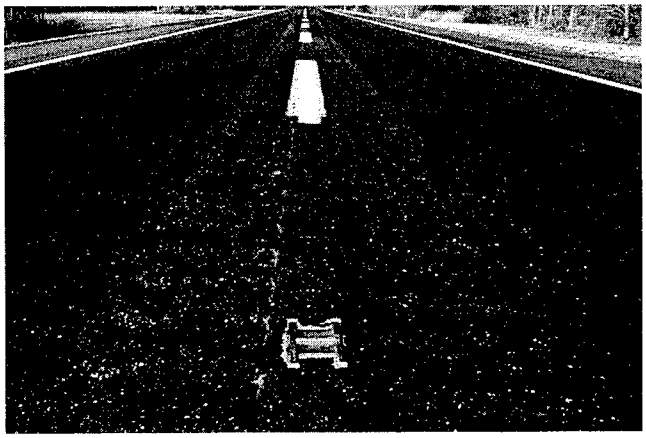


FIGURE 8 Example of a centerline rumble strip *(courtesy Maryland DOT).*

reduction in crashes, but the effects of the centerline rumble strips were again not distinguished from other improvements (e.g., shoulder rumble strips) made at the same time (Fizpatrick et al. 2000). A well-controlled study of the effectiveness of centerline rumble strips in preventing crossover collisions by drowsy drivers has yet to be carried out.

Thermoplastic Edgelines

Where shoulder width is not adequate for placement of shoulder rumble strips, an alternative treatment option is thermoplastic edgelines, or inverted profile thermoplastic striping (Figure 9). In addition to providing audible and vibratory warnings for straying motorists, such striping also enhances nighttime visibility (Fitzpatrick et al. 1999, 2000). Thermoplastic edgelines were incorporated into the California test treatment described previously: they were used in conjunction with shoulder rumble strips where the shoulder width was 6 ft or wider, and by themselves where the shoulder width was less than 6 ft (Fitzpatrick et al. 1999, 2000). A schematic for placement of inverted profile thermoplastic striping is contained in Fitzpatrick et al. (2000) based on the Caltrans project study report.

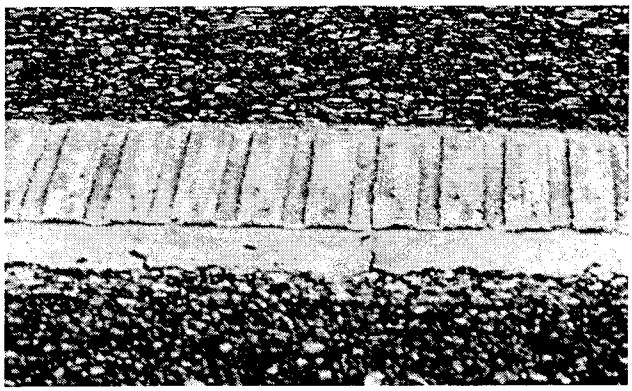


FIGURE 9 Example of inverted thermoplastic edgelines *(courtesy Kay Fitzpatrick, Texas Transportation Institute).*

Roadway Design Features

Both shoulder and centerline rumble strips function to keep the drowsy driver in the travel lane. Drowsy drivers can also be helped by more general roadway improvements, including adding paved shoulders if none exist, widening existing shoulders, and removing roadside hazards (Zegeer et al. 1987). An early Caltrans report (Rinde 1977) demonstrated significant reductions in overall crashes when shoulders on selected two-lane rural roadways were widened, and numerous studies reinforce the benefits of removing hazards such as trees, ditch-banks, telephone poles, and signs from the highway right-of-way, particularly on higher speed rural roads (see, e.g., Perchonok et al. 1978; Graham and Harwood 1982; Zegeer and Parker 1983). Roadway design elements that can significantly influence safety include horizontal alignment (degree of roadway curvature, superelevation), vertical alignment (grade, critical length of grade, vertical sags, and crests), cross section (number of lanes, lane width, shoulder type and width, median type and width), and roadside characteristics (sideslopes, horizontal clearance to obstruction, ditch design, traffic barriers) (McGee et al. 1995). Good roadway design practices are an important first step in mitigating the impact of drowsy driving.

In addition to these roadway design elements, the safety of drowsy drivers can be further enhanced by improved pavement markings and highway signs. In particular, raised and/or retroreflective lane markers and edgelines have been shown to reduce lane departure crashes (Blaaw 1985; Good and Baxter 1986).

STATE/PROVINCIAL SURVEY RESULTS

The survey sent to state and provincial transportation departments contained a section on the use of continuous shoulder rumble strips and other roadway treatments to reduce drowsy driving crashes. Survey results are summarized in Appendix D and highlighted in the following sections.

Use of CSRSs

All but 1 of the 37 states responding indicated some experience with the use of CSRSs. Four of five states reported having warrants or guidelines in place for installing CSRSs on the shoulders of rural interstate highways, freeways, or other limited-access roadways when undergoing resurfacing or reconstruction. Only about one-half, however, reported having warrants or guidelines for installing rumble strips on the shoulders of other roadway types, and fewer than one-half (43 percent) indicated that they have guidelines for retrofitting shoulders of interstate highways or freeways *not* undergoing resurfacing or reconstruction.

About one-half of the states responding to the survey also reported that they maintain information on the number of miles or kilometers of installed CSRSs for various categories of roadways. For those that do maintain this information, the reported miles vary greatly, both across states and across roadway types. Part of these differences, of course, can be attributed to the varying sizes of the states and miles of available roadway types. As might be expected, the greatest number of miles of CSRSs have been placed on rural interstate and limited-access freeways. However, more than one-half of the states reporting have also placed CSRSs on urban interstate and limited-access freeways. Fewer states reported using CSRSs on other types of roadways. When asked about future plans for placement of CSRSs, more than 90 percent of the states indicated that mileage on their interstate highways and limited-access freeways was likely to increase over the next 5 years. Three-fourths said use was also likely to increase on rural multi-lane divided roadways, but only about one-half said it was likely to increase on other roadway types, including urban interstates and rural two-lane roadways.

Three of the seven reporting Canadian provinces indicated the use of CSRSs. Alberta has an estimated 1200 km of roadway with CSRSs and has guidelines in place for both installing and retrofitting CSRSs on its rural limited-access highways. Saskatchewan just recently adopted its CSRS standards, so that results are just now being seen in this year's roadway projects. Both provinces expect to increase their use of CSRSs over the next 5 years on roadways under their jurisdiction. In Canada, municipalities and local governments have jurisdiction over secondary highways and local roads.

Problems with CSRS

Two-thirds of responding states reported that they had experienced no significant problems with the use of CSRSs. Problems that were identified by the remaining states are discussed here:

- *Bicyclist concerns*—Concerns about bicyclist safety and comfort were raised by six states, including three that had reported experiencing no significant problems. California noted that it was reviewing its policy regarding installation of ground-in rumble strips in response to feedback from the bicycle community. Colorado also noted strong bicycle community opposition, which it has worked to resolve through extensive partnering and revision of details. Kansas, New Jersey, Pennsylvania, and Wyoming all noted opposition from bicyclist groups, especially to placement of CSRSs on two-lane rural roads and other non-limited-access highways. DOT personnel in Pennsylvania are working with researchers at Pennsylvania State University to design more bicycle friendly rumble strips.

Although not identifying bicyclist concerns as a particular problem, in its response to other portions of the survey Florida noted that it does not allow installation of rumble strips on non-interstate roadways except where warranted by high accident rates. Bicyclists in Florida are encouraged to ride on paved shoulders, and wider pavement widths would be needed to accommodate both bicyclists and rumble strips. In Massachusetts, rumble strips are only installed on full-access controlled roadways because of potential problems for bicyclists.

- *Milled versus rolled CSRSs*—Three states (Colorado, Minnesota, and South Carolina) indicated dissatisfaction with the rolled variety of CSRSs (inadequate depth) and noted that they had switched entirely to the milled variety.

- *Noise*—Two states (Connecticut and New Hampshire) reported receiving complaints about the noise generated by CSRSs.

- *Maintenance problems*—Two states (Oregon and Wyoming) noted potential maintenance problems in mountainous areas and where snow accumulates ("snow plow operators don't like them"). Two others states (New Hampshire and South Dakota) noted problems with water accumulating either in the grooves or at the edge of the rumble strip when placed on an asphalt shoulder next to concrete. Moving the rumble strip farther away from the edge of the roadway helps.

- *Crashes*—One state (Maine) cited reports that CSRSs may have contributed to two crashes. In one instance, an elderly driver claimed that the rumble strip made him lose control of his car, causing him to cross the roadway and strike a guardrail. In another, a police officer indicated that a rumble strip caused him to lose control as he was braking immediately prior to a crossover.

- *Other*—One state (Florida) noted some complaints from wide-load transporters and a possible increase in truck tire unraveling.

Both of the Canadian provinces where rumble strips are used also indicated concerns from local bicycle clubs and complaints about noise when CSRSs were installed near developed areas. In addition, one of the provinces noted that truckers moved to the left, closer to the centerline, to avoid the rumble strips, and the other province noted a problem in placing rumble strips on new pavement without shoulder stripes as a guide.

Use of Centerline Rumble Strips

Ten states reported some experience installing rumble strips between the centerlines of roadways in an attempt to prevent potential head-on collisions. Two other states said that they were considering such a treatment, whereas 22 currently had no plans to do so. Experience with this particular type of roadway treatment is limited. However, both California and Delaware reported conducting before/after studies on limited sections of roadway with encouraging results, and several states reported plans for future studies.

Alberta reported using centerline rumble strips on two-lane roadways based on the following criteria:

- horizontal curves on all undivided highways with a high collision history,
- horizontal curves on all undivided highways where there are double barrier lines (no passing in both directions),
- double barrier lines (no passing zones) of climbing lanes or passing lanes,
- double barrier lines (no passing zones) at tangent sections where the length is greater than 300 m.

Other Roadway Treatments to Prevent Drowsy Driving Crashes

Respondents were asked to identify any other roadway treatments being used in their state that might help to reduce drowsy driving crashes. Thirteen states and two Canadian provinces identified one or more roadway treatments, including the following:

- Raised pavement markers, thermoplastic strips, or other high profile markers (five states)
- Microsurfacing or use of different shoulder textures (two states)
- Rumble strips placed in the travel lane/in advance of stop intersections on rural highways (three states/provinces)
- Guardrail and Jersey barrier treatments (two states)
- Increased lane width and paved shoulder width (one state)
- Increased median width (one state)
- Rest areas, truck pull-outs (three states/provinces)

This list suggests that, although some new materials and procedures are available that may help make roadways safer for drowsy drivers, CSRSs and a generally forgiving roadway are, at least for now, the most popular countermeasures.

CHAPTER FIVE

ENVIRONMENTAL COUNTERMEASURES—SAFE STOPPING AREAS

The primary environmental measure for preventing drowsy driving crashes is the provision of locations along the roadway where motorists can safely stop and rest to avert drowsiness or fatigue. Often, these safe stopping locations take the form of roadside rest areas. Although rest areas can serve a variety of functions, their primary purpose is to increase motorist safety. Today's national system of highway rest areas originated with the Federal-Aid Highway Act of 1938. This act allowed states to use federal funds to provide "such sanitary and other facilities as may be deemed necessary to provide for the suitable accommodation of the public . . ." The rest area program did not gain real momentum, however, until the 1960s, drawing upon the funding and support of the Highway Trust Fund and the Highway Beautification Act of 1965. Since their inception, rest areas have been viewed as "functional and desirable elements of the complete highway development" (Disque 1973; AASHTO 1994).

This chapter provides information on the use, availability, and benefits of safe stopping areas, focusing primarily on the general motoring public, but also noting the special needs of commercial motor vehicle (CMV) operators. Much of the information available at the national level is a direct result of recent Congressional concern for the "adequacy of places for truck drivers to stop and rest, both public and private" (TRI et al. 1996). Issues such as rest area safety, available amenities, and length of stay restrictions are also addressed. The information presented on rest area availability and operations at the state level draws primarily from the state transportation department survey administered as part of the current synthesis project.

POPULARITY AND SAFETY BENEFITS

The official definition of a rest area as adopted by AASHTO is:

> . . . a roadside area, with parking facilities separated from the roadway, provided for the motorist to stop and rest for short periods. It may include drinking water, toilets, tables and benches, telephones, information, and other facilities for travelers (AASHTO 1994).

Figure 10 contains photographs of some safety rest area facilities in several states.

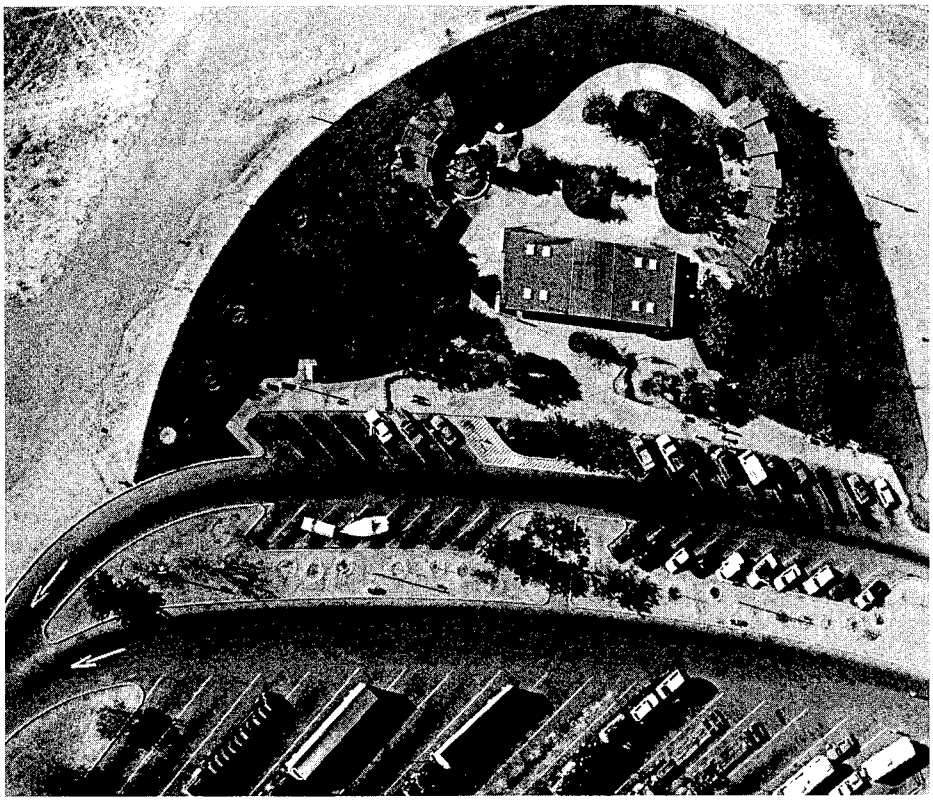
Rest areas are clearly popular with both the general driving public and commercial vehicle operators. An estimated 95 percent of all drivers have used rest areas at some time (King 1989), and surveys of users have consistently demonstrated a high level of satisfaction with the available facilities (King 1989; Blomquist and Carson 1998; Minnesota DOT 1998). Although percentages vary greatly depending upon the location, studies have shown that approximately 10 percent of all passing vehicles stop at an interstate rest area–with a somewhat higher percentage for trucks and recreational vehicles and a lower percentage for passenger vehicles.

Most motorists stopping at rest areas do so for the restroom facilities and simply to relax and take a break from driving; but some also stop because they are sleepy. A survey of licensed drivers in New York State revealed that 45 percent had stopped at a roadside rest area in the last year when feeling drowsy (Fact Finders, Inc. 1994; McCartt et al. 1996). Of those who had stopped, two-thirds indicated that the stop helped "a great deal" to combat their drowsiness. Perhaps even more significantly, 3 in 10 drivers interviewed said that they had needed or wanted to stop at a roadside rest area, but none was available (Fact Finders, Inc. 1994).

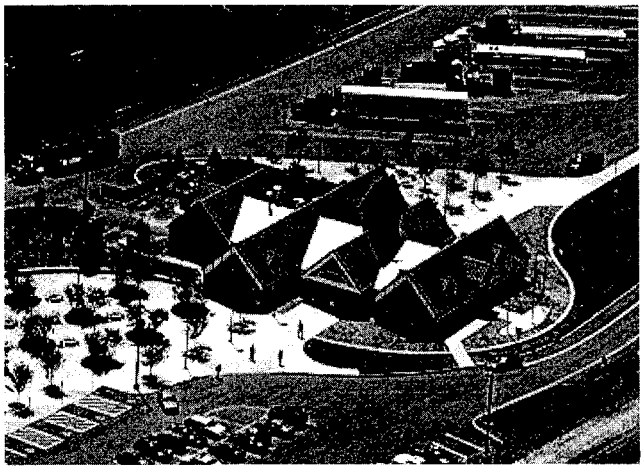
There is general agreement that rest areas have a beneficial effect on highway safety; however, there is little empirical data to support this claim. A comprehensive evaluation of the safety benefits of roadside rest areas found them to be difficult to measure and quantify (King 1989). The author drew the following conclusions:

> The preceding analysis of the effects of highway rest areas on highway safety has shown that these effects operate through different mechanisms including: reduction in driver fatigue and other adverse physiological effects; reduction in voluntary shoulder stops; some reduction in involuntary stops and in vehicle-miles of travel by defective vehicles and impaired drivers; reduction of driver or passenger discomfort or other sources of driver distraction; transmission of safety-related information to drivers; and reduction of driving under hazardous weather, roadway and visibility conditions (King 1989).

To the extent that sleepy or fatigued drivers use rest areas as an opportunity to nap, drink a cup of coffee, and stretch or exercise, one might anticipate at least a short-term lowering of accident risk once they return to the roadway. As part of the above-mentioned evaluation of safety roadside rest areas, King (1989) interviewed 817 rest area users in five states, and observed a total of 1,630 users. Forty-eight percent of passenger car drivers and 62 percent of truck drivers said that they used the stop for resting or stretching. Other studies have shown that average length of stay at rest areas increases at nighttime: a 1987 Nebraska study found that the average stay for passenger cars was 29 minutes at night, compared with 13 minutes during the day. Average nighttime stays for drivers of recreational



(a)



(b)

(c)

FIGURE 10 Safety rest area facilities in *(a)* California, *(b)* New York State, and *(c)* North Carolina showing pull-through truck parking *(courtesy state DOTs).*

vehicles (59 minutes) and trucks (65 minutes) were even longer (Nebraska Department of Roads 1987). These results suggest that increased napping or sleeping may be occurring during nighttime rest area stops.

It is unknown to what extent drivers who stop at rest areas use the opportunity to also consume caffeine. Coffee is seldom available at rest areas in the United States, and even though vending machines may sell caffeinated beverages, purchasing such beverages was noted by less than 3 percent of participants in the national survey cited above (King 1989). Additional information on use of rest area facilities is included below in the section on motorist use of rest areas.

RECENT FEDERAL ACTIVITY

Much of the current interest in safety rest areas at the national level stems from concerns for the safety of commercial vehicle

operators (Figure 11). In 1992, the FMCSA (then FHWA's Office of Motor Carriers) contracted with the TRI, affiliated with the American Trucking Associations, to conduct research "to determine the supply, utilization, parking statutes and practice, and demand for truck parking at public rest area and private rest stops at the state and national levels." Based on the research findings, the study sought to identify "policies and programs to meet truck drivers' rest needs and to improve the efficiency of rest area planning and development" (TRI 1996). The research involved a national inventory of rest areas on the nation's interstate highway system, observational studies of rest area usage by truck drivers, a national survey of motor carriers, and a mail survey of private truck stop operators.

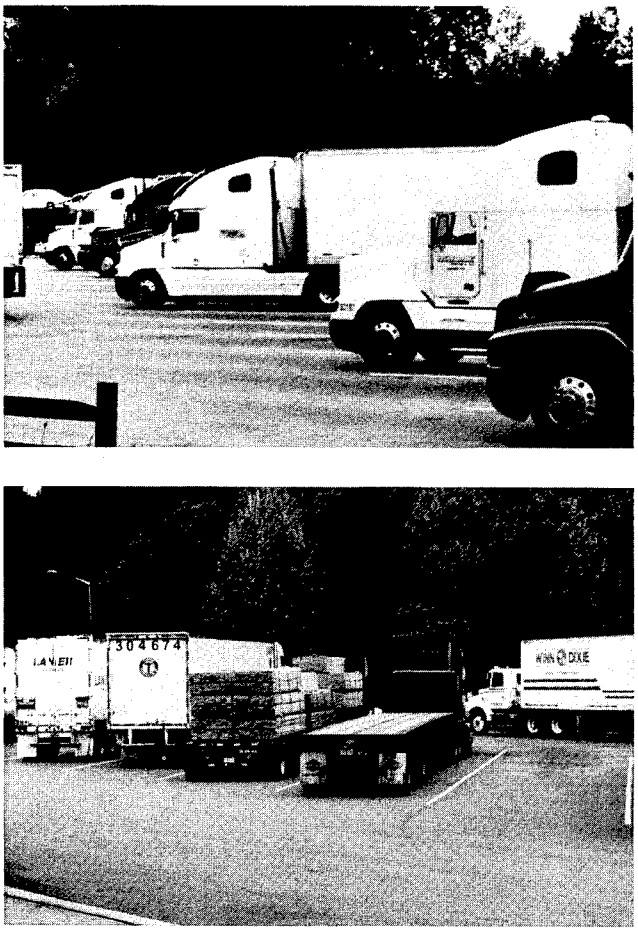


FIGURE 11 Safety rest areas in North Carolina—and throughout the nation—are often crowded with large trucks.

Results of the research documented in the report, *Commercial Driver Rest and Parking Requirements: Making Space for Safety* (TRI 1996), raised serious concerns about the adequacy of facilities for commercial vehicle operators to stop and rest. Key findings include the following:

- More than 90 percent of commercial drivers sampled perceived that there is a shortage of truck parking facilities, particularly for long-term or overnight parking.
- A majority of drivers preferred public rest areas for short-term parking, but two-thirds preferred private truck stops for overnight or long-term rest needs.
- In meeting their need for rest, 54 percent of truck drivers rated public rest areas as "fair" or "poor." Reasons for the low ratings included overcrowding, safety concerns, other vehicles parked in truck parking spaces, time restrictions, not enough public rest areas, dirty or poorly kept facilities, and poor parking area/space design.
- Nearly 8 in 10 rest areas reported truck parking utilization as either full or overflowing onto the ramps at night. During the day, nearly one-half of the rest areas were reported full or overflowing.
- Overcrowding at rest areas and truck stops peaks between 10 p.m. and midnight.
- More than 40 percent of rest areas limit the hours that trucks can park.
- Currently there is an estimated shortfall of 28,400 truck parking spaces in public rest areas. This number is projected to reach 36,000 spaces over the next 5 years and almost 39,000 spaces over the next 10 years. Although some of this shortfall might be met by planned expansions of private truck stop facilities, the two facility types, public and private, are not viewed as interchangeable.

In response to this study, a number of actions have been taken to improve opportunities for commercial vehicle operators to rest while on the road. The 1995 National Highway Safety System Designation Act included a provision for 100 percent Federal funding of safety rest area construction and modification. About one-half of all states now permit commercial vehicle weigh stations to remain open as rest areas when not in active use (FHWA 1998). Some states are going a step further; in Pennsylvania, for example, the PennDOT is retrofitting weigh stations with comfort and convenience facilities (phones, rest rooms, vending machines) and allowing truckers to park overnight.

Also, in response to the "Making Space for Safety" study, the FHWA hosted a Rest Area Forum in Atlanta, Georgia, in June of 1999, to address parking needs for commercial vehicles traveling on the nation's highways. The forum brought together state DOT and enforcement officials, motor carriers, private truck stop operators, commercial drivers, safety advocates, and other interested parties. Conference participants identified the following seven areas as being of particular concern for commercial vehicle operators:

- Safety and security at public and private rest stops.
- Ability of privately owned truck stops to meet the rest parking need.
- Availability of alternative parking sites (e.g., weigh stations, park-and-ride lots).
- Location of rest stops (i.e., spacing along the roadway).

- Adequacy of financial support (federal, state, local) for parking facilities.
- Imposed time limits on legal CMV parking.
- Education of CMV operators about fatigue (Hamilton 1999; Krammes 1999).

Preliminary recommendations were developed within each of the identified areas and will be used to help direct future FMCSA research and program activities.

Plans are being made to conduct an updated and expanded review of truck parking needs in response to a TEA-21 (Transportation Equity Act for the 21st Century) mandate. The TEA-21 legislation calls for a nationwide inventory of rest areas and other parking facilities along all of the National Highway System, an analysis of real and projected shortages, and development of a plan to reduce the shortages.

RELATED ACTIVITIES AT THE STATE LEVEL

A number of states have conducted their own safety rest area studies. Some of the studies have been in direct response to the "Making Space for Safety" report, whereas others are part of continuing efforts to assess rest area status and needs within the state. Larger scale efforts in the states of New York and California are summarized first, followed by highlights from other states.

New York

In New York, FHWA Motor Carrier Safety Assistance Program (MCSAP) funds were used to study truck driver fatigue. A total of 593 randomly selected long distance truck drivers were interviewed at public rest areas and private truck stops in the state during the spring of 1997 (Schneider et al. 1999). In addition to confirming the pervasiveness of drowsy driving, the interviews revealed that nearly one-third (30 percent) of the drivers took their longest period of sleep in their sleeper berths at public rest areas. Truck drivers were 20 times more likely to sleep at rest areas than at motels or hotels. However, just over one-half reported being discouraged from the use of public rest areas by inadequate parking: 80 percent said that they always/often were unable to find a parking space at a public rest area at night. The drivers also reported being discouraged by enforcement of the state's two-hour parking limit (28 percent), prostitution/solicitation (16 percent), lack of security (15 percent), and poor or expensive food (14 percent). The frequency of not finding nighttime parking spaces at rest areas was found to be associated with falling asleep at the wheel in the past year and violations of federal hours-of-service regulations (Schneider et al. 1999; McCartt et al. 2000).

In a related effort, 303 long distance tractor-trailer drivers were interviewed about the limited-service public rest areas along two specific routes in New York State (Hammer et al. 1997). Nine in 10 drivers said that improved commercial vehicle parking and services were needed, and 80 percent said that they would be very likely to use a full-service truck stop for resting or napping if available (Hammer et al. 1997; Schneider et al. 1999).

The New York State DOT has undertaken a major program to upgrade and expand its rest areas and to ensure that the needs of both motorists and commercial vehicle operators are met (Schneider et al. 1999). The program has the following four components: (1) a departmental rest area policy, (2) a departmental statewide rest area plan, (3) regional rest area plans, and (4) roadway corridor studies. The following list highlights some of the lessons learned to date that the program hopes to build upon:

- Public rest areas serve a critical public safety need.
- The public expects first class rest area facilities and services.
- Inadequate attention has been paid to the needs of commercial vehicle drivers, especially with respect to parking and resting places.
- A high level commitment is necessary to ensure that rest areas receive proper attention.
- Input from many officials and interest groups are desired in planning rest areas.
- The public sector probably cannot satisfy all rest area needs in the future, as costs are substantial.
- Increased federal flexibility appears desirable for (1) appropriate commercialization of public rest areas, especially where such services are not readily accessible and (2) encouraging development of more private truck stops.

California

Like New York, California has also taken significant steps to improve safe stopping opportunities for motorists traveling on its roadways. In the spring of 1999, Caltrans convened a task force "to develop a vision and recommendations" for improving the state's Safety Roadside Rest Area System (Caltrans 1999). The task force developed the following eight recommendations to ensure that the safety and comfort of the state's driving public are served:

- Raise the priority of rest area system safety as integral to highway safety.
- Develop an updated safety roadside rest area system master plan.
- Rescind the mandatory privatization policy.
- Expand and formalize public and private partnerships.
- Conduct ongoing evaluation of rest area system performance.
- Investigate in-route truck parking capacity issues.
- Maintain ongoing stakeholder involvement.

- Update safety roadside rest area design standards and guidelines.

In developing its recommendations, the task force placed particular emphasis on the safety role of rest areas, especially with respect to providing a safe location for drowsy drivers to stop and sleep or for a safe and quick change of drivers.

Although the recommendations were recently endorsed by the Director of Caltrans, implementing them will require considerable effort and resources. The background material developed by the task force notes that:

- The state has built no new rest areas in the past 14 years and has closed 4 rest areas.
- More than eight major efforts to secure private partners to jointly develop needed rest areas have failed.
- There are major deficiencies in parking capacity for commercial truckers.
- Of all rest area units, 95 percent have exceeded their 20-year design life and are very difficult to maintain.
- More then $77 million worth of rest area upgrading projects have been identified.
- The rest area master plan is obsolete, priorities for funding improvements are unclear, and existing policy hinders Caltrans' ability to address traffic capacity and safety issues at many locations (Buckley 1999).

Additional information on California's efforts to revitalize its safety rest area program is contained in chapter 7.

Other State Activities

Other examples of state activities are briefly highlighted here.

- In Tennessee, a statewide survey of nighttime parking at public rest areas and welcome centers found that only 39 percent of stopped trucks observed at night were in designated spaces in rest areas. The other 61 percent were along ramps, in undesignated "pull-out" areas, at interchanges, or along mainline shoulders (Wegmann et al. 1999).

- In addition to a program of regular user surveys, during 1997 and 1998 the Minnesota DOT conducted the following safety rest area studies: (1) a review and summary of all available user data from previous studies, (2) focus groups to explore public attitudes and service expectations, (3) a statewide telephone survey of safety rest area usage and satisfaction, and (4) a nighttime parking demand analysis for commercial truck usage. This last study confirmed a greater demand for nighttime truck parking at safety rest areas than spaces available (Minnesota DOT 1998).

- A Colorado rest area task force noted problems with inadequate space for overnight truck parking, aging structures, and safety and maintenance at that state's 34 public rest areas. The task force developed a system for prioritizing sites for renovation and reconstruction and recommended increased funding for capital construction and maintenance activities (Colorado DOT Rest Area Task Force Committee 1997).

- In Montana, a survey was conducted to obtain information related to the needs and expectations of rest area users. Survey questions addressed overall satisfaction with the facility, specific areas needing improvement, priorities for improvement, and rest area locations, accessibility, and safety. This information will be incorporated into the state's planning efforts to better direct rest area improvements and resources (Blomquist and Carson 1998).

ISSUES AFFECTING MOTORISTS

In contrast to commercial vehicle operators, there is no evidence of a shortage of parking spaces for motorists wanting to stop and rest at public rest areas. In fact, the "Making Space for Safety Study" documented an underutilization of parking spaces for cars: 6 of 10 interstate rest areas had a surplus of available car parking during the day, and 8 of 10 had a surplus in car parking capacity at night (TRI 1996). However, this does not mean that all motorists who might benefit from stopping and resting at public rest areas are doing so. Research, including surveys of the general driving public as well as user surveys conducted at rest area locations, has identified a number of factors that impact the potential usefulness of safe stopping areas as a countermeasure for preventing drowsy driving crashes. These factors are reviewed here.

Concerns for Personal Safety

A 1994 survey of 1,000 New York State licensed drivers revealed that 45 percent had stopped at a rest area during the past year when feeling drowsy (Fact Finders, Inc. 1994). However, 30 percent also reported that they had needed or wanted to stop at a rest area, but none was available. In addition, although two-thirds of the drivers stated that they would be very likely to stop at a rest area if they felt drowsy while driving, less than 30 percent of all respondents, and 17 percent of all female respondents, stated that they would do so if driving alone at night (Fact Finders, Inc. 1994). These results are similar to those reported in an earlier Texas study. Although 68 percent of the motorists surveyed in this latter study reported that they frequently stopped at rest areas, a majority said that they would never stop at night if they were alone, and some women even said that they were afraid to stop during the day (Euritt et al. 1992).

The New York State Drowsy Driving Task Force worked with its FHWA Division Office to conduct an informal survey of rest area security in other states (New York State Task Force 1994). A total of 24 states responded to the survey, and most indicated some problems with safety and security. Most frequently cited problems were illicit sexual activities, vandalism, drug use and sales, and assaults. Measures implemented by the states to improve safety and security at rest areas included 24-hour maintenance personnel, improved lighting, periodic patrol by law enforcement, establishing "mini" patrol posts, installation of public telephones and posting of emergency numbers, and establishing time limits for stopovers.

In its report to the full New York State Task Force on Drowsy Driving, the Rest Area Team recommended the following:

- establishing State Police substations or satellite offices at key rest area locations;
- installing security lighting;
- providing direct telephone access to the police;
- investigating the feasibility of security cameras where appropriate;
- employing uniformed DOT maintenance personnel at each rest area, with 24-hour staffing at selected rest areas; and
- implementing design improvements, such as improved lighting and visibility from the roadway, to enhance rest area safety, security, and appearance.

Rest area security was also addressed in the *NCHRP Report 324* review and evaluation of roadside rest areas described earlier (King 1989). Results from the 1,630 user interviews revealed that although 99 percent of these motorists felt safe and secure stopping at rest areas during the daytime, almost half had reservations about stopping at night. This was especially true for older travelers (only 34 percent said that they felt safe stopping at night) and women (only 43 percent said that they felt safe). Although these data suggest less of a safety and security problem than the New York State data, they are more than a decade old, and it is very likely that security and safety concerns have increased over the years.

The concerns voiced by rest area users were reinforced to some degree by feedback obtained from highway agencies on operational problems and security at rest areas (King 1989). "Moral offenses" and vandalism headed the list of problems rated as "very serious" or "extremely serious" by one or more responding states. States reported dealing with security issues by increasing law enforcement patrols, but most relied primarily on only irregular patrols. The author of the study noted that although perceived security problems of rest area users may not correspond to actual conditions, "the fact that these perceptions exist does act as a deterrent to rest area users. A perceived problem may thus turn into a real one if needed rest area stops, to combat fatigue at night, are not made" (King 1989).

Rest Area Amenities

A number of surveys, both state and national, have examined the reasons why motorists stop at rest areas and what services they typically use when they do stop. Not surprisingly, use of restroom facilities generally tops the list. In the NCHRP study (King 1989), 87 percent of all persons stopping at rest areas used the restrooms (King 1989). The next most frequently noted reason for stopping was to rest or stretch, and this was cited by 48 percent of the survey participants. Other reasons for stopping included getting a drink at the water fountain (14 percent), eating food packed for the trip (9 percent), checking the car (7 percent), and using the telephone (5 percent). Less than 3 percent of those stopping purchased anything to eat or drink, including coffee.

One reason for the absence of coffee at rest area facilities is a current Federal law that prohibits commercial operations within the interstate right-of-way. Although this law has been relaxed somewhat to allow for the placement of vending machines, coffee and other food and drink are often unavailable except in cases where private nonprofit groups are allowed to dispense them (often during holiday or peak travel periods). This situation may change as states explore joint public/private ventures at rest areas outside the highway right-of-way (King 1989; New York State Task Force 1994; Colorado DOT 1997). Already, increased amenities (e.g., gas and automotive services, fast food) are being provided at rest area facilities on toll roads, parkways, and other frequently traveled private roadways.

Rest Area Availability

FHWA guidelines recommend that rest area facilities on interstate highways be located every 50 miles or 1-hour driving time (FHWA 1981). The NCHRP study by King (1989) estimated that the average spacing between rest areas on interstate highways nationwide was 44 miles and on primary roadways 31 miles. However, the average spacing of rest areas on interstates within individual states ranged from 25 to 105 miles. These figures are based on the total number of rest areas reported by the states, and include both full- and limited-service facilities. When rest area users were questioned directly about the adequacy of current numbers of rest areas, 42 percent indicated that there were too few facilities, 54 percent said that the number of facilities was about right, 0.5 percent said that there were too many, and 4 percent had no opinion (King 1989).

Hours of operation and length of stay restrictions also impact the potential usefulness of rest areas as countermeasures for reducing drowsy driving and drowsy driving crashes. Although most rest areas are open 24 hours a day, some are closed at nighttime or during off-seasons (King 1989). Also, those that remain open are not necessarily staffed during nighttime hours. Length-of-stay restrictions vary as well, from less than 1 hour (generally not enforced) to 24 hours. Clearly rest areas that are

closed or otherwise unavailable cannot be effective countermeasures for drowsy driving crashes.

STATE AND PROVINCIAL SURVEY RESULTS

Results of the state and provincial survey pertaining to rest areas, conducted as part of the current synthesis study, are presented in Appendix E and highlighted in this section. In contrast to the "Making Space for Safety" study, a goal of this survey was to collect data on rest area facilities along *all* roadway types, not just interstate highways. Results were received from 37 states and 7 Canadian provinces. Although not all states completed all questions on the survey, only one state (Hawaii) reported not having motorist rest areas.

Numbers of Rest Areas

Appendix Table E-1 contains information on the number of reported rest areas in each state or province by type of roadway. Participating states identified a total of 1,829 rest areas. Just over one-half of these, 55 percent, are located on interstate highways and limited-access freeways. More than one-fourth, 29 percent, are on rural two-lane roadways. This number includes 63 facilities in Kansas that were described as "picnic" areas with no other facilities and 23 in Minnesota that had vault toilets only. Only 6 percent of the rest areas are located on rural multi-lane divided roadways and 3 percent on rural multi-lane undivided roadways. Five percent are situated on urban interstates. Listed in the "other" category are 22 rest areas in Massachusetts and 4 in Wisconsin on urban multi-lane roadways. (The eight "other" rest areas for California are welcome centers that are likely to be located on main roadways.)

Another way to view these results is in terms of the proportion of states having rest area facilities on each of the different types of roadway. Whereas all 35 of the states reporting have rest areas on rural interstate highways or limited-access freeways, 19 (54 percent) have at least one rest area facility on rural two-lane roadways, 14 (40 percent) have at least one facility on rural multi-lane divided roadways, eight (23 percent) have at least one facility on rural multi-lane undivided roadways, and 13 (37 percent) have at least one facility on urban interstates. States with more than half of their total rest area facilities on rural two-lane roadways include Illinois, Kansas, Maine, Oklahoma, and Wyoming.

In Canada, rest area facilities were primarily reported as being located on rural limited-access freeways and on rural two-lane roadways. The large number of facilities reported by the provinces of Ontario and Saskatchewan includes picnic areas or tourist campsites, as well as truck stops, weigh scale turnouts, and visitor information centers. Larger rest area facilities in Canada are typically joint public/private ventures. In Ontario, there are 24 large service centers on the province's two major freeways that provide fuel and food, with attached rest areas at 21 of these facilities. The smaller "picnic site" facilities generally offer few amenities and are not large enough to accommodate trucks. Neither Ontario nor Saskatchewan services rest area facilities year round. In Saskatchewan, where trucks can only be accommodated at a few of the weigh station locations, the current policy is to allow commercial vehicle rest stop needs to be served by the private sector (Saskatchewan Highways and Transportation 1993). In Alberta, businesses serving travelers on highways outside of urban centers are being encouraged to apply for designation as two-, three-, or four-star service rest areas, depending on the level of service they can provide to travelers.

Parking Limitations

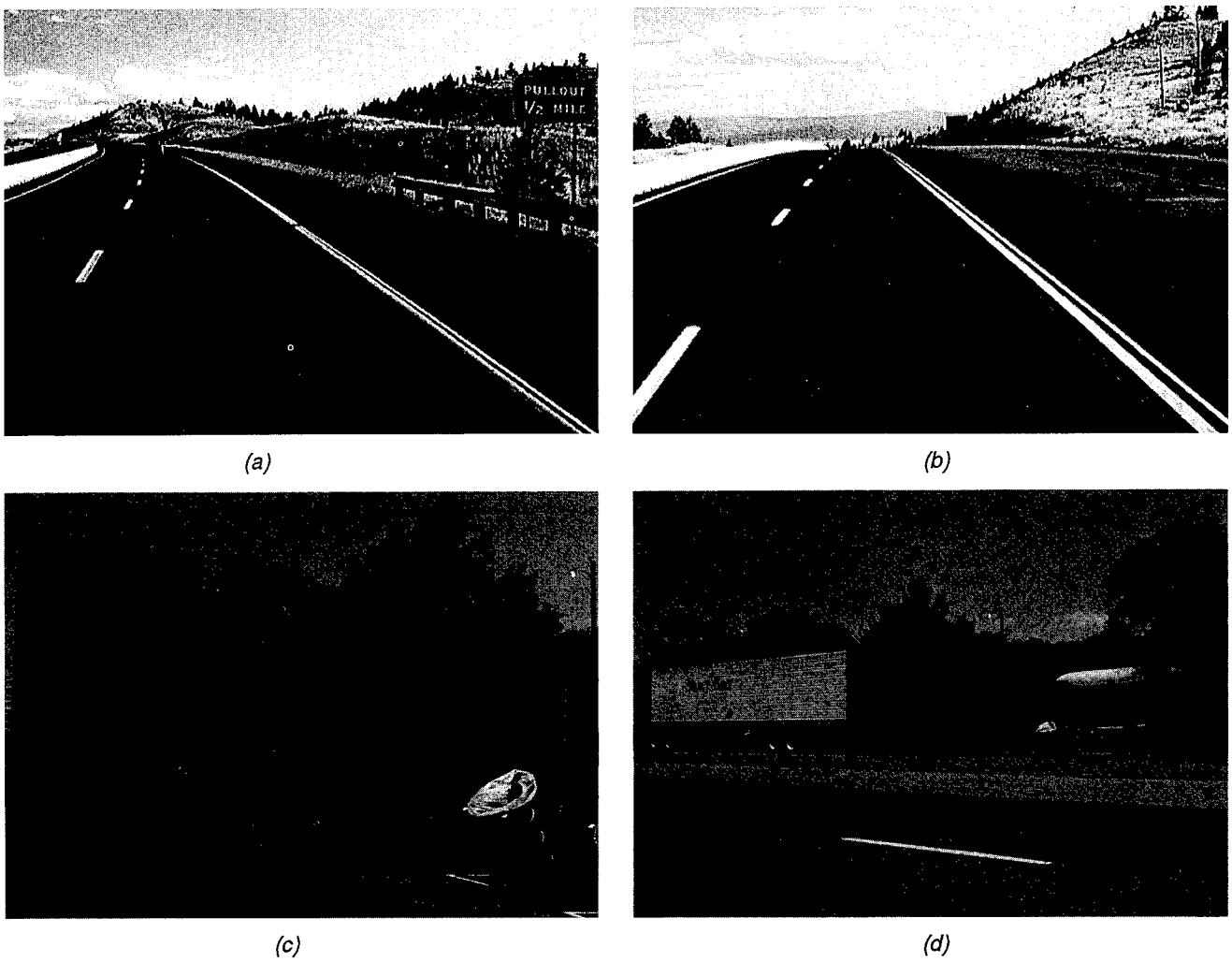
Nearly a one-third of the responding states reported no limitations on the length of time that motorists can park at rest areas, and several others indicated that their reported time limits are not enforced. None of the states reported any differences in regulations between private and commercial vehicle parking. Although some states do not allow overnight parking, and a few others have 24-hour limitations, parking limitations of 3 to 4 hours are the most common.

In Canada, four provinces reported no limitations on parking times, and one reported a limit of 12 hours and/or no overnight parking. Generally, the length of stay has not been a concern affecting Canadian rest area facilities.

Adequacy of Facilities

A number of questions on the survey dealt with the adequacy of rest area facilities, particularly parking capacity. Only a few of the states reported rest areas being full at night with respect to private vehicle or car parking. Several respondents noted that their reported percentages were rough estimates, and some simply indicated that they did not have this information and left the question blank. As expected, many more states reported problems in accommodating commercial vehicles. Five states reported that 100 percent of their rest areas are full at night with respect to commercial vehicle parking, and a number of others indicated that between 70 and 90 percent are full. Also, one-half of the states indicated that 50 percent or more of their rest areas are inadequate for commercial vehicles, but only a one-fourth stated that 50 percent or more of their rest areas are inadequate for private vehicles.

Approximately one-third of the states reported having some information on parking demand versus parking capacity at their rest areas. Some have collected their own data, but several referenced the recent "No Room in the Inn" report (TRI 1996) as their source of information on commercial vehicle parking.



(a) (b)

(c) (d)

FIGURE 12 (*a* and *b*) Pullout facility on Interstate 15 north of Helena, Montana (*courtesy of Craig Abernathy, Montana DOT*); (*c* and *d*) Truck pullout facility in Oklahoma (*courtesy of Wilson Brewer, Jr., Oklahoma DOT*).

Only two states (California and Maryland) reported having any information available on the use of roadway shoulders or interchange ramps for resting. However, a number of states expressed concern for the problem, based on their own informal observations and evidence from failed shoulders and roadside rutting. A few respondents noted that parking on roadway shoulders was illegal, suggesting that they did not believe it to be a significant problem in their state.

Although nearly one-half of the states reported 50 percent or more of their rest areas needing major renovation or expansion, aging and outdated buildings were cited more often than inadequate capacity. Also, several states noted needed improvements to satisfy Americans with Disabilities Act requirements.

In contrast, none of the Canadian provinces reported any capacity problems at their rest areas, although Ontario noted that traffic count data were needed for its larger facilities. Canadian motorists typically rely on commercial truck stops where food and fuel, and in some cases showers and sleeping stalls, are available. There is little if any overnight parking at the smaller "picnic type" facilities available, due at least in part to the absence of amenities. Only a small number of facilities were reported in need of major renovation or expansion.

Recent and Planned Improvements

Two-thirds of the states responding to the survey indicated that they have a master plan for public rest area construction and/or maintenance, and in most cases 90 percent or more of the planned rest area facilities have already been built. More than 60 percent of the states have built new rest areas during the past 5 years, and 85 percent have renovated or expanded existing rest areas. New rest areas are sometimes replacements for old facilities that have been closed, but which may or may not be located at the same site. At least some of the new facilities are on rural two-lane roadways. Several states noted that rest area renovation is an ongoing process; however, one state (Iowa) indicated that it is no longer renovating old facilities, but

instead has established a program to replace all rest area buildings at a rate of two each year. Nearly 60 percent of the responding states had closed at least one rest area during the past 5 years, but in many cases this was done in conjunction with the opening of a new facility nearby.

The states were less confident in projecting new rest area construction or renovation/expansion over the next 5 years. Although the large majority of states indicated that at least some new construction and/or renovation is planned, in many cases the exact number of facilities will depend upon available funds.

A number of states indicated an interest in pullout facilities that allow for resting, but which typically provide no other amenities (Figure 12). Such facilities have been constructed in 7 of the 35 reporting states over the past 5 years. At least three additional states reported having previously constructed pullout facilities, and three others reported allowing some closed rest areas or weigh station sites to remain open for parking, either for commercial vehicles only or for both commercial and private vehicles. Five states reported plans to construct pullout facilities over the next 5 years, including three that have not used them in the past. Five additional states volunteered that they either plan to convert closed rest areas to parking-only facilities or that they are studying such an alternative.

The seven Canadian provinces that responded to the survey reported very little rest area construction and renovation/expansion activity over the previous 5 years. The one exception was The Northwest Territories, which reported all new construction/renovation. Also, no rest area construction or renovation is planned over the next 5-year period. One province (Alberta) did report plans to construct additional truck pull-off facilities, which it does as part of general highway reconstruction. The Northwest Territories also uses truck pull-offs, but had no plans to construct additional such facilities.

Rest Area Security

Nearly all responding states reported that they have taken specific steps to help motorists feel safe at rest areas. The specific actions and percentage of states indicating them are summarized in Table 4. More than half of the states have taken steps to improve nighttime lighting, especially in parking lot and pedestrian walkway areas. One-half have also increased patrols or security; specific measures include routine patrol by state police or other law enforcement agencies, added patrols at selected locations and times, state police substations at rest area locations, monitoring systems linked to state police offices, and contracting additional (private) security. Nearly one-third of the states have increased attendants' hours of service or responsibilities, including 24-hour staffing of rest areas in several states. One of five states has added video surveillance cameras. Design changes include constructing new buildings with glass fronts that make lobby areas visible from the outside, placing the building itself so that it is easily visible from the roadway, creating doorless entries to restrooms, and designing the building so that men and women enter restroom facilities from the same side. Landscaping changes primarily involve removal of vegetation near building and parking areas. One state (North Carolina) has used signs to inform motorists of their "Rest Assured" program involving regular patrol by state police, and another (Virginia) reported creating signs and brochures addressing personal safety and providing police telephone numbers.

TABLE 4

MEASURES TAKEN BY STATES TO HELP MOTORISTS FEEL SAFE AT REST AREAS

Rest Area Security Measure	No. (%) of States Reporting ($N = 33$)	
Improved lighting	17	(52)*
Increased patrol/security	16	(48)
Increased attendant hours, responsibilities	10	(30)
Surveillance cameras	7	(21)
Landscaping changes	3	(9)
Building design changes	4	(12)
Telephone	2	(6)
Signage, information	2	(6)
Other	2	(6)

*Percentages total more than 100% due to multiple responses per state.

In response to a related rest area security question, two-thirds of responding states reported that all of their rest areas were routinely patrolled or monitored. However, this patrol often occurred at the discretion of local and state police, and the frequency of patrols was variable.

In sharp contrast to these U.S. results, security issues were generally not a concern for the Canadian rest areas. Only one province (Alberta) reported efforts to improve lighting on rest area premises and none of the rest areas are routinely patrolled or monitored.

CHAPTER SIX

REGULATORY AND JUDICIAL COUNTERMEASURES

A wide range of regulatory and judicial countermeasures for reducing drowsy driving crashes is potentially available for commercial vehicle operators. However, the possibilities are much more limited for the general motoring public. This chapter focuses on three areas that have general applicability: reporting of drowsy driving crashes, legal sanctions against drowsy drivers, and driver licensing.

REPORTING OF DROWSY DRIVING CRASHES

As noted in the initial chapter of this report, the magnitude and scope of the drowsy driving crash is not well defined. It is generally recognized that numbers based on police-reported data significantly underestimate crashes in which driver fatigue or sleepiness is a contributing factor (Knipling and Wang 1995; Pack et al. 1995; Webb 1995). Although not a regulatory or judicial issue per se, the difficulty in identifying and reporting drowsy driving crashes has important legal and policy implications. At the very least, accurate identification of a problem is needed to justify program funding and, later, to evaluate the effectiveness of any interventions undertaken.

Twenty-nine of the 37 states (78 percent) and all 7 of the Canadian provinces responding to the survey distributed as part of the current synthesis project indicated that there is a checkbox or category on their accident report form for identifying sleep- or fatigue-related crashes (see Appendix F). Not all report forms include places for identifying both fall asleep and fatigue crashes—in some states only one of the categories is identified, and in others they are combined. Also, several survey respondents volunteered that the number of reported sleep and fatigue crashes may not be accurate, because this condition often will not be known by the investigating officer. Only about one of five states, and no Canadian provinces, reported that law enforcement personnel were provided any special training or guidelines to help them identify whether or not a crash was related to driver sleepiness or fatigue.

Unlike the intoxicated driver, there is no simple test to determine a drowsy driver's level of alertness, especially once an accident has occurred. Chapter 3 described some new technologies being evaluated for monitoring driver alertness, but these will likely only be marketed to commercial vehicle operators and possible high-risk driving groups, such as shift workers and persons with sleep disorders.

The most practical and straightforward approach for improving the recognition and reporting of drowsiness as a causal factor in crashes likely rests in increased training and education of law enforcement personnel. Noted sleep researcher William Dement has observed that although the National Transportation Safety Board has established guidelines for identifying fatigue as a direct or contributing cause of accidents, these guidelines are rarely used in investigating highway crashes (Dement 1997). Nevertheless, work and rest schedules prior to a crash, length of time awake, hours of sleep the previous night, and time of day are important clues that state and local law enforcement officers could be trained to use when investigating a potential sleep-related crash.

In New York, education on drowsy driving has been integrated into training courses for law enforcement personnel at both the state and local levels (McCartt et al. 1998). As described in one recent report:

> Officers are encouraged to watch for the following indicators that falling asleep or drowsiness may be involved in a crash: single-vehicle run-off-road crash, lack of evidence of evasive maneuvers (e.g., skid marks), driver alone, occurring late at night or mid-afternoon, lack of evidence of other causation, and the driver's recent sleep-work history. When drowsiness is suspected, officers are advised to ask the driver whether drowsiness was involved in the crash, about his/her sleep and work history in the past 24 hours, how long he/she had been awake, and how long he/she had been driving (McCartt et al. 1998).

As part of their training, officers are also encouraged to consider that they themselves might be at risk for a sleep-related crash.

Efforts such as these to improve the accuracy and completeness of police crash data as a source of information on drowsy driving crashes can provide a better basis for countermeasure development and evaluation, and can also aid in enlisting law enforcement support for public education and enforcement activities to reduce drowsy driving. At the same time, however, it should be cautioned that increased training *only* in the detection of drowsiness as a causal factor in accidents can lead to added bias in the data. Instead, training is needed in identifying *all* potential factors contributing to a crash, including, for example, various forms of awake inattention.

LEGAL SANCTIONS

An overriding goal of many drowsy driving public awareness and information campaigns is to create a public mindset that drowsy or fatigued driving is as risky and irresponsible a behavior as drunk driving (Willis 1996; Nelson 1997). Currently,

except perhaps in the most extreme cases, there is no social stigma attached to falling asleep at the wheel (Dement 1997). This absence of social stigma carries over to the legal realm and affects what sanctions are applied to drowsy drivers who cause crashes.

This issue is also one that has been addressed by the New York State Task Force on Drowsy Driving. The Task Force observed that although laws are in place to regulate hours-of-service of commercial vehicle operators and to prevent bus drivers from working when impaired by fatigue, there are no laws specifically prohibiting operation of a private vehicle when drowsy. Laws against "gross negligence in the operation of a motor vehicle" or "reckless disregard for life and property" can be cited in extreme cases, but are rarely applied to the drowsy driver (McCartt et al. 1998).

Although it reported struggling with the issue, the Task Force came to the conclusion that "special sanctions for drowsy driving should not be imposed until the level of awareness about the problem had been heightened among the general population and among the enforcement and judicial communities." It determined that institution of criminal sanctions would be premature, and recommended that "current efforts be directed at providing a more in-depth administrative review of crashes involving a reported drowsy or fall-asleep driver, and at education for drivers, police officers, and the judiciary" (McCartt et al. 1998).

DRIVER LICENSING

There is ample evidence that certain sleep disorders are associated with an increased risk of motor vehicle crash involvement. This evidence was reviewed in the chapter 2 discussion of high-risk populations for drowsy driving crashes. Specifically, sleep apnea, a disorder in which the upper airway collapses recurrently, disrupting nighttime sleep and causing excessive daytime sleepiness, and narcolepsy, a disorder that involves sleep "attacks" along with excessive daytime sleepiness, have both been shown to be associated with a higher risk of crashing (Findley et al. 1988, 1989; Aldrich 1989; Cohen et al. 1992). The question is whether or not persons with these disorders should be restricted from driving.

In the case of commercial vehicle operators restrictions do apply. Interstate commerce regulations set forth in the Federal Motor Carrier Safety Regulations (49 CFR 390-399) state that:

> A person is physically qualified to drive a motor vehicle if that person . . . (5) Has no medical history or clinical diagnosis of a respiratory dysfunction likely to interfere with his ability to control and drive a motor vehicle safely, . . . (8) Has no established medical history or clinical diagnosis of epilepsy or any other condition which is likely to cause loss of consciousness or any loss of ability to control a motor vehicle, . . . (9) Has no mental, nervous, organic, or functional disease or psychiatric disorder likely to interfere with his ability to drive a motor vehicle safely (Part 391.41, as cited in Pakola et al. 1995).

Although these regulations do not specifically identify narcolepsy or sleep apnea as conditions that might disqualify a person from operating a commercial vehicle, it can be argued that these conditions are covered under these regulations (Pakola et al. 1995). These or similar regulations have been adopted by all states to also govern intrastate commerce (Pakola et al. 1995).

Only a few states have regulations or guidelines in place that govern the *licensing* of drivers with narcolepsy or sleep apnea. These regulations are summarized in Table 5. According to this 1995 publication, California and Texas have guidelines for both narcolepsy and sleep apnea; Maryland, North Carolina, Oregon, and Utah have guidelines for narcolepsy only; whereas Maine has proposed guidelines for sleep apnea. Three of the states (North Carolina, Texas, and Utah) have stricter criteria for commercial vehicle operators than for private vehicle operators, whereas the remaining four states do not make any distinctions regarding class of licensure (Pakola et al. 1995).

Generally, licensing of individuals with medical conditions that may affect their driving is handled by state driver medical review boards on a case-by-case basis (Petrucelli and Malinowski 1992). In the absence of specific guidelines, narcolepsy and sleep apnea are often subsumed under other more general categories such as "epilepsy and other episodic disorders" or "pulmonary disorders."

TABLE 5

STATES WITH REGULATIONS OR GUIDELINES FOR ALL MOTOR VEHICLE OPERATORS DEALING WITH SLEEP APNEA AND/OR NARCOLEPSY (Source: Pakola et al. 1995)

State	Sleep Apnea	Narcolepsy	Time Required to Be Symptom Free Before Resuming Driving	Recommended Frequency of Medical Review
California	Yes	Yes	Not mentioned	Not mentioned
Maine (proposed)*	Yes	No	Not mentioned	12 months
Maryland	No	Yes	12 months	Not mentioned
North Carolina	No	Yes	12 months	Not stipulated
Oregon	No	Yes	Not mentioned	6 months
Texas	Yes	Yes	6 months	12 months
Utah	No	Yes	12 months	Not mentioned

*Guidelines for sleep apnea effective 10/94 are based on functional ability profiles that determine driving status and frequency of reviews (Maine Bureau of Motor Vehicles 1994).

A key issue is how individuals with sleep disorders become identified to state driver licensing authorities. Only one of four states mandate physician reporting of medically impaired drivers, and this requirement is often tied to specific medical conditions, such as epilepsy or dementia (Petrucelli and Malinowski 1992). An even more important issue in the case of sleep disorders is that the vast majority of cases are undiagnosed, and persons may be even less likely to seek a diagnosis (and treatment) if they fear losing their driver's license. By requiring reporting, or by placing restrictions on drivers who have an identified sleep disorder, states may discourage persons from receiving the treatment they need to be safe drivers.

In contrast to the legal situation here in the United States, almost all Canadian provinces have guidelines in place for the licensing of individuals with narcolepsy or sleep apnea (Pakola 1995). Generally, these guidelines follow recommendations found in the Canadian Medical Association publication, *Physicians' Guide to Driver Examination* (CMA 1991). The following section from the guide pertains specifically to persons with sleep disorders:

> Patients with severe sleep apnea or other syndromes that chronically interfere with sleep are at increased risk of an accident or injury while driving because of daytime sleepiness. Sleep apnea is often accompanied by obesity, a condition affecting many professional drivers. Patients with a history of pathologic daytime sleepiness should be referred to a consultant for further assessment. If their condition is severe enough to impair driving ability, they should not be allowed to drive any class of motor vehicle until the condition has been adequately treated and controlled (CMA 1991).

The Association for the Advancement of Automotive Medicine is in the process of updating guidelines for licensing of persons with medical conditions. As a part of this NHTSA-supported effort, the Canadian guidelines, as well as Australian and British guidelines, are being reviewed and evaluated.

Also underway is an FMCSA-initiated research program to determine the level of sleep apnea that constitutes a safety risk for the operation of a commercial vehicle and development of a screening tool to identify at-risk drivers. This research will form the basis for future regulations on commercial driver qualifications with respect to sleep apnea (R. Knipling, FMCSA, personal communication, 1999).

In summary, although currently limited in scope, regulatory and judicial measures clearly have the potential for mitigating drowsy driving. These measures can be used to help improve the quality of our crash data and thus our understanding of the problem, they can communicate to the public the seriousness of the problem by levying stricter sanctions against drowsy drivers who crash, and they can control who is licensed to drive by defining medical conditions under which a license may be denied. In the future, these measures may play an increased role in efforts to address the problem of drowsy driving on our streets and highways.

CHAPTER SEVEN

THREE EXAMPLES OF GOOD STATE PRACTICES

NEW YORK STATE'S COMPREHENSIVE APPROACH TO DROWSY DRIVING

Throughout this report, reference has been made to research and program activities conducted in New York State. The reason behind this is clear: New York has been a leader in establishing a comprehensive statewide program to address the problem of drowsy driving. It has also documented its efforts extensively, providing an opportunity for other states to benefit from its experiences.

New York's drowsy driving program was inaugurated in December of 1993 at a statewide "Highway Safety Forum on Fatigue, Sleep Disorders and Traffic Safety" (Institute for Traffic Safety Management and Research 1993). The forum was jointly sponsored by the Institute for Traffic Safety Management and Research at the University at Albany, the State University of New York and the New York State Governor's Traffic Safety Committee, in cooperation with the NHTSA and the NSF. In addition to bringing together experts in the fields of sleep and traffic safety, the forum served as a backdrop for launching the first statewide "Drive Alert . . . Arrive Alive" campaign. This campaign was carried out in partnership with the NSF to raise public awareness of the dangers and causes of driver fatigue.

Shortly thereafter, in January of 1994, a Task Force on the Impact of Fatigue on Driving was appointed and charged with examining the scope and causes of drowsy driving and developing recommendations to address the problem. Its 82 members represented a broad range of expertise from both the public and private sectors. Members organized themselves into the following eight working groups:

- commercial drivers,
- crash reporting,
- curriculum,
- public information and education,
- roadside rest areas,
- shoulder rumble strips,
- legal sanctions, and
- research.

By the end of the year, the Task Force had identified specific initiatives in each of these areas (New York State Task Force 1994). A smaller group of Task Force members has continued to help guide the development and implementation of the highest ranked recommendations.

In addition to a variety of public awareness efforts, successful initiatives have included programs by the New York State Thruway Authority and the New York State DOT to install rumble strips on interstate highways and parkways and to improve the security and adequacy of the public roadside rest area system, including facilities for commercial vehicle drivers. If fully implemented, the New York State DOT's rest area plan would significantly increase the number of public rest areas and enhance existing facilities.

Several community programs have also recently been organized in the state. An informational packet, including sample publicity materials, was prepared by the state partners and made available to communities throughout the state. The community programs represent joint partnerships between the Governor's Traffic Safety Committee, the State Department of Health, and the Institute for Traffic Safety Management and Research, with local public health and traffic safety coalitions, high schools, colleges, employers, the medical community, and other community organizations. The programs have not only sought to put research results into practice in their educational efforts, but have participated in research as well, helping to pilot test educational materials for shift workers in an NHTSA-funded research project.

Over the past 6 years, New York State's drowsy driving program has been characterized by three important features: (1) a firm basis in research; (2) a broad, comprehensive set of countermeasures; and (3) a wide range of state and federal government agencies and private sector participants (McCartt et al. 1998). This three-pronged approach has made it a leader among states in addressing the issue of drowsy driving.

REVITALIZATION OF REST AREAS IN CALIFORNIA

In the fall of 1997, the California Transportation Commission (CTC), the board responsible for allocating that state's transportation funds, directed the California Department of Transportation (Caltrans) to develop a plan for closing rest areas that "had become obsolete for various reasons" (Buckley 1999). Caltrans officials returned with alternative closure options, but recommended instead that the system be revitalized to better serve the needs of present and future users. The CTC agreed, and Caltrans established a Safety Roadside Rest Area System Improvement Team (Rest Area Team) consisting of Caltrans experts and external stakeholders to develop a vision for the rest area system and specific recommendations for its improvement. The Rest Area Team met five times during 1999 to accomplish its goals. Their recommendations were identified in chapter 5. Two themes underlie these recommendations. One

is that rest areas provide definite safety benefits for the motoring public and are an integral part of the overall highway system. The other is that *all* parties that have a stake in the system must work cooperatively to ensure its success.

California currently has 88 rest areas. Its original statewide rest area plan, developed in 1962, called for the construction of 269 units at roughly 30-mile intervals. This number was lowered to 162 units in 1974, and to 104 units in 1985. At that time, 91 rest areas had been constructed and the CTC endorsed a privatization policy requiring that the remaining 13 units "be developed by the private sector with minimal state cost" (Caltrans 1999). However, despite some early promises of success (Kress and Dornbusch 1991) and at least eight major efforts to secure private partners to jointly develop needed facilities, no new rest areas have been constructed in California since 1985. In addition, although a major vista point was designated as a rest area in 1996, four facilities have since been closed (Caltrans 1999; R. Carhart, California DOT, personal communication, 2000). Meanwhile, the state's population is expected to increase by 15 million persons over the next 20 years.

To address its growing needs, Caltrans is exploring new and creative ways of partnering with the private sector and involving key stakeholders in the process. The initial Safety Roadside Rest Area Improvement Team included broad representation from both the public and private sectors (Figure 13). This policy of inclusiveness was carried over to the creation of subcommittees to specifically address issues of privatization and the special needs of truckers. Working directly with truck stop owners and industry representatives, for example, a new plan is being developed for expanding existing public rest area facilities by identifying nearby private facilities that are interested in increasing their services. Under this plan, Caltrans would acquire and develop land adjacent to the private facility specifically for longer stopovers or overnight parking, thereby reducing capacity demands at the public rest area. Truckers, as well as general motorists, would be encouraged to use the "satellite" facility for extended rest and sleep stops. The private facility would both manage and reap the financial benefits from the satellite parking area (R. Carhart, California DOT, personal communication, 2000).

Creative partnerships have also helped Caltrans reduce annual maintenance costs for its existing 88 facilities. Currently, the department budgets approximately $11 million per year for rest area maintenance, but this amount would be higher if not for the very successful partnerships established with "Rehabilitation Facilities," nonprofit businesses that, under the guidance of the California Department of Rehabilitation and the California Department of Mental Health, employ persons with disabilities to perform contract janitorial and grounds maintenance at rest areas. Another successful partnership that provides service and security to the public is the Department of Rehabilitation's Business Enterprise Program for blind entrepreneurs, which provides vending machines at many of the state's rest areas (Caltrans 1999; Coleman 1999). An additional $7 million per year is budgeted for rest area rehabilitation. By emphasizing the safety benefits of rest areas, proponents hope to attract additional resources within Caltrans to expand this basis of support.

External Representatives
American Association of Retired Persons
Automobile Club of Southern California
California Department of Mental Health
California Department of Rehabilitation
California Commission on Aging
California Division of Tourism
California Highway Patrol
California Roundtable on Parks, Recreation and Tourism
California State Automobile Association
Collier Interpretative Information Center Agency
Federal Highway Administration
Parents Against Tired Truckers
Traveler Center Services

Caltrans Representatives
Rest Area Coordinators (all districts)
Office of State Landscape Architecture
Maintenance
Engineering Service Center
Traffic Operations
Traffic Planning
Traffic Information
Ken Steele, Retired District Director
Ralph Carhart, Team Leader, Office of State Landscape Architecture

FIGURE 13 Caltrans Safety Roadside Rest Area Improvement Team (Caltrans 1999).

A revised statewide rest area plan is currently being developed under the direction of the Office of State Landscape Architecture. The plan provides further confirmation of California's renewed commitment to providing safe stopping opportunities for all motorists traveling its highways.

RESEARCH AND EDUCATION EFFORTS IN WASHINGTON STATE

The Director of Washington State's Traffic Safety Commission, John Moffat, became interested in the issue of sleep deprivation and its effects on drivers after attending an NTSB/NASA symposium on countermeasures for reducing fatigue-related accidents in all modes of transportation (NTSB/NASA 1996). Moffat followed up the symposium by attending a training session on operator fatigue developed by NASA for its flight crews (J. Moffat, personal communication, 2000).

Convinced of the significance of the problem, and realizing the difficulties that individuals living on the West Coast have attending events like the NTSB/NASA conference held in

Washington, D.C., Moffat led his office in organizing a "Western States Forum on Driver Fatigue." The Forum, held November 21–22, 1996, brought key researchers and program directors to the West Coast to share their knowledge and experience. The goal of the forum was to increase awareness of the issue of driver fatigue and to begin the process of developing intervention strategies for the Western states. The Washington Traffic Safety Commission (WTSC 1996) published a summary of the proceedings of the forum in pamphlet form.

The WTSC also funded a 2-year epidemiological study to gather information on driver risk factors for motor vehicle collisions. The study did not specifically examine collisions attributed to drowsy driving; instead, a unique approach was taken whereby interviews were conducted with a population of drivers involved in recent crashes, and with a matched control population of drivers not in crashes. The rationale behind the study was that drowsiness could be an underlying factor in crash occurrence, even if the crash is not specifically identified by investigating officers as drowsiness related. A paper documenting the results of the study has been prepared and is undergoing review (J. Moffat, personal communication, 2000).

The WTSC continues to share its experiences with other states in the area and to work with them in developing countermeasures to address the problem of drowsy driving. It has also developed a network of partners to assist in its public education efforts, including the NSF, Harborview Injury Prevention and Research Center, the American Automobile Association of Washington, and Northwest Ford Dealers. The WTSC actively supports the application of CSRSs to reduce run-off-road crashes, as well as centerline rumble strips to reduce lane crossovers along high-risk corridors. However, the primary thrust of its educational activities has been to convince motorists *not* to drive when drowsy. The WTSC has used 402 funds to support a wide range of public awareness and education activities directed at the general driving public as well as commercial vehicle operators. Future education activities will incorporate findings from the recently completed research study (J. Moffat, personal communication, February 2000).

CHAPTER EIGHT

CONCLUSIONS

Driver sleepiness is a direct causal factor in many highway crashes. It also likely contributes to many more crashes by reducing driver alertness and performance. Although adequate sleep is the only 100 percent effective countermeasure for sleepiness, countermeasures do exist that can help make driving safer. This study has reviewed those countermeasures, which include driver, vehicle, roadway, environmental, and regulatory/judicial measures. The following conclusions can be drawn from the review:

- *Education of high-risk populations.* Research has identified a number of groups at increased risk for involvement in a sleep-related crash. These include young adults (especially young males), shift workers, persons with undiagnosed and/or untreated sleep disorders, and commercial vehicle operators. Many public education and awareness activities have focused on these populations. There is particular benefit in educating the public about sleep disorders, because they are relatively common, the vast majority are undiagnosed, and effective medical treatments are available.

- *Education of the general driving public.* At the same time, we know that many sleep-related crashes involve drivers who do not fit a high-risk profile. Some of these drivers suffer from chronic sleep deprivation and others from acute episodes of sleep loss. From state and national surveys we know that a large percentage of the driving public is all too familiar with the experience of trying to drive while sleepy. Public education materials and programs have been developed that target the general driving population, but additional work is needed to evaluate the impact and effectiveness of these activities.

- *Knowledge of which behavioral countermeasures work and which do not work.* There is still considerable debate, and much public misperception, about which behavioral countermeasures are and are not effective for reducing drowsiness and decreasing the risk of an accident. Research indicates that brief (15 to 20 minute) napping and consuming caffeine can be effective short-term measures, particularly if done in tandem, but we still do not know about the benefits of other potential countermeasures such as brief exercise, smoking, eating, and some of the new over-the-counter drugs. At the same time, there are clearly some measures, such as listening to the radio and rolling down the car windows, which the public perceives to be effective, but that have not proven so when studied. More research is needed on the effectiveness of various strategies (including identification of potential new strategies) for increasing driver alertness and how this information can best be conveyed to the driving public.

- *Other groups in need of education.* In addition to targeting drivers, comprehensive public awareness and education campaigns have also sought to educate other key groups, including law enforcement personnel, driver licensing authorities, driver educators, employers, physicians, and school administrators and teachers. Examples of such activities include development of training courses for police personnel in how to identify sleep-related crashes, working with the medical community to establish guidelines for the licensing of individuals with sleep disorders, developing an educational curriculum for young beginning drivers that incorporates information on drowsy driving, developing educational materials that target employers of shift workers, and introducing the topic of good sleep hygiene to middle school age students. These are all-important components to a comprehensive public awareness and education program designed to reduce sleep-related crashes.

- *Effective collaboration.* Related to the previous item, many examples of highly effective collaborations have been highlighted throughout this synthesis report. These collaborations extend beyond public awareness and education activities to the full range of countermeasures being pursued—new technologies, roadway improvements, rest area management, and regulatory/judicial actions. In addition to extensive inter- and intra-agency coordination (FHWA, FMCSA, NHTSA, NCSDR, Transport Canada), effective partnerships have been developed with many private organizations and groups including the NSF, AAA Foundation for Traffic Safety, Trucking Associations of America, and ITS America. The development and validation of new technologies and the search for solutions to the problem of rest area overcrowding have also involved working with the private sector. The importance of effective collaboration has carried over to the state/provincial level, where a broad range of collaborators and sponsors were identified.

- *Goal of changing the public mindset.* An underlying goal of many educational interventions has been to change the public mindset about both the danger and the inappropriateness of trying to drive when sleepy. Both are needed to motivate appropriate changes in behavior.

Public disapproval of drowsy driving, similar to what has emerged with respect to drunk driving, is also a critical step towards establishing stronger legal sanctions against drowsy driving and against those drowsy drivers who cause crashes.

- *A place for new technologies.* To date, new technologies that monitor driver alertness and help drivers maintain alertness have primarily been directed toward commercial vehicle operators. Many of these technologies also have potential application in the overall driver population. Before this can occur, however, a number of challenges must be met, including making the technology easy to use, acceptable to the driver, unobtrusive, robust to daily use, and economically viable. Although many promising technologies have been developed, most have only seen limited validation in the field, and extensive research is needed before they are ready for large-scale implementation.

- *The need for countermeasures beyond education.* No matter how extensive the public education, it is unlikely that drowsy driving will ever be eradicated, and additional countermeasures are needed to lessen the negative consequences of drowsy driving. Continuous shoulder rumble strips (CSRSs) are one such countermeasure that has already been proven highly cost-effective in preventing run-off-road crashes on rural interstates. Additional research is needed to determine the effectiveness of CSRSs on other types of roadways, including two-lane rural highways, as well as their effectiveness for operators of heavy trucks.

- *Variable state practices regarding CSRSs.* Although almost all states have some experience with the use of CSRSs, there is no uniform approach to deciding when and where they should be installed and how they should be constructed. Most states have developed warrants or guidelines to assist in this process. Answers are still being sought to many questions, however, including how CSRSs can be made more compatible with bicycle travel, how to overcome maintenance problems (e.g., on roadways requiring snowplowing), how noise issues can be effectively addressed, and which types of CSRSs are suitable for which situations. In the past, states have had to struggle more or less independently with these issues; however, an FHWA-directed website on the Internet has made it possible for states to more easily share their experiences and learn from one another.

- *Other roadway treatments.* There was much less experience with, although considerable interest in, the use of centerline rumble strips to help prevent drowsy drivers from crossing into approaching travel lanes. This is another area where states might benefit from sharing their individual experiences.

- *Potential for misuse of certain countermeasures.* With CSRSs, as well as with many of the in-vehicle technologies being developed to monitor alertness and warn drivers when they are about to fall asleep, there is potential for misuse by the public. Specifically, drivers may use these countermeasures to help them continue to drive for longer periods of time, rather than heed their warning that they should stop and sleep. Although there is little evidence to support such a concern, education about the appropriate response to crossing a rumble strip or to being awakened by an in-vehicle alarm is seen as an important component to the successful implementation of these countermeasures.

- *A revived interest in rest areas.* Although widely available in the United States since at least the 1960s, public rest areas have received renewed attention as havens for sleepy truckers and motorists. The findings of this study suggest that nearly one-half of these rest areas, however, are in need of major renovation or expansion. Many states are looking to other approaches for meeting the needs of motorists, especially commercial vehicle operators. Allowing truck parking at closed rest area facilities or unused weigh stations is one solution being tried, as is constructing pullout facilities alongside the roadway. A number of states (as well as Canadian provinces) are also exploring cooperative public/private ventures where allowed by law.

- *Encouraging sleepy drivers to stop at rest areas.* Although rest areas are extremely popular, many motorists are wary about using them at night. Also, states vary in the extent to which they encourage, and even allow, motorist use of rest areas for sleeping or napping. Although rarely enforced, many have parking restrictions that discourage overnight stays. More important from the motorist viewpoint, however, is rest area security. In the United States, states have actively pursued a variety of measures to increase rest area security, including increased staffing/longer attendant hours, increased patrol by state police as well as private security services, improved lighting in parking lot and pedestrian areas, use of video surveillance cameras, improved building and landscaping design, and establishment of state police substations on rest area premises. In Canada, such measures have generally not been seen as necessary.

- *Opportunities for regulatory and judicial action.* Although currently limited in scope, regulatory and judicial measures clearly have potential for mitigating drowsy driving. These measures can be used to help improve the quality of our crash data and thus our understanding of the problem, they can communicate to the public the seriousness of the problem by levying stricter sanctions against drowsy drivers who crash, and they can control

who is licensed to drive by defining medical conditions under which a license may be denied. In the future, these measures may play an increased role in efforts to address the problem of drowsy driving on our streets and highways.

- *Making information available to the states.* State transportation departments share many of the same needs with respect to improving the roadway environment for sleepy drivers. They need to know where CSRSs should be placed, what specifications should be used, how bicyclists' concerns can be addressed, whether centerline rumble strips are an effective deterrent to crossover crashes, how to finance needed improvements to rest areas, how to make rest areas more secure, and much more. The FHWA can play a valuable role in making key information available to the states, including research results and information about what other states are doing. In this regard, its "rumblestrip" website (as well as the NHTSA's drowsy driving website) are valuable resources that should be widely publicized.

As these varied results suggest, there is no single solution to the problem of drowsy driving. There are many causes of driver drowsiness and many levels at which one can intervene to prevent a drowsy driving crash. Multifaceted programs that combine public education/awareness with roadway, environmental, and regulatory countermeasures, and that are poised to take advantage of available new driver monitoring and alerting technologies, offer promise.

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APPENDIX A

Questionnaire for State Transportation Departments

National Cooperative Highway Research Program

Project 20-5, Synthesis Topic 30-06

Sleep Deprivation Countermeasures for Motorist Safety

QUESTIONNAIRE

Loss of alertness due to sleepiness is a serious impairment to highway safety. Research has shown that the only effective solution to sleep deprivation is adequate sleep. However, countermeasures exist or are under investigation that have the potential to make highway travel safer.

This survey is being conducted to gather information on programs and policies at the state level to reduce drowsy driving and the crashes that may result from drowsy driving. Although considerable attention has been directed to commercial vehicle operators, **the primary focus of this survey is on operators of passenger vehicles, or the general motoring public**. We are especially interested in the extent to which motorist education programs, roadway modifications (such as the application of shoulder rumble strips), and public rest areas might be useful measures to counteract drowsy driving.

The information you supply will provide valuable input to the development of a summary report of current research and practices addressing this important topic.

Please return your completed questionnaire, along with any supporting documents, by **MAY 21** to:

Jane C. Stutts, Ph.D.
University of North Carolina
Highway Safety Research Center
730 Airport Road, Campus Box 3430
Chapel Hill, NC 27599-3430

If you have any questions, please call Dr. Stutts at 919-962-8717, or e-mail her at Jane_Stutts@unc.edu.

Below, please provide the name of the person completing this questionnaire or someone else who may be contacted to obtain any needed follow-up information:

Name _____
Title _____
Agency _____
Street Address _____
Town/State/Zip _____

Telephone _____
Fax _____
E-mail _____

Thank you very much for your help.

Reporting of Drowsy Driving Crashes

1. Does your state's motor vehicle crash report form contain a checkbox or category by which sleep- or fatigue-related crashes can be identified?

   ____ Yes ____ No

   Comment: _____

2. Are law enforcement personnel provided any special training or guidelines to help them identify whether or not a crash was related to driver sleepiness or fatigue?

   ____ Yes *(Please provide a copy of any guidelines available.)* ____ No

   Comment: _____

3. Have any reports or summaries been produced that document the nature and/or extent of drowsy driving in your state, either by the general driving public or by commercial vehicle operators?

   ____ Yes *(Please provide a copy of this information or summarize below.)* ____ No

   Comment: _____

Public Education and Awareness

4. Over the past 5 years, has your state engaged in any activities to raise public awareness and concern about drowsy driving?

   ____ Yes ____ No *(Skip to Question #11)*

   Comment: _____

5. What types of activities have taken place? *(Check all that apply.)*

   ____ Developed/distributed brochures, posters, other print materials
   ____ Developed/distributed public service announcements for radio or TV
   ____ Developed press releases, held news conferences, etc.
   ____ Made presentations, conducted conferences, held training sessions, etc.
   ____ Worked with trucking companies/commercial vehicle operators
   ____ Worked with businesses, industry, etc.
   ____ Worked with state/local government offices
   ____ Worked with state/local law enforcement personnel
   ____ Other *(Please describe below)*

   Comment: _____

6. What messages about drowsy driving have been conveyed in these activities/materials? *(Check all that apply.)*

____ Causes of drowsy driving (e.g., sleep deprivation, long distance driving, medications)
____ Individuals or groups at high risk for involvement in drowsy driving crashes (e.g., shift workers, young adult males, people with sleep disorders)
____ Dangers associated with drowsy driving (e.g., crash frequency and severity)
____ Countermeasures to reduce drowsiness while driving (e.g., adequate pre-trip rest, caffeine, shared driving)
____ Other *(Please describe below)*

Comment: _____

PLEASE PROVIDE COPIES OF ANY EDUCATIONAL MATERIALS DEVELOPED OR DESCRIPTIONS OF THESE MATERIALS

7. What audiences have been targeted in these educational programs or activities? *(Check all that apply.)*

____ General driving public
____ Commercial vehicle operators
____ Other *(Please specify below.)*

Comment: _____

8. Who has participated in or sponsored these educational programs or activities?

_____

9. What has been the primary source, or sources, of funds for your state's drowsy driving education and/or public awareness activities?

_____

10. Was information collected on the effectiveness of these activities?

____ Yes *(If yes, please provide a copy of this information or summarize results below.)*
____ No

Comment: _____

Continuous Shoulder Rumble Strips and Other Roadway Treatments

***Definition*:**
Continuous shoulder rumble strips (CSRSs) are raised or grooved patterns inserted on the shoulder of a roadway to alert drivers drifting off the road that they are about to depart the roadway.

11. Does your state have warrants or guidelines for the installation of rumble strips on the shoulders of rural Interstate highways, freeways, or other limited access roadways undergoing resurfacing or reconstruction?

    ____ Yes
    ____ No

    Comment: _____
    _____

12. Does your state have warrants or guidelines for the *retrofitting* of shoulders on rural Interstate highways, freeways, or other limited access roadways *not* undergoing resurfacing or reconstruction?

    ____ Yes
    ____ No

    Comment: _____
    _____

13. Does your state have warrants or guidelines for the installation of rumble strips on the shoulders of roadways *other than* rural Interstate highways or limited access freeways?

    ____ Yes
    ____ No

    Comment: _____
    _____

14. Approximately how many miles/kilometers of CSRSs are in place on each of the following roadway types in your state? *(Please circle whether reporting miles or kilometers.)*

	mi./km.
Rural Interstate highways and limited access freeways	_____
Rural multi-lane divided roadways	_____
Rural multi-lane undivided roadways	_____
Rural two-lane rural roadways	_____
Urban Interstate highways and limited access freeways	_____

    Comment: _____
    _____
    _____
    _____

15. For each roadway type, are current miles/kilometers of CSRSs likely to increase, decrease, or remain about the same over the next 5 years? *(Check one for each roadway type.)*

	Increase	*Decrease*	*Remain same*
Rural Interstate highways/limited access freeways	_____	_____	_____
Rural multi-lane divided roadways	_____	_____	_____
Rural multi-lane undivided roadways	_____	_____	_____
Rural two-lane rural roadways	_____	_____	_____
Urban Interstate highways/limited access freeways	_____	_____	_____

16. Does your state have any data on the impact of CSRSs on run-off-road or sleep-related crashes?

____ Yes
____ No

PLEASE PROVIDE A COPY OF ANY AVAILABLE DATA OR REPORTS, OR REFERENCE TO A SOURCE FOR THIS INFORMATION.

Comment: _____
_____
_____

17. Has your state experienced any significant problems with the use of CSRSs?

____ Yes *(If Yes, please explain below.)*
____ No

_____
_____
_____

18. Has your state placed rumble strips between the centerlines of two-lane or four-lane undivided roadways to help prevent head-on collisions?

____ Yes
____ No
____ Not yet, but considering or planning to do so

Comment: _____
_____

19. Are there other roadway treatments used by your state that might help to reduce sleep-related crashes?

____ Yes *(Please tell us about these below.)*
____ No

_____
_____
_____
_____

Rest Areas

20. How many public rest areas (including welcome centers) are there in your state?

_____ Rest areas *(If none, skip to end of survey.)*

Please provide a breakdown of the number of rest areas by type of roadway:

Roadway Type	*# Rest Areas*
Rural Interstate highways and limited access freeways	_____
Rural multi-lane divided roadways	_____
Rural multi-lane undivided roadways	_____
Rural two-lane roadways	_____
Urban Interstate highways and limited access freeways	_____
Other (please specify) _____	_____

Comment: _____
_____
_____

21. Does state policy limit the length of time a motorist can park at a rest area?

____ Yes If Yes, what is the limit? _____
____ No

Does it limit the length of time a commercial vehicle operator can park at a rest area?

____ Yes If Yes, what is the limit? _____
____ No

Comment: _____
_____
_____

22. Approximately what percentage of rest areas in your state are full at night with respect to

Commercial vehicle parking: _____ percent of rest areas are full
Private vehicle (car) parking: _____ percent of rest areas are full

Comment: _____
_____
_____

23. Does your state have a master plan for public rest area construction and maintenance?

____ Yes If yes, In what year was this plan developed? 19___
____ No In what year was it last reviewed, revised, or updated? 19 ___
Approximately what percentage of your state's planned rest areas have been built? ____ %

Comment: _____
_____
_____

24. How many new rest areas have been constructed in your state during the past 5 years?

____ Rest areas

Comment: _____
_____
_____

25. How many rest areas have been renovated and/or expanded in your state during the past 5 years?

____ Rest areas

Comment: _____
_____
_____

26. How many rest areas have been closed in your state during the past 5 years?

____ Rest areas

Comment: _____
_____
_____

27. Some states have constructed pull-off facilities that allow for resting but typically provide no other amenities. Has your state constructed any such pull-off facilities during the past 5 years?

____ Yes
____ No

If yes, do these serve (*check one*):
____ Motorists only
____ Commercial vehicle operators only
____ Both motorists and commercial vehicle operators

Comment: _____
_____
_____

28. Does your state plan to construct any new rest areas during the next 5 years?

____ Yes If Yes, how many? _____
____ No

Comment: _____
_____
_____

29. Does your state plan to expand or renovate any of its existing rest areas during the next 5 years?

____ Yes If Yes, how many? _____
____ No

Comment: _____
_____
_____

30. Does your state plan to construct any pull-off facilities, i.e., places for resting only?

____ Yes If Yes, how many? _____
____ No

Comment: _____
_____
_____

31. Approximately what percentage of rest areas in your state are adequate in capacity:

For private vehicles (cars)? _____ percent
For commercial vehicles (trucks)? _____ percent

Comment: _____
_____
_____

32. Approximately what percentage of areas in your state are in need of major renovation or expansion?

_____ percent

Comment: _____
_____
_____

33. Has your state done anything specific to help motorists feel safe at rest areas?

____ Yes *(Please describe below.)*
____ No

_____
_____
_____

34. Approximately what percentage of rest areas in your state are routinely patrolled or monitored to increase security and safety for motorists?

____ percent

Comment: _____
_____
_____

35. Does your state have any data or reports providing information on parking demand versus parking capacity at its rest areas, either for motorists, commercial vehicle operators, or both?

____ Yes *(Please provide a copy of this information or summarize below.)*
____ No

Comment: _____
_____
_____

36. Does your state have any data or information on the use of roadway shoulders or interchange ramps for resting, either by motorists, commercial vehicle operators, or both?

____ Yes *(Please provide a copy of this information or summarize below.)*
____ No

Comment: _____
_____
_____

37. Does your state have any data relevant to the benefits of rest areas for increasing driver alertness? This might include, for example, information on:

Trip length of motorists stopping at rest areas
Length of time spent at rest areas
Reasons for motorists stopping at rest areas
Motorists' use of rest areas for napping or sleeping.

____ Yes *(Please provide a copy of any available information.)*
____ No

Comment: _____
_____
_____
_____

Thank You!

Remember! Please enclose any information you may have on:

- Guidelines and requirements for reporting of sleep-related crashes, and documentation of the drowsy driving problem in your state.
- Educational programs or materials for preventing drowsy-driving/sleep-related crashes, and any information on their effectiveness.
- The impact of CSRSs on run-off-road or sleep-related crashes.
- Rest area parking demand versus capacity, parking along roadway shoulders or at interchange areas, and rest area use and benefits to motorists.

APPENDIX B

Questionnaire for State Highway Safety Offices

National Cooperative Highway Research Program
Project 20-5, Synthesis Topic 30-06

Sleep Deprivation Countermeasures for Motorist Safety

STATE HIGHWAY SAFETY OFFICE QUESTIONNAIRE

Loss of alertness due to sleepiness is a serious impairment to highway safety. Research has shown that the only effective solution to sleep deprivation is adequate sleep. However, countermeasures exist or are under investigation that have the potential to make highway travel safer.

This survey is being conducted to gather information on programs and policies at the state level to reduce drowsy driving and the crashes that may result from drowsy driving. Although considerable attention has been directed to commercial vehicle operators, **the primary focus of this survey is on operators of passenger vehicles, or the general motoring public**. We are seeking information from state highway safety offices as well as transportation departments, since both can play important roles in preventing drowsy driving crashes.

The information you supply will provide valuable input to the development of a summary report of current research and practices addressing this important topic. We will be happy to send you a copy of this report when completed.

Please return your completed questionnaire, along with any supporting documents, by **JUNE 5** to:

Jane C. Stutts, Ph.D.
University of North Carolina
Highway Safety Research Center
730 Airport Road, Campus Box 3430
Chapel Hill, NC 27599–3430

If you have any questions, please call Dr. Stutts at 919-962-8717, or e-mail her at Jane_Stutts@unc.edu.

Below, please provide the name of the person completing this questionnaire or someone else who may be contacted to obtain any needed follow-up information:

Name _____
Title _____
Agency _____
Street Address _____
Town/State/Zip _____

Telephone _____
Fax _____
E-mail _____

Thank you very much for your help.

1. Have any reports or summaries been produced that document the nature and/or extent of drowsy driving in your state, either by the general driving public or by commercial vehicle operators?

   ____ Yes *(Please provide a copy of this information or summarize below.)*
   ____ No

   Comment: _____
   _____
   _____

2. Over the past 5 years, has your state engaged in any activities to raise public awareness and concern about drowsy driving?

   ____ Yes
   ____ No *(Skip to Question #9)*

   Comment: _____
   _____
   _____

3. What types of activities have taken place? *(Check all that apply.)*

   ____ Developed/distributed brochures, posters, other print materials
   ____ Developed/distributed public service announcements for radio or TV
   ____ Developed press releases, held news conferences, etc.
   ____ Made presentations, conducted conferences, held training sessions, etc.
   ____ Worked with trucking companies/commercial vehicle operators
   ____ Worked with businesses, industry, etc.
   ____ Worked with state/local government offices
   ____ Worked with state/local law enforcement personnel
   ____ Other *(Please describe below)*

   Comment: _____
   _____
   _____

4. What messages about drowsy driving have been conveyed in these activities/materials? *(Check all that apply.)*

   ____ Causes of drowsy driving (e.g., sleep deprivation, long distance driving, medications)
   ____ Individuals or groups at high risk for involvement in drowsy driving crashes (e.g., shift workers, young adult males, people with sleep disorders)
   ____ Dangers associated with drowsy driving (e.g., crash frequency and severity)
   ____ Countermeasures to reduce drowsiness while driving (e.g., adequate pre-trip rest, caffeine, shared driving)
   ____ Other *(Please describe below)*

   Comment: _____
   _____
   _____

5. What audiences have been targeted in these educational programs or activities?

   ____ General driving public
   ____ Commercial vehicle operators
   ____ Other *(Please specify below.)*

Comment: _____

_____

_____

6. Who has participated in or sponsored these educational programs or activities?

_____

_____

_____

7. What has been the primary source, or sources, of funds for your state's drowsy driving education and/or public awareness activities?

_____

_____

_____

8. Was information collected on the effectiveness of these activities?

____ Yes *(If yes, please provide a copy of this information or summarize results below.)*
____ No

Comment: _____

_____

_____

9. Does your state have a comprehensive program in place to help counteract drowsy driving and prevent drowsy driving crashes?

____ Yes
____ No

Comment: _____

_____

_____

Thank You!

IMPORTANT! Please provide copies of any educational materials developed or descriptions of these materials, as well as any reports or other documentation of your state's activities related to drowsy driving. Also, please feel free to write in additional comments on the back of this page.

APPENDIX C

Survey Results—Public Education and Awareness

TABLE C-1

PUBLIC EDUCATION AND AWARENESS ACTIVITIES

States	PI&E Activities Last 5 Years	Types of Activities[1]									Messages Conveyed[2]					Audiences			Participants and Sponsors	Sources of Funding	Evaluation Data?
		a	b	c	d	e	f	g	h	i	a	b	c	d	e	Gen.	CMV	Other			
Alabama*	No																		(See Table C-2)	(See Table C-2)	
Alaska*	No																				
Arkansas**	No																				
California**	Yes	x	x	x	x	x	x	x	x		x	x	x	x		x	x				No
Colorado	No																				
Connecticut	No																				
Delaware	No																				
District of Columbia*	No																				
Florida	Yes	x	x	x		x					x	x	x	x		x	x				No
Georgia**	No																				
Hawaii**	Yes	x						x			x	x	x	x		x	x				No
Idaho	Yes	x									x	x	x	x		x	x				No
Illinois	Yes	x	x		x	x	x	x	x		x	x	x	x		x	x				No
Iowa**	Yes									x	x	x	x	x				x			No
Kansas	No																				
Kentucky*	No																				
Louisiana	No																				
Maine	Yes	x			x						x	x	x	x		x	x				No
Maryland	Yes	x		x		x	x		x		x		x	x		x	x				No
Massachusetts**	Yes									x	x	x	x	x							?
Michigan**	Yes		x		x	x		x	x		x	x				x	x	x			No
Minnesota	Yes	x	x	x	x			x	x		x					x		x			No
Mississippi*	No																				
Montana	Yes				x						x					x	x				No
Nebraska**	Yes			x	x		x				x	x	x	x		x					No
Nevada*	Yes		x											x		x					No
New Hampshire**	Yes	x			x			x	x		x	x	x	x		x		x			No
New Jersey**	Yes	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x			No
New York	Yes	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				Yes
North Carolina																					
North Dakota**	No																				
Ohio	Yes	x				x	x	x	x		x	x	x	x		x	x				No
Oklahoma*	Yes	x	x	x	x	x	x	x	x		x		x	x		x	x				No
Oregon	Yes	x		x		x	x	x	x		x			x	x	x	x				No
Pennsylvania**	Yes	x								x	x	x	x	x		x		x			No

TABLE C-1 *(Continued)*

South Carolina**	Yes	x	x	x	x	x	x	x	x		x	x	x	x		x	x				No
South Dakota**	No																				
Texas**	No																				
Utah**	Yes	x	x					x		x	x	x	x	x		x		x			No
Vermont**	Yes				x						x	x	x	x		x					No
Virginia	No																				
Washington*	Yes	x	x	x	x	x	x	x	x		x	x	x	x		x	x				No
Wisconsin	No?																				
Wyoming	Yes		x								x	x	x	x	?						No
SUMMARY	26 Yes 17 No 1 Unknown	18	13	11	14	12	11	13	12	5	25	20	21	23	3	23	16	7			1 Yes 24 No 1 Unknown

Canadian Provinces	PI&E Activities Last 5 Years	Types of Activities[1]									Messages Conveyed[2]					Audiences			Participants and Sponsors	Sources of Funding	Evaluation Data?
		a	b	c	d	e	f	g	h	i	a	b	c	d	e	Gen.	CMV	Other			
Alberta	Yes	x		x	x	x	x	x	x		x	x	x	x		x	x		Alberta Infrastructure, Transport Canada, Alberta Trucking Association, Workers Compensation Board	At this point only public funds	Yes (planned)
Manitoba	Yes	x	x	x															Manitoba Public Insurance		
New Brunswick																					
Newfoundland	Yes				x						x	x	x	x			x	x	Transport Canada, CMV operators	No cost	Yes
Northwest Territories	No																				
Ontario	No																				
Saskatchewan	Yes	x			x	x	x	x	x		x	x	x	x			x		Saskatchewan Highways and Transportation, STA, SGI	Government funding, Industry	No
SUMMARY	4 Yes, 2 No	3	1	2	3	2	2	2	2	0	3	3	3	3	0	1	3	1			2 Yes

*Response from state highway safety office only. **Response from both state highway safety office and state transportation department.
[1]Codes for types of activities: a) Developed/distributed brochures, posters, other print materials; b) Developed/distributed public service annnouncements for radio or TV; c) Developed press releases, held news conferences; d) Presentations, conferences, training sessions; e) Worked with trucking companies CMV operators; f) Worked with businesses, industry, etc.; g) Worked with state/local government offices; h) Worked with state/local law enforcement personnel; and I) Other.
[2]Codes for messages conveyed: a) Causes of drowsy driving; b) High-risk groups for drowsy driving; c) Dangers of drowsy driving; d) Countermeasures to reduce drowsiness while driving; and e) Other.
PI&E = public information and education; CMV = commerical motor vehicle operators; Gen. = general; STA = Saskatchewan Trucking Association; and SGI = Saskatchewan Government Insurance.

TABLE C-2

COMMENTS TO QUESTION ABOUT EDUCATIONAL ACTIVITY PARTICIPANTS AND SPONSORS AND SOURCES OF FUNDING (in parentheses)

State	Sources of Funding
CA	State Highway Safety (Federal 402 funds)
FL	AAA Auto Club South as part of national campaign; uncertain for CMV activities (N/A; private)
GA	State DOT, County DOT, Trucking Association (state funds)
HI	HI DOT and HI Trucking Association (N/A)
IA	Highway safety professionals, including law enforcement, traffic engineers, health professionals (Speaker expenses covered by Federal 402 funds)
ID	AAA members (AAA budget)
MD	Office of Traffic and Safety, MC Administration, Save Community Centers (Federal 402, NCSAP, State)
ME	PATT, Main Bureau of Highway Safety (unknown)
MI	MI State Safety Commission, MI Truck Safety Commission (Federal 402, truck licensing fees)
MN	State Department of Public Safety, local and country law enforcement agencies (Federal 402)
MT	MT Highway Patrol (normal budget)
NE	Safety councils, AAA, motor carriers, hospitals, and health departments (Federal 402 funds)
NH	Program for state employees (Federal 402 funds)
NJ	NJ Division of Highway Traffic Safety, AAA, insurance companies, Trucking Association, hospitals (Federal 402 funds)
NV	Highway patrol (sponsors)
NY	Governor's Traffic Safety Committee, Institute for Traffic Safety Management and Research, DOT, DMV, Department of Health, other agencies involved in Task Force (federal, state, private sectors) (Governor's Traffic Safety Commission, other private, in-kind resources)
OH	OH Trucking Association and Roadway Express Company (general budget)
OK	OK Highway Safety Office, Association of Central OK Governments (Federal 402)
OR	FHWA, ODOT Motor Carrier Transport Division, OR State Police (Federal 402)
PA	Penn DOT, Comprehensive Highway Safety Programs, Shering Corp., driver license centers, AAA, 55 Alive, Department of Aging (Shering Corp. paid for first printing of brochure)
SC	SC Department of Public Safety, SC Trucking Association, NHTSA, FHWA (state and Federal funds)
VT	All students, guest speakers, presenters, Department of Education, DMV (Department of Education funds)
WA	Ford dealers (Federal 402)

APPENDIX D

Survey Results—Rumble Strips

TABLE D-1

STATE AND PROVINCIAL USE OF CONTINUOUS SHOULDER RUMBLE STRIPS (Part 1)

States	Does State Have Warrants or Guidelines for:			Approximate miles/kilometers of CSRS on each of Following Roadway Types:					Plans to Increase or Decrease Amount of CSRS over next 5 Years				
	Installing CSRS on Rural Interstates, etc., During R/R?	Retrofitting CSRS on Rural Interstates, etc., *Not* During R/R?	Installing CSRS on Other Roadway Types?	Rural Interstate/ Limited Access Freeway	Rural Multilane Divided	Rural Multilane Undivided	Rural 2-lane Roadways	Urban Interstate/ Limited Access Freeway	Rural Interstate/ Limited Access Freeway	Rural Multilane Divided	Rural Multilane Undivided	Rural 2-lane Roadways	Urban Interstate/ Limited Access Freeway
Arkansas	Yes	No	No	150	0	0	0	27	Inc.	Inc.	Same	Same	Inc.
California	Yes	No	Yes	(Detail data maintained but not summarized.)					Inc.	Inc.	Inc.	Inc.	Inc.
Colorado	Yes		Yes						Inc.	Inc.	Inc.	Inc.	Same
Connecticut	No	Yes	Yes	250	0	0	0	550	Inc.	Same	Same	Inc.	Inc.
Delaware	?	No	No	0	0	0	0	16	Inc.	Inc.	Same	Inc.	Inc.
Florida	Yes	No	No	(Date not available.)					Inc.				Inc.
Georgia	Yes	No	Yes	700	200	30	1000	400	Inc.	Inc.	Inc.	Same	Inc.
Hawaii	No	No	No										
Idaho	No	No	No	(Just beginning to use on Interstates.)					Inc.	Same	Same	Same	Same
Illinois	Yes	No	Yes	(Data not available.)					Inc.	Inc.	Same	Same	Inc.
Iowa	No	No	No	1210 km	150 km	0	0	236 km		Inc.	Same	Dec.	Same
Kansas	Yes	No	No						Inc.	Inc.	Inc.	Inc.	Inc.
Louisiana	No	No	No	15	25	0	0	0	Inc.	Inc.	Same	Same	Same
Maine	Yes	Yes	No	201	0	0	0	0	Inc.	Inc.	Same	Same	Inc.
Maryland	Yes	Yes	Yes	240	40	0	0	0	Inc.	Inc.	Inc.	Inc.	Same

TABLE D-1 *(Continued)*

Massachusetts	Yes	Yes	Yes	1820	0	0	0	780	Inc.	Same	Same	Same	Inc.
Michigan	Yes	No	No						Inc.	Inc.	Same	Same	Same
Minnesota	Yes	Yes	Yes						Inc.	Inc.	Inc.	Inc.	Same
Montana	Yes	Yes	Yes	880+	0	0	190+	0	Inc.	Inc.	Inc.	Inc.	
Nebraska	Yes	No	Yes						Inc.	Inc.	Same	Inc.	Inc.
New Hampshire	Yes	Yes	No	120	0	0	0	0	Same	Same	Same	Same	Same
New Jersey	Yes	Yes	Yes	(Estimated 815 total miles.)					Inc.	Inc.	Inc.	Inc.	Inc.
New York	Yes	Yes	Yes	725 + 561	90	90	0	45	Inc.	Inc.	Inc.	?	Inc.
North Carolina	Yes	No	No	1000	0	0	0	50	Inc.		Same		Same
North Dakota	Yes	No	Yes						Inc.	Inc.	Inc.	Inc.	Inc.
Ohio	Yes	No	Yes						Inc.	Inc.	Inc.	Same	Inc.
Oklahoma	Yes	Yes?	Yes										
Oregon	Yes	Yes	Yes	600	0	100	0	0	Inc.	Same	Same	Same	Same
Pennsylvania	Yes	Yes	Yes	350		10–15			Inc.	Inc.	Inc.	Inc.	Inc.
South Carolina	Yes	No	Yes	671	0	0	0	212	Same	Same	Same	Same	Same
South Dakota	Yes	Yes	Yes	809	0	0	600+	0	Inc.	Inc.	Inc.	Inc.	Same
Texas	Yes	Yes	Yes						(Expect to increase.)				
Utah	Yes	No	No										
Vermont	No	No	No	0	0	0	0	0	Inc.	Same	Same	Same	Same
Virginia	Yes	No	No	485					Inc.				
Wisconsin	Yes	Yes	No	400	200	0	0	150	Inc.	Inc.	Same	Same	Inc.
Wyoming	Yes	Yes	Yes	550				311	Inc.	Inc.	Inc.	Inc.	Same
SUMMARY	30 Yes 6 No 1 Unknown	16 Yes 20 No 1 Unknown	21 Yes 16 No						31 Inc. 2 Same 4 Unknown	24 Inc. 7 Same 6 Unknown	15 Inc. 17 Same 5 Unknown	15 Inc. 14 Same 1 Dec 7 Unknown	18 Inc. 13 Same 6 No

TABLE D-1 *(Continued)*

Canadian Provinces	Does State Have Warrants or Guidelines for:			Approximate miles/kilometers of CSRS on each of Following Roadway Types:					Plans to Increase or Decrease Amount of CSRS over next 5 Years				
	Installing CSRS on Rural Interstates, etc. , During R/R?	Retrofitting CSRS on Rural Interstates, etc., *Not* During R/R?	Installing CSRS on Other Roadway Types?	Rural Interstate/ Limited Access Freeway	Rural Multilane Divided	Rural Multilane Undivided	Rural 2-lane Roadways	Urban Interstate/ Limited Access Freeway	Rural Interstate/ Limited Access Freeway	Rural Multilane Divided	Rural Multilane Undivided	Rural 2-lane Roadways	Urban Interstate/ Limited Access Freeway
Alberta	Yes	Yes	No	400 km	300 km		500 km		Same	Inc.		Inc.	
Manitoba	No	No	No										
New Brunswick	No		No										
Newfoundland	No	No	No						Same	Same	Same	Same	Same
Northwest Territories	No	No	No						Same	Same	Same	Same	Same
Ontario													
Saskatchewan	Yes	Yes	No		45 km		30 km			Inc.		Inc.	
SUMMARY	2 Yes 4 No 1 Unknown	2 Yes 3 No 2 Unknown	5 No 1 Unknown						3 Same 4 Unknown	2 Inc. 2 Same 3 Unknown	2 Same 5 Unknown	2 Inc. 2 Same 3 Unknown	2 Same 5 Unknown

Inc. = increase; Dec. = decrease.

TABLE D-2

STATE AND PROVINCIAL USE OF CONTINUOUS SHOULDER RUMBLE STRIPS (Part 2)

States	Data on Effects of CSRS	Experienced Any Significant Problems with Use of CSRS	Experience with Use of Rumble Strips between Centerlines of Roadway	Other Roadway Treatments
Arkansas	No	No	No	No
California	Yes	Bicyclist concerns	Yes	Thermoplastic traffic strip
Colorado		Bicyclist concerns. Inadequate depth of rolled-in CSRS	Yes	No
Connecticut	No	Noise complaints	(Considering)	No
Delaware	Yes	No	Yes	Use of microsurfacing

TABLE D-2 *(Continued)*

Florida	No	No. But some complaints from wide-load transporters, possible increase in truck tire unraveling	No	Profile markings are qualified, but not approved to replace rumble strips
Georgia	No	No	No	No
Hawaii	No	Not applicable		No
Idaho	No	Unknown; just beginning to use	No	No
Illinois	No	No	No	Rumble strips in advance of stop intersections on rural highways
Iowa	No	No	No	No
Kansas	No	No, but bicyclist concerns	No	Improved lane widths, paved shoulders
Louisiana	No	No	No	
Maine	Yes	No, but may have contributed to a few accidents	No	No
Maryland	Yes	No	Yes	Transverse rumble strips
Massachusetts	No	No	Yes	No
Michigan	No			
Minnesota	No	Rolled-in variety inadequate	Yes	No
Montana	Yes	No	No	Different surface for shoulders
Nebraska	No	No	No	No
New Hampshire	Yes	Noise. Water in grooves a potential problem. Problems if too close to edge of roadway	No	No
New Jersey	Yes	Bicyclist concerns	Not yet	No
New York	Yes	No	No	Raised pavement markers. Rumble strips in lanes in advance of work zones
North Carolina		No	Yes	Median guardrails
North Dakota	No	No	No	No
Ohio	No	No		RPMs (but they don't use)
Oklahoma	No	No	No	Jersey barriers, large clear areas
Oregon	No	Routine maintenance adversely affected in mountain areas	Yes	
Pennsylvania	No	No. But bicyclist concerns	Yes	No
South Carolina	No	Changed to milled in CSRS	No	Median rumble strips plus pavement markers
South Dakota	No	When placed on asphalt shoulder next to concrete, edge of rumble strip sometimes develops a crack that will allow water in	No	No
Texas	Yes	No	No	No
Utah	Yes	Bicyclist concerns	No	No
Vermont	No	No	No	No
Virginia	Yes	No	No	No
Wisconsin	No	No	Yes	No
Wyoming	No	No. But bicyclist concerns and snow plow operators don't like driving over them	No	Truck pull-outs
SUMMARY	11 Yes 24 No 2 Unknown	10 Yes 5 Said no, but a concern indicated 19 No 3 Unknown	10 Yes 2 No 22 Considering 3 Unknown	13 Yes 21 No 3 Unknown

RPM = raised pavement markers.

TABLE D-2 *(Continued)*

Canadian Provinces	Data on Effects of CSRS	Experienced Any Significant Problems with use of CSRS	Experience with Use of Rumble Strips between Centerlines of Roadway	Other Roadway Treatments
Alberta	No	Bicyclist concerns. Noise. Cause truckers to move toward centerline	Yes	Approach rumble strips at stop conditions
Manitoba	No		No	No
New Brunswick	No		No	No
Newfoundland	No		No	No
Northwest Territories	No		No	No
Ontario				
Saskatchewan	No	Placement on new pavement without shoulder stripe as guide has proven an issue. Local cycling club questioned its layout	No	Construction of pull-offs, etc.
SUMMARY	6 No 1 Unknown	2 Yes	1 Yes 4 No 1 Unknown	2 Yes 4 No 1 Unknown

APPENDIX E

Survey Results—Safety Rest Areas

TABLE E-1

RESULTS OF STATE AND PROVINCIAL SURVEY PERTAINING TO REST AREAS (Part 1)

States	Total No. Rest Areas in State	Number of Rest Areas on Each Roadway Type						Limit on Time One Can Park at Rest Area	% Full at Night		State Master Plan for Construction/ Maintenance	
		Rural Interstate	Rural Multilane Divided	Rural Multilane Undivided	Rural Two-lane	Urban Interstate	Other		CMV Parking	Private Vehicle Parking	Master Plan	% of Plan Built
Arkansas	36	19	2	2	13	0	0	Overnight	40	0	Yes	100
California	96	60	7	3	15	3	8	8 h	100	20	Yes	93
Colorado	34	23	0	11	0	0	0	No overnight			Yes	90
Connecticut	7	7	0	0	0	0	0	24 h	85	35	No	
Delaware	3	1	1	0	0	1	0	None	0	0	No	
Florida	67	26	1	0	0	40	0	3 h	40	30	Yes	100
Georgia	29	29	0	0	0	0	0	No overnight	80	5	No	
Hawaii												
Idaho	29	21	0	0	8	0	0	8 h on interstate 16 h on rural 2-lane	50	0	Yes	90
Illinois	114	53	0	0	61	0	0	3 h	60	10	Yes	85
Iowa	39	39	0	0	0	0	0	24 h	100	30	Yes	
Kansas	40 + 63 picnic	28	0	0	12 + 63 picnic	0		None	50	20	Yes	90
Louisiana	34	34	0	0	0	0	0	No overnight	90	5	Yes	95
Maine	95	11	0	0	84	0	0	No overnight	12	0	No	
Maryland	10	9	1	0	0	0	0	None	100	0	No	
Massachusetts	108	7	12	0	44	23	22	None (if attended)	10	0	Yes	85
Michigan	70	63	0	0	2	5	0	15 min	70	0	Yes	99

TABLE E-1 *(Continued)*

Minnesota	55	31	11	3	6 + 23	4	(23)	6 h	11*	0	Yes	
Montana								None			Yes	
Nebraska	27	25	0	0	2	0	0	5 h	67 (est.)	0 (est.)	Yes	100
New Hampshire	16	9	0	0	5	2		4 h	0	0	No	
New Jersey	30	30	0	0	0	0	0	None	?		Yes	
New York	37	37	0	0	0	0	0	3 h at night	90	10	No	
North Carolina	61	42	2	7	9	1	0	4 h	20	0	No	
North Dakota	31	22	4	0	5	0	0	None	10	0	No	
Ohio	121	48	36	0	37	0	0	3 h (not enforced) No overnight	100		No	
Oklahoma	155	49	0	23	81	2	0	None			Yes	
Oregon	70	21	0	13	33	3	0	12 h in 24			Yes	100
Pennsylvania	46	40	0	0	0	6	0	2 h	100	40	Yes	
South Carolina	31	31	0	0	0	0	0	None	0	0	Yes	
South Dakota	14	14						3 h			Yes	100
Texas	110	79	31	0	0	0	0	24 h	50	20	Yes	
Utah								None	Closed 11 pm–7 am			
Vermont	19	16	1	1	1	0	0	None	0	0	No	
Virginia	41	34	1	0	0	6	0	2 h	100	10	Yes	
Wisconsin	34	22	5	0	1	2	4	None	15	0	Yes	100
Wyoming	34	16	0	0	18	0	0	4 h	10	0	Yes	98
SUMMARY	1743	996 (54.5%)	115 (6.3%)	63 (3.4%)	523 (28.6%)	98 (5.4%)	34 (1.9%)	11 None 4 No overnight			24 Yes 11 No 2 Unknown	

*Based on a recent 3-year truck parking study. Percentage of rest areas found to meet or exceed capacity on 70% percent or more weekday nights.

TABLE E-1 *(Continued)*

Canadian Provinces	Total No. Rest Areas in Province	Number of Rest Areas on Each Roadway Type						Limit on Time One Can Park at Rest Area	% Full at Night		State Master Plan for Construction/ Maintenance	
		Rural Interstate	Rural Multilane Divided	Rural Multilane Undivided	Rural Two-lane	Urban Interstate	Other		CMV Parking	Private Vehicle Parking	Master Plan	% of Plan Built
Alberta	11	2	3	0	2	0	4 WC	12 h No overnight	0	0	Yes	10
Manitoba												
New Brunswick												
Newfoundland	12	8	0	0	4	0		None	0	0	No	
Northwest Territories	10	0	0	0	10	0		None	0	0	No	
Ontario	190*	21	0	0	169	0		None	Unknown	0	No	
Saskatchewan	536**	116	0	0	420	0		None	Unknown	Unknown	No	
SUMMARY	759	147 (19.4%)	3 (0.4%)	0 (0.0%)	605 (41.2%)	0 (0.0%)	4 (0.5%)					

* Approximate total; includes 21 joint public/private service centers on major freeways, plus ~170 picnic site facilities on rural two-lane roadways.
** Total includes tourist campsites, truck stops, weigh scales, turnouts, and visitor information sites. The 116 sites are on provincial highways that would qualify under a proposed Canadian National Highway Program.
WC = welcome center.

TABLE E-2

RESULTS OF STATE AND PROVINCIAL SURVEY PERTAINING TO REST AREAS (Part 2)

States	Rest Area Construction and Renovation/ Expansion in Past 5 Years			Planned Rest Area Construction and Renovation/ Expansion Next 5 Years		Pull-off Facilities for Resting Only		% Adequate Capacity		Information on Demand vs. Capacity	% in Need of Major Renovation/ Expansion	Information on Use of Shoulders or Ramps for Resting
	New RAs Built	Ren./ Exp. RAs	Closed RAs	New RAs	Renovation or Expansion	Built Past 5 Years?	Plan to Build?	For Private Vehicles	For CMV			
Arkansas	1	11	1	None	?	No	No [1]	100	70	Yes	50	No
California	0	0	1	1–2	10–12	No	No [1]	50	20	No	80	Yes
Colorado	3	5	4	2	None	Yes	No	90	50	Yes	10	No
Connecticut	0	7	0	None	None	No	No	100	80	No	0	No
Delaware	1	0	0	None	None	No [2]	No	100	100	No	0	
Florida	0	8	4	None	Unknown	No	No	100	100	No	20	No
Georgia	0	17	0	None	2	No	No	100	90	No	10	No
Hawaii												
Idaho	2	3	2	2	6	No	No [1]	90	10	No	20	No
Illinois	7	6	15	1–3	1–2	No	No	85	60	Yes	10	No
Iowa	1	5	2	2	2/year	No [2]	No	100	50	No (but no room)	10	No
Kansas	1	0	22	3	7	No [1]	No	90	15	No	10	No
Louisiana	1	0	0	1		No	No	85	10	No	10	No
Maine	0	3	0	1–2	7–9	No	No	100	88	No	90	No
Maryland	0	4	0	None	3	Yes	?	50	30	Yes	50	Yes
Massachusetts	1	22	5	?	10	No	No	90	90	No	20	No
Michigan	4	1	3	9	8	No	No	95	50	Yes	60	No
Minnesota	2	18	0	1–2	13	No [1]	No	100	89	Yes	50	No

Table E-2 *(Continued)*

Montana	5	3				Yes	Yes	?	?	No	75	No
Nebraska	0	8	2	None	8	No	No	90	49	Yes		No
New Hampshire	1	2	1		1	Yes	No	25	25	No	20	No
New Jersey				33 [3]	18	Yes	Yes	?	?	No		?
New York	1	3	0	2	6	No	No [1]	50	10	Yes	90	No
North Carolina	5	7	1	3	8	No	No	95	90	Yes	10	No
North Dakota	1	6	6	1	7	No	No	100	65	No	30	No
Ohio	1	2	25	2	?	No	Yes	50	0	No	100	No
Oklahoma	3	2	1	2	1	Yes	No	100	85	No		No
Oregon	0	4	1	1	4	No	No	100	70	Yes	20	No
Pennsylvania	3	2	0	5	5	No	Yes	0	0	No	50	No
South Carolina	5	4	0	8	2	No	No	25	25	No	75	No
South Dakota	4	6	0	2	3	No	No	100	100	Yes	20	No
Texas	0	31	9	26	53	No [1]	No [1]	80	10	No (but no room)	90	No
Utah												
Vermont	0	0	1		6	No	No	100	100	No	40	
Virginia	0	7	0		20	No	Yes	50	50	No	50	No
Wisconsin	0	3	0	1	2	No	No	80	40	No	30	No
Wyoming	0	4	1	2	30	No [2]	No	100	80	No	80	No
SUMMARY	22 > 1 12 = 0	28 > 1 6 = 0	20 > 1 13 = 0	22 > 1 12 = 0	7 None	7 Yes	5 Yes			11 Yes 24 No		2 Yes

Table E-2 *(Continued)*

Canadian Provinces	Rest Area Construction and Renovation/ Expansion in Past 5 Years			Planned Rest Area Construction and Renovation/ Expansion Next 5 Years		Pull-off Facilities for Resting Only		% Adequate Capacity		Information on Demand vs. Capacity	% in Need of Major Renovation/ Expansion	Information on Use of Shoulders or Ramps for Resting
	New RAs Built	Ren./ Exp. RAs	Closed RAs	New RAs	Renovation or Expansion	Built Past 5 Years?	Plan to Build?	For Private Vehicles	For CMV			
Alberta	0	0	1	None	None	Yes	Yes	100	100	No	5	No
Manitoba												
New Brunswick												
Newfoundland	1	0	0	None	None	No	No	100	100	No	0	No
Northwest Territories	10	4	0	None	None	Yes	No	100	100	No	0	No
Ontario	0	0	0[4]	None	None	No	No	Unknown	Unknown	No		No
Saskatchewan	0	0	0	None	None	No	No	Unknown	Unknown	No	Unknown	No
SUMMARY	2 > 1 3 = 0	1 > 1 4 = 0	1 > 1 4 = 0	5 None	5 None	2 Yes	1 Yes			0 Yes		0 Yes

[1]Allow parking at some closed facilities. [2]No new facilities, but do have some. [3]Truck pullovers. [4]Larger rest area facilities were closed at one time, but have since reopened. A number of the small picnic facility sites that were not being used have been permanently closed.

RA = rest area; Ren. = renovation; Exp. = expansion.

TABLE E-3

RESULTS OF STATE AND PROVINCIAL SURVEY PERTAINING TO REST AREAS (Part 3)

States	Any Specific Activities to Help Motorists Feel Safe?	% of Rest Areas Routinely Patrolled or Monitored for Motorist Safety	Data on Benefits of Rest Areas for Increasing Driver Alertness?
Arkansas	Routine patrol, improved lighting, video surveillance	100	No
California	Increase hours of maintenance, coordination with HP surveillance	100	No
Colorado	Established SHP offices adjacent to 1–2 rest areas	100	Yes
Connecticut	Attendants patrol parking areas	100	No
Delaware	Security agency provided at night, full nighttime lighting	67	No
Florida	Security personnel at night	100	No
Georgia	Lighting, shrubs kept trimmed, facilities visible from road	100	No
Hawaii			
Idaho	Increased night lighting	90	No
Illinois	Lighting, attendant presence, State Police patrols	100	No
Iowa	About one-half have 24-h attendants, surveillance cameras	100	No
Kansas	None noted	100	No
Louisiana	None noted	10	No
Maine	Lighting, surveillance cameras, expanded staffing hours	?	No
Maryland	Additional police at some, contract security during holidays, on-site staff, coordination with police	60	No
Massachusetts	Parking area improvements, information services		No
Michigan	Improved lighting, police checks	?	Yes
Minnesota	Increased lighting, added HP offices, video surveillance	0	Yes
Montana	New rest areas have glass fronts, security cameras	0	Yes
Nebraska	Increased lighting, doorless entries to restrooms, inside of lobby visible from outside approach	100	

Table E-3 *(Continued)*

New Hampshire	Lighting, administrative guidelines for safe areas	90	No
New Jersey	Increased police surveillance	100	No
New York	New rest areas have State Police Patrol office	100	Yes
North Carolina	"Rest Assured" Program, DMV patrol, signage noting this	100	No
North Dakota	Increased lighting, more glass in lobby, surveillance cameras	100	No
Ohio	24-h caretakers and SHP surveillance	60	No
Oklahoma	None noted	100	No
Oregon	Phones, lighting, removal of vegetation	100	Yes
Pennsylvania	24-h staffing	30	No
South Carolina	Improved lighting, "Open area" design, males/females enter restrooms from same side of building	0	No
South Dakota	Lighting, vegetation removal, HP presence	100	No
Texas	Increased attendant hours, lighting, security at some sites	100	No
Utah	None noted		
Vermont	Lighting, outside phones, information boards	100	No
Virginia	All staffed 24 h, some unarmed security officers, some monitoring system linked to police, increased patrols, signs and brochures	100	No
Wisconsin	Experimented with surveillance cameras	100	No
Wyoming	Experimented with surveillance cameras	10	No

HP = highway patrol; SHP = state highway patrol.

Table E-3 *(Continued)*

Canadian Provinces	Any Specific Activities to Help Motorists Feel Safe?	% of Rest Areas Routinely Patrolled or Monitored for Motorist Safety	Data on Benefits of Rest Areas for Increasing Driver Alertness?
Alberta	Improved lighting	0	No
Manitoba			
New Brunswick			
Newfoundland	No	0	No
Northwest Territories	No	Daily maintenance checks	No
Ontario	No	Regular maintenance checks	No
Saskatchewan	No	0	Yes (draft rest area study)

APPENDIX F

Survey Results—Reporting Requirements

TABLE F-1

REPORTING OF SLEEP- OR FATIGUE-RELATED CRASHES

State	Sleep or Fatigue Crashes Identified on Crash Report Form	Law Enforcement Personnel Provided Special Training or Guidelines	Reports or Summaries of Drowsy Driving *
Arkansas	Yes	Yes	
California	Yes	No	No
Colorado	Yes		Summary
Connecticut	Yes	No	No
Delaware	No	No	No
Florida	Yes	No	No
Georgia	Yes	No	No
Hawaii	Yes	No	No
Idaho	Yes	No	No
Illinois	Yes	No	Summary
Iowa	Yes	No	No
Kansas	Yes	No	No
Louisiana	Yes	No	No
Maine	Yes	?	Yes
Maryland	Yes	No	Yes
Massachusetts	No	No	No
Michigan	No		Yes
Minnesota	Yes	No	No
Montana	Yes	Yes	No
Nebraska	Yes	No	Summary
New Hampshire	Yes	No	No
New Jersey	No	Yes	Yes
New York	Yes	Yes	Yes
North Carolina	Yes	Yes	Yes
North Dakota	Yes	No	No
Ohio	Yes	No	No
Oklahoma	Yes	Yes?	Summary

TABLE F-1 *(Continued)*

Oregon	Yes	No	No
Pennsylvania	No	No	Yes
South Carolina	Yes	No	Summary
South Dakota	Yes	No	No
Texas	No	?	Yes
Utah	Yes	No	Summary
Vermont	Yes	?	Summary
Virginia	No	No	No
Wisconsin	No	No	No
Wyoming	Yes	Yes	Summary
SUMMARY	28 Yes 9 No	7 Yes 25 No 5 Unknown	8 Yes 8 Summary 20 Unknown

Canadian Provinces			
Alberta	Yes	No	Summary
Manitoba	Yes	Unknown	No
New Brunswick	Yes		
Newfoundland	Yes	No	Summary
Northwest Territories	Yes	No	No
Ontario	Yes	No	No
Saskatchewan	Yes	No	No
SUMMARY	7 Yes 0 No	0 Yes 5 No 2 Unknown	0 Yes 2 Summary 4 No 1 Unknown

*Some "yes" responses may also only refer to annual crash report summaries. Presumably such summaries might also be available for any state or province having a checkbox or category for reporting sleep- and/or fatigue-related crashes.

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