Research on Fatigue in Transit Operations

DETAILS

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Research on Fatigue in Transit Operations

Summary of a Conference

Katherine F. Turnbull, *Rapporteur*

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Preface

The Transportation Research Board (TRB) Conference on Research on Fatigue in Transit Operations was conducted October 12–13, 2011, at the Keck Center of the National Academies in Washington, D.C. The conference, which was sponsored by the Transit Cooperative Research Program (TCRP) and TRB, focused on operator fatigue in public transportation.

TRB assembled a committee, appointed by the National Research Council, to organize and develop the conference program. Speakers highlighted experiences addressing fatigue in other transportation modes, health effects of fatigue, safety impacts of fatigue, and fatigue issues and initiatives in transit. Participants also discussed potential topics for further research and outreach activities. The conference summary report is based on the conference agenda and includes summaries of the presentations and the research needs discussion. The conference attracted 49 participants from transit agencies, federal agencies, labor unions, universities, and the private sector. Their range of experience provided for a stimulating exchange of ideas.

This report has been prepared by the conference rapporteur as a factual summary of what occurred at the conference. The planning committee's role was limited to planning and convening the conference. The views contained in the report are those of individual participants and do not necessarily represent the views of all conference participants, the planning committee, TRB, or the National Research Council.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published summary as sound as possible and to ensure that the report meets institutional standards for clarity, objectivity, and responsiveness to the project charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

TRB thanks the following individuals for their review of this report:
Judith Gertler, QinetiQ North America, Inc., Waltham, Massachusetts; Karen E. Philbrick, Mineta Transportation Institute, San José, California; John R. Plante, Chicago Transit Authority, Chicago, Illinois; James Stem, United Transportation Union, Washington, D.C.; and Eric Wolf, AMTRAN, Altoona, Pennsylvania.

Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the report before its release. The review of this summary was overseen by C. Michael Walton, University of Texas at Austin. Appointed by the National Research Council, he was responsible for ensuring that an independent examination of this report was conducted in accordance with institutional procedures and that all review comments were carefully considered. Suzanne Schneider, Associate Executive Director, TRB, managed the report review process.

The conference planning committee thanks Katherine Turnbull for her work in preparing this conference summary report and extends special thanks to TCRP and the Federal Transit Administration for providing the funding support that made the conference possible.

Welcome and Conference Overview

Robert E. Skinner, Jr., Transportation Research Board
Judith Gertler, QinetiQ North America, Inc., Chair, Program Committee

CONFERENCE WELCOME

Robert E. Skinner, Jr.

On behalf of the Transportation Research Board (TRB) of the National Academies, it is a pleasure to welcome you to this important conference on Research on Fatigue in Transit Operations. The conference is sponsored by the Transit Cooperative Research Program (TCRP), which is administered by TRB on behalf of the transit industry and the Federal Transit Administration.

Fatigue in transit operations was identified as an important topic by the TCRP Oversight and Project Selection Committee a year ago, and this conference was funded to initiate a dialogue between researchers and practitioners. The conference planning team, chaired by Judith Gertler of QinetiQ North America, Inc., has done an excellent job of developing an informative program with an outstanding group of speakers.

Fatigue and other human factor issues affect all modes of transportation. Fatigue is truly a multimodal concern. Opportunities exist for cross-modal information sharing and research related to fatigue. Your discussions on research needs will be of benefit to the transit industry and TCRP, as well as other modes.

TRB provides the logical place for these types of discussions. Established in 1920, TRB provides a focal point for sharing information, discussing critical issues, identifying research needs, and disseminating research results. TRB has expanded from an initial focus on highways to encompass all modes and types of transportation issues.

This conference provides an excellent example of the important role TRB plays in bringing diverse stakeholders together to discuss critical issues such as fatigue. I hope you have an interesting and productive conference. I look forward to reading your suggestions for research needs and further information-sharing opportunities.

CONFERENCE OVERVIEW

Judith Gertler

It is a pleasure to welcome you to TRB's Conference on Research on Fatigue in Transit Operations. I had the opportunity to serve as chair of the conference planning committee.

Ten years ago, when I worked on *TCRP Report 81: Toolbox for Transit Operator Fatigue*, fatigue was on the National Transportation Safety Board (NTSB) list of its 10 most wanted transportation safety improvements. Improvements with regard to operator fatigue have been made since then, but addressing human fatigue is still on NTSB's most wanted safety improvement list. The TCRP Oversight and Project Selection Committee is sponsoring this conference because it believes that more needs to be accomplished to reduce transit employee fatigue.

Unfortunately, the effect of human fatigue on transit operations tends not to receive attention unless there is a catastrophic accident, such as the Williamsburg Bridge incident in New York City in 1995. In that incident, a train operator failed to respond to a stop signal because he fell asleep at the controls. His train collided with a stopped train on the same track. The operator was killed, 69 people sustained injuries, and damages exceeded $2.3 million.

My instinct tells me that throughout the transit industry there are probably many near-misses and minor incidents that result from fatigue. Last year I reviewed several years of accident reports from the New York State Public Transportation Safety Bureau in conjunction with a project on rules compliance. I was not specifically looking for fatigue-related incidents, but I came across two. In one case the operator of a rail transit vehicle worked a schedule that limited the opportunity to get adequate rest. The operator ran a red signal because lack of sleep caused reduced alertness. In the other case, the operator fell asleep and hit the bumper post at the end of the line.

We are all here because we believe that fatigue remains an issue for transit agencies. The program today is designed to present current research and best practices on fatigue in transit operations. The planning committee believed that there was value in learning about fatigue management initiatives in other modes of transportation. The initial speakers this morning will highlight the experience of other modes. Then we will hear about the relationship between fatigue and accidents and about the health effects of fatigue. Both topics apply across all modes of transportation.

Speakers will also focus on transit. First, we will hear about a study that examined the relationship between bus operator schedules and fatigue. This afternoon there are two panels. The first includes representatives of transit agencies that have implemented initiatives to manage fatigue. The second focuses on labor's perspective on fatigue management initiatives. After the afternoon break, Mark Rosekind from NTSB will speak on the importance of managing fatigue. The final session focuses on the work schedules and fatigue of commuter rail employees and the new hours-of-service regulations affecting this group.

A key objective of this conference is to identify one or more research topics that are candidate TCRP projects. As you listen to today's speakers, keep this objective in mind. At the end of the day, I will ask for your suggestions for research topics. We can add to the list tomorrow morning if further ideas percolate overnight. When we reconvene tomorrow morning, Gwen Chisholm Smith of TCRP will provide guidance on formulating statements of research needs. We will discuss the candidate topics and prepare one or more statements.

Let me recognize and thank members of the planning committee: Mike Glikin, Brenda Himrich, Heidi Howarth, Steve Klejst, Javier Nieto, Karen Philbrick, Ed Watt, and Vic Wiley. Each of the speakers will be introduced by one of these committee members. I also want to introduce and thank Jennifer Rosales, the TRB program officer responsible for this conference, and TRB staff members Mary Kissi, Freda Morgan, and Katie Debelack.

Fatigue in Other Transportation Modes

Jackie Keenan, *Union Pacific Railroad*
Alan Smith, *Greyhound Lines, Inc.*
Rick Narvell, *National Transportation Safety Board*
Michael Belzer, *Wayne State University*
Thomas Balkin, *Walter Reed Army Institute of Research*

UNION PACIFIC RAILROAD FATIGUE MANAGEMENT PROGRAM

Jackie Keenan

It is a pleasure to share our experience at Union Pacific (UP) Railroad with fatigue risk management. I will begin by providing an overview of UP and some of the challenges we face in addressing fatigue. I will describe the components of UP's Fatigue Risk Management System (FRMS) and the various levels of controls.

UP is the largest railroad in North America. It operates in the western two-thirds of the United States, serving 23 states. UP provides freight transportation services but also has commuter rail service in the Chicago, Illinois, area. The railroad has approximately 32,300 miles of track, 45,500 employees, 8,500 locomotives, and 104,700 freight cars.

UP faces a number of challenges in addressing fatigue risk management. Its employees are geographically dispersed, and many are in rural areas. Employees often travel long distances to get to their duty locations. Among them are engineers, yard police, and track and rail car maintenance workers. UP's employee demographics are diverse, but the aging of the workforce is a concern. UP also has newer employees with less experience. There are 13 unions at UP, which represents another challenge in addressing fatigue-related issues.

The FRMS model at UP follows the "Swiss cheese" model outlined by James Reason in *Managing the Risks of Organizational Accidents*. This concept is based on using levels of control to block the potential for critical incidents. Each level of control represents a slice of Swiss cheese. A concern that makes it through a hole in one slice of Swiss cheese is blocked by subsequent slices.

The FRMS is based on identifying, measuring, and prioritizing risk and developing and implementing controls. It provides a broad and comprehensive approach focusing on safety and health priorities. The FRMS addresses challenges, including 24/7 operations and a 24/7 society, unsupervised train engineer and yard workforces, the aging of the workforce and new workers, and an unhealthy society. UP's FRMS uses a scientifically based toolbox approach.

Key elements of the FRMS focus on policy, training, and education and on ensuring adequate average sleep opportunities. UP's risk management policy addresses corporate, national, and local guidance. Training and education are ongoing key elements of the FRMS. Ensuring an adequate average sleep opportunity is a company responsibility. Approaches include software analysis and measurement, provision of adequate facilities, and cooperation with unions and labor groups.

Maintaining employee preparedness focuses on ensuring that individuals who received an adequate average sleep opportunity have achieved sufficient sleep to ensure a safe level of alertness. Education on signs and symptoms of sleep-related concerns is provided. Education and policies address minimal sleep and reporting. These efforts are shared-responsibility partnerships with employees, labor organizations, and government. Additional countermeasures are in place, and there is an ongoing process of pertinent research to ensure that the FRMS is evidence-based.

For example, UP has partnered with Oak Tree Inns to help combat fatigue and provide better sleeping environments for employees. Additional features at Oak Tree Inns include blackout curtains, quiet plumbing, and automatic timers for televisions. Educational activities also focus on employees' families to enhance their understanding of the needs of shift workers.

UP's FRMS has five levels of controls. This fatigue risk trajectory provides multiple layers that precede a fatigue-related incident for which there are identifiable hazards and controls. The approach attempts to manage each layer of risk. Hazard assessment and control mechanisms are provided at each level. The first three levels address the potential for latent errors, and the last two levels address the potential for active errors.

Level 1 controls are qualitative or behavior-based. UP was the first railroad to require employees to have 10 hours of undisturbed rest between assignments. UP uses a.m. markup, which means that employees on extended time off begin their first work shift in the morning, not the evening.

UP uses proactive notification for shift employees. This optional program allows employees to identify how they want to be contacted and how frequently they want to be notified before their shift begins. Most shift employees participate in some type of proactive notification program.

A software package called the UP Board Game is used to program work and rest cycles and call windows. The system provides a comprehensive and integrated process that is more than merely crew scheduling. It considers historical data and current needs. The approach has been piloted in Seattle, Washington; North Platte, Nebraska–Marysville, Kansas; and the Los Angeles Basin, California. The Seattle example measured fatigue and stress associated with the implementation of a 6-day-on and 4-day-off schedule. Fatigue and stress increased with this schedule, since work levels were higher during the 6-day period. As a result, that schedule is no longer used. The pilot in North Platte–Marysville used a 91-hour cycle, with employees knowing they would begin their next shift 91 hours after the start of their current shift. The pilot in the Los Angeles Basin used overlapping work windows.

The Level 1 controls include qualitative controls. The Fatigue Audit Interdyne (FAID) modeling process uses a software package to identify the extent of any fatigue problems based on employee tie-up and tie-down times. Factors considered in this analysis include the time of day of work and nonwork periods, the duration of work and nonwork periods, work history in the preceding 7 days, and biological limits on recovery sleep. Hours of work data are used in the analysis, which identifies when reduced sleep opportunities may lead to work-related fatigue. It assesses whether interventions have increased sleep opportunity. The FAID analysis is used in conjunction with the Board Game software for simulating the impact of changes at the board–pool level.

Fatigue scores are based on a statistical analysis of research performed on fatigue levels over a broad sample of populations and provide guidance on the fatigue of an individual.

Level 2 controls are designed to ensure that individuals who received an adequate average sleep opportunity have achieved sufficient sleep to ensure a safe level of alertness. Level 2 controls require a high level of shared responsibility between UP and employees. Labor unions play an important role in shaping employee attitudes, and labor–management consultation is an essential part of the process. Level 2 controls focus on education and awareness among employees, management, and families.

Level 2 is implementation. The partnership with employees, their families, unions, the Federal Railroad Administration (FRA), and other groups is critical in Level 2. This level has three stages. The first is developing an initial awareness of minimum sleep–wake needs and the 5/12 rule. Educational efforts focus on ensuring that employees understand the minimum sleep requirements.

The prior sleep–wake model and behavioral scale are introduced and used to manage personal behavior and ensure a safe level of alertness. The second stage includes use of a personal management tool. There are no reporting requirements. The third stage includes organizational integration and planning. It introduces the scoring system and requires reporting of nonzero scores. Local decision matrices are developed.

Additional Level 2 controls include industry collection of U.S. sleep–wake data to ensure that Level 1 models are valid and to link Level 1, 2, and 3 frequencies to ensure evidence-based policy. The data are also used to establish industry benchmarks and policy guidelines for sleep–wake behavior.

UP is also partnering with labor, FRA, and industry on research projects. Among the projects is collection of work–rest, sleep–wake, and behavioral data in Kansas City, Missouri; Des Moines, Iowa–St. Paul, Minnesota; San Antonio, Texas; and Denver, Colorado. Surveys, interviews, diaries, and actigraphy are being used in these projects.

Level 3 controls focus on employee involvement in fatigue hazard identification and self-management of fatigue. This approach reflects a general organizational shift in philosophy and policy. The focus is on self- and peer education leading to self-assessment and on provision of clear policy guidelines for managing predefined unacceptable levels of fatigue-related behavior. A *Pocket Guide to Alertness* is given to all new employees during training. There is also an alternative to a discipline approach, which uses peer intervention.

There are physiological monitoring systems, with ongoing internal technological review processes. Self- and peer identification of fatigue-related behaviors is monitored by using generic symptom and task-specific symptom checklists. Sleep disorder screening is available. There is an FRA–UP assessment research project, which is a voluntary program using occupational health nurses and a network guided by the UP Safety Department. Education and awareness activities are an important component of the sleep disorder screening process. As part of the FRA grant, UP included an assessment tool in the engineer recertification package. The assessment tool proved successful in identifying individuals with sleep disorders.

Level 4 and Level 5 controls focus on identifying fatigue as a cause of errors or incidents. The nature of an incident is examined to identify whether it is consistent with fatigue-related errors. Partnerships and coordination with industry are needed in these efforts.

Fatigue hazard analysis (FHA) workshops have been conducted in Fort Worth, Texas; Chicago, Illinois; and San Antonio, Texas. Additional workshops will be conducted in the future. The workshops evaluate fatigue risk conditions associated with train and engine personnel at a specific location. Topics covered are identification of workplace tasks, selection of fatigue risk severity and fatigue risk frequency gradings, and development of an organizational risk tolerance boundary.

Numerous benefits have been realized from the workshops. The workshops assist in the identification of safe levels of fatigue for tasks with improvement actions and cost estimates that can lead to the reduction of overall fatigue-related risk. The results help establish the foundation for the fatigue component of the Safety Risk Metric and Action Plan Development.

UP applied to the FRA Broad Agency Announcement (BAA) Phase I for enhancements to FRMS. UP received a $150,000 grant from FRA in 2009 and 2010. UP also received $75,000 in funding through the FRA BAA Phase II Award for a fatigue management education review and FHA workshops. These activities are being conducted in 2011 and 2012. The first workshop was held in San Antonio, and others will be conducted throughout the UP system.

At UP, safety, including fatigue-related issues, is a shared responsibility of employees and the company. Safety is the outcome of appropriately managed risks. A number of videos and brochures on alertness and fatigue have been developed by UP. They are available on the UP website. Examples of topics covered include sleep basics, fatigue and family support, sleep deprivation, drowsy driving, and healthy living.

GREYHOUND FATIGUE MANAGEMENT INITIATIVES

Alan Smith

My presentation focuses on recent activities at Greyhound examining motor coach operator fatigue.

According to the National Transportation Safety Board (NTSB), human error is a causative factor in approximately 85 percent of all commercial vehicle crashes. NTSB has documented numerous motor coach accidents that have resulted in fatalities in which driver fatigue has been determined to be a principal cause. On February 11, 1999, NTSB published a highway special investigation report on selected motor coach issues (NTSB/SIR-99/01). That study concluded that driver fatigue played a significant role in the two crashes investigated. NTSB recommended that bus drivers be made aware of the dangers of inverted duty–sleep periods as part of a video on driver fatigue. There has always been concern with regard to driver fatigue, especially for drivers of commercial vehicles.

Hours-of-service regulations for bus drivers have been in existence in the United States since 1935. These regulations are undergoing scrutiny in preparation for changes based on current scientific knowledge. To identify unique operating characteristics that influence bus driver fatigue and stress, the collective input and wisdom of the industry are needed. A firm understanding of research and knowledge from past studies and projects is also important. One of the first research studies that addressed bus driver fatigue was the October 1978 report prepared by Mackie and Miller for the National Highway Traffic Safety Administration titled *Effects of Hours of Service, Regularity of Schedules, and Cargo Loading on Truck and Bus Driver Fatigue*.

The most significant finding of the report was that bus drivers operating on irregular schedules suffer greater subjective fatigue and physiological stress than do drivers operating on a regular schedule. The subjective fatigue and physiological stress were most significant on trips with irregular operating schedules that involved late night and early morning driving. While cumulative fatigue effects appear to be minor between regular and irregular bus driving operations, such effects became more significant if the final driving hours of the trip occurred in the late night or early morning hours.

Many other factors, such as eating habits and the quantity and quality of sleep, influence driver fatigue. Stressors associated with the other responsibilities of drivers include loading and unloading, customer interaction, selection of alternative routes, traffic and weather conditions, and schedule sensitivities. A report compiled and published by the Federal Highway Administration in December 1999 provides a clearer understanding of these factors and their impact. Much of the information in the next presentation is taken from that report and from the focus groups used to assist in the study of motor coach driver fatigue. On the basis of input from the participants in the focus groups, the following issues are relevant to bus driver fatigue and stress.

Stress and fatigue issues that were identified by the focus group have unique aspects related to the motor coach industry. The issues were consistent and similar throughout the focus groups. This consistency provides a strong foundation on which to identify issues and recommend solutions. The focus groups were made up of drivers, operations managers, and safety directors throughout the industry. Greyhound's corporate director of safety was a member of one of the focus groups. The results from the study, along with additional information collected within the Greyhound organization, prompted an additional study conducted exclusively for Greyhound.

The 1999 study noted that fatigue is a generic term used to encompass a range of experiences, from sleepiness and tiredness to mood and temperament changes and inattentiveness. Two major physiological phenomena create fatigue: sleep loss and disruption of circadian rhythm. These two phenomena combine to produce adverse fatigue effects. Proper nutrition and physical conditioning are important influences on the effects of fatigue for commercial motor vehicle drivers.

Several factors influence fatigue, including wellness and lifestyle—a driver's physical fitness, diet, and personal living habits influence and contribute to fatigue on the job. Family matters, state of health, and sense of self-worth also contribute to a mental state of mind or attitude, which in turn influences stress and fatigue while operating a motor coach. Personal accountability, including a driver's level of personal accountability for his or her actions, can significantly affect fatigue while operating a motor coach. Professional standards directly influence the levels of stress and fatigue associated with being a motor coach operator. Many drivers may accept motor coach operations that take them beyond their physical limits because of the related economic opportunities.

Many areas are experiencing driver shortages and lack of quality drivers. With fewer drivers available, employed drivers must drive more to meet operating schedules and customer demands. Because the dispatcher's motivation is simply to move buses without sensitivity to driver needs, the dispatch protocol can increase driver stress. Regulations related to current hours of service allow for "extended days" and specify a minimum of 8 hours off duty. A driver can comply fully with the 10/15 hour rule even though he or she may have a much longer day from punch-in to punch-out. Both of these situations are believed to influence or cause fatigue for a motor coach driver. Several other factors can contribute to driver fatigue, but these are the primary factors identified.

On the basis of input from the focus group, the following countermeasures to driver stress and fatigue were identified. Increase the minimum off-duty time for drivers to at least 10 hours between trips and improve opportunities for drivers to get better rest during long and overnight trips. Minimize inverted duty–sleep cycles for drivers. Establish "first in–first out" dispatch protocols to minimize stress and fatigue-producing situations associated with dispatch. Enhance total compensation packages for drivers to attract more quality drivers to the motor coach industry. Provide training on fatigue causes and countermeasures for bus drivers on a regular basis. Increase and enhance federal regulation of the motor coach industry.

In November 2002, Greyhound engaged Alertness Solutions, a scientific consulting firm with extensive expertise and experience in creating real-world safety and performance solutions for 24/7 operators, to conduct a comprehensive review of its fatigue management practices and procedures. The remainder of the information presented focuses on the findings reported to Greyhound by Alertness Solutions. In April 2003, Greyhound initiated an Alertness Management Program (AMP) in an effort to enhance safety and reduce fatigue-related risks within its operations. The program was implemented in collaboration with Alertness Solutions.

The guiding principles of the AMP were to base all activities on and incorporate the latest and most relevant scientific knowledge, to use multiple components in addressing various aspects of fatigue management, and to emphasize the need and role for shared responsibility of all involved parties for AMP effectiveness. The AMP involved education, analysis of scheduling policies and practices, and examination of sleep and performance during operations.

Education is an essential foundation for any program that addresses operational fatigue-related issues. Topics that should be addressed in educational activities include sleep basics; circadian rhythm basics; the effects of sleep loss and disruption of circadian rhythm on alertness; and performance, sleep disorders, and alertness strategies. Alertness Solutions developed new educational materials for Greyhound.

A PowerPoint presentation module with the new core educational information was developed for use in driver training. A variety of exercises were incorporated into the educational presentations to help personalize the information. A driver's resource handout with highlights from the presented material and four pre- and postquizzes to provide trainers with a formal tool for assessing knowledge gained by the course attendees were also developed. Greyhound used the materials to develop a CD-ROM–based video for use in computer-based training. These educational materials and activities have been implemented by Greyhound and are an ongoing component of its training program.

The scheduling component involved several activities and began with an overall systems analysis of Greyhound scheduling guidelines and practices by Alertness Solutions. The approach involved identifying core physiological fatigue factors, such as sleep loss, circadian disruption, and length of continuous hours awake related to scheduling; defining operational metrics that apply to these fatigue factors; and identifying strengths and vulnerabilities related to the factors in scheduling guidelines and practices.

The core physiological factors used in the scheduling analysis focused on factors such as acute sleep loss, cumulative sleep debt, continuous hours of wakefulness, and time of day. These factors were then related to specific scheduling considerations. For example, acute sleep loss was related to the minimum length of the off-duty period and whether off-duty periods were predictable and protected. Overall, this analysis demonstrated that Greyhound scheduling guidelines were excellent in effectively addressing core physiological fatigue factors and in almost all cases exceeded Federal Motor Carrier Safety Administration (FMCSA) regulatory requirements.

To improve its understanding of its own 24/7 operations, Greyhound identified several operational issues for more in-depth analysis. Three of them were extra board drivers, nighttime driving, and day–night and night–day schedule transitions. Alertness Solutions used its Alertness Metrics Technology (AMT) to obtain subjective and objective alertness and performance data from a group of drivers during workdays and nonworkdays.

The AMT data were collected from March 2004 to February 2005 from 16 drivers ranging in age from 31 to 64 years old; the average age was 49.4. Seven drivers were regular night run drivers, representing 14.9 years of experience; nine were extra board drivers who do not have regular driving assignments but wait on site or at home to be called to fill in for a regular driver, representing 3.3 years of experience. Data were collected from a 31-item background questionnaire; a subjective diary that was completed at the beginning and end of each day; a wrist-worn actigraph, which provides a valid estimate of sleep quantity and quality; and a 5-minute reaction time–performance test completed up to three times per day.

Data were collected for a 7- to 9-day period that included both workdays and nonworkdays.

The data showed that despite the irregular nature of extra board scheduling, the extra board drivers slept more than did the drivers on regular night runs. The cause was the circadian disruption related to night driving and daytime sleep periods. Confronted with the circadian challenges of day sleep and night work, night run drivers accumulated about twice the sleep debt of extra board drivers. Extra board drivers accumulated a minor sleep debt; however, it did not significantly affect total sleep time. While all night run drivers accumulated a sleep debt, only half of the extra board drivers accumulated one. Though extra board and night drivers accumulated a sleep debt during their work cycles, they demonstrated consistent performance levels on workdays and nonworkdays. Thus, there was no measurable difference or change in driver performance related to sleep amount or sleep debt.

One significant finding was that extra board operations allowed for night sleep periods more often than for night run drivers. In addition, the data suggested that extra board drivers might make sleep a higher priority when the opportunity to sleep is available because of the unpredictable nature of their work schedule. One of the most important findings was that performance for night run and extra board drivers was consistent between workdays and nonworkdays. That is, overall performance was not significantly different for the drivers whether they were working or not. The powerful effects of the internal circadian clock were well represented in both groups; clear circadian performance vulnerabilities related to time-of-day effects emerged.

Generally, it is assumed across transportation settings that extra board, reserve, or on-call personnel will have the worst sleep and performance because of the unpredictable nature of their scheduling. However, the Greyhound data showed that unavoidable circadian vulnerabilities due to time of day had a greater and more detrimental effect on the total sleep obtained than did extra board operations. This operational data set also was compared with Greyhound scheduling guidelines. Overall, the data collected further confirmed that Greyhound successfully meets its scheduling guidelines during operations. In 2003, Greyhound implemented its AMP to improve safety and reduce fatigue-related risks in its 24/7 nationwide operations.

Education for drivers has been extensively updated. Scheduling guidelines and practices have been analyzed in detail and found to be effective in addressing known physiological fatigue factors. Subjective and objective data collected from a small set of drivers during actual night run and extra board operations further demonstrate the effectiveness of Greyhound practices in addressing fatigue-related risks. These activities, outcomes, and data demonstrate that Greyhound's guidelines and practices reflect the extensive scientific knowledge concerning alertness and performance and provide an effective means of managing the fatigue challenges associated with 24/7 operations in all modes of transportation. Greyhound has established a leadership position with its innovative, scientifically based AMP and data-driven examination of operations. The Greyhound AMP approach, and many of its practices, should be transportation industry benchmarks.

Resource

Arrowhead Space & Telecommunications, Inc. *Bus Driver Fatigue and Stress Issues Study*. DTGH61-99-Z-00027 Final Report. Prepared for the Federal Highway Administration Office of Motor Carriers, December 8, 1999. http://ntl.bts.gov/lib/7000/7800/7883/busfatigue.pdf.

FATIGUE AND ACCIDENTS

Rick Narvell

I have been asked to discuss how NTSB investigates fatigue in accidents. Fatigue is physical or mental exhaustion that can be triggered by stress, medication, illness, overwork, disease, and inadequate sleep.

One of the first questions we ask at an accident investigation site is whether the operator was susceptible to being fatigued. If the answer is yes, we obtain basic information concerning the individual or individuals involved in the accident. The first thing we try to capture is a 72-hour work–rest history for the individual. The history would include when the individual got up in the morning and went to sleep at night. We are also interested in personal activities, including any problems at work or at home. We examine sleep quantity and quality and the individual's work habits.

The investigation focuses on determining whether the individual suffered from acute or chronic sleep loss in the previous 72 hours. We ask individuals to describe their sleep pattern, including awakening, retiring, and how much sleep they obtained during the previous 72 hours. We especially focus on the night before the accident. We want to know when the operator went to bed, when he or she woke up the following morning, and the quality of sleep. We also want to know whether any naps were taken and the details of those naps, such as the time and location.

We interview family members, hotel staff, or other witnesses who can assist in completing the operator's sleep–activity schedule before the accident. These individuals are especially important in cases of a deceased operator. We examine receipts, cell phone records, work schedules, alarm clock settings, and other records to help complete the sleep–activity schedule.

We examine the potential for fragmented and disturbed sleep. We determine whether the operator's sleep was fragmented or disturbed by examining factors in the operator's environment such as noise, light, and phone calls. We ascertain whether the individual's sleep pattern was different or disrupted in the days before the accident.

The investigation examines circadian factors, which include physical, mental, and behavioral changes that follow a 24-hour cycle corresponding to light and darkness in an environment. Circadian factors are found in living things, including humans, animals, and plants.

The primary circadian trough is approximately from midnight until 6:00 a.m.; the secondary circadian trough occurs approximately from 3:00 to 5:00 p.m. The investigation examines whether the operator suffered from circadian issues attributable to crossing multiple time zones or to rotating, inverted work–sleep schedules.

Health issues are also examined. We inquire about the difficulty of falling or staying asleep. We follow up with discussions with a physician about sleep issues. We obtain information on all medications regularly used and taken as prescribed. Any drugs or medications located in the wreckage or cab would be documented.

Information on other medical concerns or health issues that affect sleep, such as chronic pain and gastroesophageal reflux disease, would be obtained. We determine whether the operator had been recently evaluated by a sleep specialist or had polysomnography. The investigation reviews toxicological results for substances affecting sleep or alertness.

A crash in 2009 involving a passenger train rail operator who failed to stop in the presence of another train on the track was investigated. We found that the operator had a high body mass index, meaning that she was overweight. An over-the-counter medication that can be sedating was found in her system. We also examined human performance variables. At the time of the incident, she was sedentary.

Work, department of motor vehicle, and insurance records are checked for evidence of falling asleep during operations. We determine whether fatigue management training was completed. The investigation determines whether environmental factors on the day of the accident could affect alertness. Potential environmental factors include low lighting, wet pavement, and boredom.

Behavioral indications of fatigue are examined. We determine whether an operator's performance declined before the accident. We examine whether any specific tasks or steps were overlooked or skipped by the operator or whether the operator performed one task and not another. Any evidence of steering or speed variability and delayed responses to stimuli or unresponsiveness is examined. We examine any evidence of impaired decision making or an inability to adapt behavior to accommodate new information or a new situation. We consider evidence that an operator's appearance or behavior before the accident was suggestive of sleepiness and fatigue.

Even when it is determined that fatigue was present, there is a need to demonstrate a connection between fatigue and the accident. A finding that fatigue is present is not sufficient for a probable cause or a contributing factor. Regardless of the findings, some data may be archived as a guide for future studies.

ECONOMIC DRIVERS OF FATIGUE IN THE TRUCKING INDUSTRY

Michael Belzer

Competition is a key latent safety factor in freight and passenger transportation. Freight and passenger transportation is a business activity. Fatigue management cannot be separated from work and business processes. The focus should be not only on technology but also on industrial organization. Focusing on technology and engineering ignores economic forces—and competition—driving the work process.

Competitors in freight and passenger transportation will do whatever they must to make a profit. Without regulatory limits on competition, shippers will make carriers do whatever is necessary to be the lowest-cost providers, and carriers will make operators do whatever is necessary to reduce costs. With regulatory limits, carriers can compete on safety and service, and safety management can become a strategic advantage.

The original U.S. regulation was in response to cutthroat competition in trucking in the 1920s, which resulted in serious safety problems. State and local authorities could not cope with the growing safety problems created by interstate trucking. The Motor Carrier Act of 1935 limited competition and improved safety. Enforcement of the act originally rested with the Interstate Commerce Commission (ICC) but shifted to the U.S. Department of Transportation (DOT) in the 1960s.

Unionization in the trucking industry grew from less than 10 percent in the early 1930s to 60 to 90 percent in the 1970s. It has returned to less than 10 percent today. Collective bargaining brought order to a fragmented industry and raised compensation to middle-class standards. Worker protections at unionized carriers spilled over to protect nonunion workers at nonunion firms and in the “exempt” sector.

Administrative deregulation in 1977 increased market competition. The Motor Carrier Act of 1980 removed most existing economic regulation of interstate trucking. Market entry was eased and transparency ended. The 1980 act favored rate discrimination, with shippers gaining bargaining power. Collective rate–making ended and cutthroat pricing returned.

Congress mandated intrastate deregulation in 1995 and abolished ICC. FMCSA of the U.S. DOT now is the major regulatory barrier to cutthroat competition. FMCSA regulates hours of work, which limits labor market competition; establishes truck and driver health and safety standards; and addresses motor carrier safety regulations.

The primary determinant of freight transportation pricing now is cost. Carriers must continuously reduce costs. Shippers view freight transportation as a commodity or a cost center. Shippers’ goals are to keep costs low. The focus on cost caused the industry to restructure completely in the 3 years after deregulation. Lowering trucking costs enabled increased trade and longer supply chains.

The rapid change in cost factors also changed industrial organization. Trucking has rapidly segmented on the basis of shipment size. Truckload carriers do not need consolidation terminals or local pickup and delivery networks. A few common carriers survived as less-than-truckload carriers, but most went out of business. Nonunion specialized and contract carriers created a booming truckload sector.

Probably one-fourth of the cost savings realized in the trucking industry came from restructuring trucking operations. Probably three-fourths of the cost savings came from lower compensation. This leads to the question of whether low compensation leads to safety management problems.

The University of Michigan Trucking Industry Program (UMTIP) conducted a survey of over-the-road truck drivers in 1997 and 1998. The survey was administered at Midwest truck stops. The results indicate that drivers average $745 per week in pay and work 65 hours per week. This figure equates to a wage of $11.46 per hour. Current population survey data for the same period show that 21.4 percent of all drivers worked more than 60 hours per week.

The survey results identified a mean mileage rate of 28.6 cents per mile. Unionized drivers earned an average of 38.6 cents per mile, but only 9.8 percent of over-the-road employee drivers were unionized. Almost no owner–drivers are union members. At the mean, truckers drove 113,843 miles. On average, 25 percent of working hours were unpaid nondriving time. The results identified a total annual working time of about 3,250 hours, assuming drivers had 2.25 weeks off for vacation and holidays.

This labor market features pervasive subcontracting and as many as 500,000 carriers. There are perhaps 300,000 owner–drivers, but no accurate measure of this group exists. Approximately 75 percent of owner–drivers are leased to motor carriers, and 25 percent operate on their own authority—actual owner–operator drivers. U.S. law treats all of these individuals as independent contractors and hence they may not organize, which is not the case in Canada or Australia.

Marginal cost pricing in transportation leads to cobweb or cutthroat pricing and destructive competition. Teamster drivers earn an average of about $50,000 a year, mostly in less-than-truckload operations. Nonunion drivers average about $36,000 a year, mostly in truckload operations. Owner–drivers net about $21,000 a year on average, but most have no health insurance and none have pensions. In 2004, U.S. DOT regulations raised drive time to 11 hours per shift and allowed drivers to reset their weekly clock to allow for an 84-hour workweek.

We conducted three studies to examine the potential impact of pay on safety. First, on the basis of driver-level data from J. B. Hunt, we determined the probability of driver crashes by using 11,540 drivers and 93,000 driver-month observations. Second, by using carrier-level data from the National Survey of Driver Wages, we determined the extent to which compensation factors predict carrier crash rates. Third, by using the UMTIP random survey of over-the-road drivers, we determined that driver pay predicts safety outcomes.

J. B. Hunt was the nation's second-largest truckload carrier in 1995. It was experiencing a 96 percent driver turnover rate and driver reliability problems. To address these issues, J. B. Hunt raised wages by 38 percent in one major move, closed training schools and hired experienced drivers, and focused on driver retention.

The analysis indicated that every 10 percent increase in driver pay is associated with a 40 percent lower crash probability. At the mean, every 1-cent increase in first observed pay leads to an 11.1 percent lower crash probability. At the mean pay rate of 34 cents per mile, every 10 percent higher first observed pay is associated with a 34 percent lower crash probability. A 10 percent pay increase is associated with a 6 percent lower crash probability. At the mean, each year of tenure reduces crashes by 16 percent. Higher pay reduces driver turnover and increases with age, experience, and unmeasured characteristics.

A second study explored the effects of compensation levels and methods for 102 truckload carriers. The data sources for this study included the National Survey of Driver Wages, the UMTIP survey of carriers, and the Safety and Fitness Electronic Records System from FMCSA. The negative binomial regression results were examined.

The overall compensation effect from the analysis indicates that for every 10 percent more that they compensate drivers, carriers have a 9.2 percent lower crash rate. Significant components include the mileage rate for drivers with 3 years of experience (5.2 percent), drivers' anticipated annual pay raise (0.6 percent), the amount of unpaid nondriving time per mile driven (1.0 percent), a safety bonus (1.0 percent), the amount of money a driver pays for family health insurance (0.8 percent), and the amortized value of life insurance provided by the carrier (0.6 percent).

The third study examined the effect of pay level on safety by using individual driver-level data from the UMTIP survey, sponsored by the Sloan Foundation Trucking Industry Program. The UMTIP Truck Driver Survey included 1,000 drivers surveyed in 1997 and 1998. The regression results were based on 247 mileage employee drivers working in the for-hire trucking industry.

At the mean pay rate, for every 10 percent more that drivers earn, the probability of having a crash is 25 percent lower. For every 10 percent higher mileage rate that the driver earns, the probability of a crash is 18.7 percent lower, and for every 10 percent more paid days off, the probability of a crash is 6.3 percent lower.

The overall effects of the three studies can be highlighted. The mileage rate alone accounted for a 4:1 safety effect at J. B. Hunt. Compensation alone accounted for a 0.92:1 safety effect for 102 truckload carriers. Compensation alone accounted for a 2.5:1 safety effect for surveyed drivers. Conservative conclusions are that higher driver pay is strongly associated with reduced crashes (2:1), and at the mean, 10 percent higher pay leads to 20 percent safety improvement.

These studies further indicate that human capital and incentives may not be independent. Better jobs go to those with the best overall record. For beginning drivers, hiring depends on factors other than commercial truck driving, but subsequent performance on the job determines future opportunities. Drivers are careful not to damage their record to maintain their labor market position, which explains the "efficiency wage" phenomenon. Further incentives, including defined-benefit pensions, which act as performance bonds, should be examined.

In conclusion, economic forces drive safety in the trucking industry. Nobody drives a commercial vehicle for fun. Trucking is an industry. Operations must make money. Deregulation has made all operations competitive. Studies show that economic competition underlies commercial vehicle safety. This effect is latent. It applies to trucking, motor coach intercity buses, airlines, and transit. Fatigue, lack of maintenance, overwork, bad judgment, and design flaws are proximate causes but not the common cause. No solution that does not deal with economic forces will last.

On the basis of these studies, the following policy suggestions were identified. The first suggestion is to engage U.S. DOT and the U.S. Department of Labor (DOL) to work together to address key issues. U.S. DOT cannot regulate compensation and employment relationships, but U.S. DOL can. U.S. DOL cannot regulate transportation safety per se, but U.S. DOT can; U.S. DOL might be able to regulate working time. A second suggestion is to adopt a chain of responsibility regulation to make everyone in the supply chain jointly responsible for safety. A third recommendation is to examine the role of subcontracting and subcontractors more closely. What role does subcontracting play in commercial motor vehicle driver safety?

Resource

Belzer, M. H. Impact of Regulation and Deregulation, Industry Structure, Pay Structure, and Hiring Practices on Road Safety. Presented at International Conference on Road Safety at Work, Washington, D.C., February 17, 2009. www.virtualriskmanager.net/main/aboutus/niosh/t1-3_michael-belzer.ppt.

HEALTH EFFECTS OF FATIGUE

Thomas Balkin

I was asked to talk about the health aspects of fatigue. I will begin by providing an overview of fatigue and sleepiness and the current model of sleep. I will also describe chronic sleep restriction and performance, sleep extension effects, and the implications for sleep models. I will close by discussing sleep and physiology and health.

Fatigue is an inconsistently defined concept. Fatigue has been defined as deterioration in human performance arising as a consequence of several potential factors, including sleepiness and the decline in performance that occurs in any prolonged or repeated task. It has also been suggested that fatigue is often confused with sleepiness and has received little study as an independent symptom of sleep disturbance and that "fatigue" has yet to be defined in a concrete fashion.

The sleep performance prediction model is used to analyze chronic sleep restriction and performance. The better a person's alertness, the better his or her performance. The model uses a performance decrement algorithm, a performance increment algorithm, and a circadian rhythm algorithm to measure an individual's performance capacity reservoir.

One can think of sleep as filling up the performance capacity reservoir. When the reservoir is full, alertness and performance are better. During performance, the reservoir is depleted, and it is refilled during sleep. The circadian rhythm rides over this process, similar to the way the moon affects the tides.

Other speakers have noted the cumulative effects of sleep loss on performance. A study conducted at the University of Pennsylvania subjected individuals to 8 hours of sleep in bed, 6 hours of sleep in bed, and 4 hours of sleep in bed. With 8 hours of time in bed, people typically get 7 hours of actual sleep. With 6 hours of time in bed, people get about 5½ hours of sleep, and with 4 hours in bed, people usually get close to 4 hours of sleep. The range of performance on the physical motor vigilance test was examined for the various levels of sleep deprivation. The study found very frequent lapses of attention in all subjects equivalent to being awake 40 to 60 hours and frequent lapses of attention in most subjects equivalent to being awake 24 to 40 hours.

A complementary study conducted by the Walter Reed Army Institute of Research (WRAIR) found that after 5 hours of time in bed, that point is reached after 4 to 5 days. With 3 hours of time in bed, that point is reached after 2 days. Most people can maintain a low but steady level of performance on 4 hours of sleep a night. The amount of recuperation they are getting each night is equal to what they are losing during the day. With less than 4 hours of sleep a night, people lose ground.

Unpublished data from Operation Iraqi Freedom examined the hours of sleep a day reported by soldiers and their self-reported mistakes that affected the mission. There appears to be a linear relationship, with approximately 3 percent of the soldiers reporting an effect with 8 hours of sleep, which is generally considered to be adequate sleep, and 10 percent reporting an effect with 4 hours of sleep or less. A similar linear relationship was found when sleep information was examined for soldiers reporting abuse of a noncombatant. Approximately 1 or 2 percent of the soldiers who reported abusing a noncombatant obtained 8 hours of sleep, while 10 percent who reported abusing a noncombatant obtained 4 hours of sleep or less. Sleep deprivation affects not only performance but also irritability, judgment, and related factors.

The fact that chronic sleep restriction impairs performance has been documented. An important question is whether sleep extension has the opposite effect. A 2009 study conducted by WRAIR examined this question. Subjects who had normal day jobs and slept at least 7 hours a night were selected for the study. In the first phase, subjects slept at home for 14 days. Second, the subjects slept in the laboratory for 7 nights but went about their normal job or school during the day. Half the group was assigned 7 hours in bed and half the group was assigned 10 hours in bed. Most of the individuals assigned the 10 hours in bed tended to sleep for 9 hours. Third, the subjects lived in the laboratory for 11 days. They were restricted to 3 hours of time in bed for 7 of the 11 days, followed by 5 days of recovery sleep with 8 hours of time in bed.

Psychomotor vigilance tests and standard performance tests were performed on the subjects while they were in the laboratory. The performance of both groups declined over the 7 days of only 3 hours in bed. The subjects who had received 10 hours of time in bed before the 7 days of 3 hours of sleep had a more gentle slope of decline. The performance of the other subjects declined much more quickly. There were still differences after a single night of recovery sleep. Subjects on the previous 10-hour sleep schedules returned to normal after 1 night of normal sleep, while the other group of subjects did not return to normal over the next 5 days.

A new, important finding from this study is that sleep can be “banked.” Extending nightly sleep time to 10 hours for 1 week prior to sleep restriction for 7 consecutive nights with time in bed limited to 3 hours resulted in improved behavioral resilience, as evidenced by a slower rate of performance decline across days of sleep restriction and a faster rate of performance recovery when nightly time in bed is restored to 8 hours.

I have translated the implications of sleep banking into what I call the pilsner beer glass analogy. Think of the performance capacity reservoir in the performance prediction model described earlier as a pilsner beer glass, which is narrow at the bottom and wider at the top. Individuals obtain a lot of recovery from the first hour of sleep. There are diminishing returns as the hours of sleep increase. Seven to 9 hours of sleep is the minimal amount of sleep when next-day performance is considered. The last few hours of sleep are at the top of the pilsner glass. Some sleep researchers have suggested that the last few hours of sleep are unnecessary, however. Chronic sleep habits mediate behavioral resilience, at least during subsequent sleep restriction. Under normal circumstances, the extra sleep may do little good, but under conditions of reduced sleep across multiple days it provides better performance.

Extra sleep is like money in the bank. Although the benefits of obtaining increased sleep may not be apparent on a typical workday, such benefits quickly become manifest when an individual is faced with a “rainy day”—the challenge of extended wakefulness, such as during an emergency situation requiring mandatory overtime. Cognitive performance capacity is a function not only of recent sleep history—such as how much sleep was obtained on the prior night—but also of how much sleep is obtained on a regular basis.

The take-home lesson is that workers subject to emergency calls need to obtain more sleep regularly than do those with predictable work schedules. Such workers who obtain only enough sleep for nominally adequate performance during a typical workday will be ill prepared when emergencies necessitating extended wakefulness or work hours arise. These circumstances are made worse by the fact that such workers will be unaware of the extent of their own sleep-loss-induced impairment.

The physiological effects of chronic sleep restriction have been examined over the past decade. Recent findings, largely from epidemiological studies, suggest that in addition to deficits in alertness and performance, chronic sleep restriction is associated with a variety of negative outcomes including heart disease and hypertension; metabolic syndrome, weight gain, and obesity; diabetes; mood disorders; and mortality.

In conclusion, recent findings suggest an association between chronic sleep restriction and deficits in health, mood, alertness, and performance. It is reasonable to hypothesize that increased nightly sleep improves physical, psychological, and behavioral resilience.

Fatigue Issues and Initiatives in Transit

Thobias Sando, *University of North Florida*
Brenda Himrich, *Metro Transit (Minnesota)*
Tony Abdallah, *New York City Transit*
James Bradford, *Connecticut Transit*
Brian Dwyer, *Massachusetts Bay Transportation Authority*
James Dougherty, *Washington Metropolitan Area Transit Authority*
Bruce Hamilton, *Amalgamated Transit Union, Greyhound*
James Stem, *United Transportation Union*
Larry Hanley, *Amalgamated Transit Union*
André Jones, Sr., *Transport Workers Union of America, Local 234*
Mark Rosekind, *National Transportation Safety Board*
Judith Gertler, *QinetiQ North America, Inc.*
Thomas Raslear, *Federal Railroad Administration*
Ed Watt, *Transport Workers Union (Panel Moderator)*
Michael Glikin, *New York City Transit (Presiding)*

SAFETY IMPLICATIONS OF TRANSIT OPERATOR SCHEDULE POLICIES

Thobias Sando

My presentation focuses on a study conducted for the Florida Department of Transportation that examined the safety implications of public transit operator schedule policies. The study was undertaken in considering the department's Bus Transit Draft Rule 14-90.006(3). The rule provides drivers with a maximum of 16 hours on duty per 24-hour period. It limits the actual time driving to 12 hours per 24-hour period over the 16 hours on duty. A minimum of 8 consecutive hours off duty is required.

With this rule, there is a chance that an operator could drive for 8 hours, have 4 hours off, have 4 hours on duty doing nondriving activities, and then drive for 4 hours. This situation meets the 12 hours driving during 16 hours on duty regulations, but it covers 20 hours from the time the operator begins driving to the time he or she ends driving. In addition, the 8 consecutive hours of required off-duty time includes not only sleeping but also traveling to and from work, running errands, accommodating appointments, eating, and other activities.

The hours-of-service regulations of the Federal Motor Carrier Safety Administration (FMCSA) related to commercial vehicles include buses, passenger vans, and the trucking industry. The federal regulation for property-carrying commercial motor vehicle drivers includes an 11-hour driving limit, a 14-hour on-duty limit, and a 60/70-hour on-duty limit. The federal regulation for interstate passenger-carrying motor coach drivers includes a 10-hour driving limit, a 15-hour on-duty limit, and a 60/70-hour on-duty limit. The Florida regulations for bus transit (Rule 14-90) include a 12-hour driving limit, a 16-hour on-duty limit, and a 72-hour on-duty limit.

The objectives of this research project were to evaluate the adequacy of the 8-hour minimum rest time, to examine the maximum of the 12-hour driving time, and to assess the maximum of the 16-hour on-duty time.

Previous research has indicated that long hours of work lead to fatigue. Fatigue can degrade performance, alertness, and concentration. It increases safety risks. The literature review found few references concerning the influence of fatigue on bus safety. The 1995 National Truck and Bus Safety Summit identified driver fatigue as a leading safety issue. Two studies from 2002 and 2004 were reviewed. There have been more studies on the influence of fatigue on other modes of transportation, especially with regard to railroad and airline personnel. A 2000 study on the truck industry by McCarty et al. documented issues associated with daytime sleepiness, longer work hours and fewer off-duty hours, sleep disorders, and nighttime drowsiness.

The operational characteristics of public transit and city buses are different from those of other modes. First, service is oriented toward the peak hours, when travel on the roadway system is heaviest. Work hours reflect this service orientation, and split shifts are used. Buses operate on fixed schedules, with little flexibility. They operate on congested freeways and city streets and make frequent stops. Operators are also responsible for collecting fares, cycling wheelchair lifts, monitoring bicycle loading and unloading, and answering questions from passengers.

The research approach used in this study included a survey of bus drivers and an analysis of operator schedules and collisions. The surveys were conducted at six transit agencies in Florida: two large agencies, two medium-size agencies, and two small agencies. The two large transit agencies were the Jacksonville Transit Authority and Lynx in Orlando. The two medium-size agencies were the Regional Transit System in Gainesville and StarMetro in Tallahassee. The two small agencies were those of Union County and Columbia, Hamilton, and Suwannee Counties. The surveys were conducted between December 2009 and October 2010. They were distributed to transit operators on site. Surveyors were available to answer questions.

The results from the survey have been summarized to provide a general picture of work hours at transit systems in Florida. Approximately 54 percent of the respondents reported spending 8 hours a day driving. Approximately 14 percent reported driving 10 hours a day, 9 percent reported 9 hours of driving, and 12 percent reported 12 hours.

Approximately 50 percent of the drivers reported working split shifts and noted that their split shift time was 3 hours. The survey included questions on the driver's activities during the split time. The most frequently reported activities were taking a nap at the work site, 20 percent; eating at home, 19 percent; relaxing at home, 14 percent; running errands, shopping, doctors' appointments, and so forth, 14 percent; relaxing at home, 10 percent; eating at work site, 10 percent; and taking a nap at home, 7 percent.

Almost 20 percent of the respondents reported commute times to and from work of more than 70 minutes. Approximately 21 percent of the respondents reported commute times of 40 to 50 minutes, 17 percent had commute times of 30 to 40 minutes, and 15 percent reported commute times of 50 to 60 minutes.

Split shift drivers reported higher levels of sleep debt than did nonsplit drivers. Sleep debts of 4 hours, 3 hours, 2 hours, and 1 hour were all higher for split shift operators.

The sleep time model estimation was used to analyze the results. The regression in the model uses the STATA statistical package to examine three categorical variables. The variables are schedule type, arrival time, and departure time.

The bus collision data were examined. The incident reports for 2007 through 2009 were reviewed for noncollisions, which include onboard passenger injuries and related situations, and collisions or crashes involving other vehicles, bicycles, pedestrians, or fixed objects. The collisions recorded were screened, and those that could have been avoided were coded as preventable.

Operator schedules were collected and analyzed. Schedules for 2-week periods in 2007 to 2009 were randomly selected. The schedules for the lowest number of preventable crashes per month and the highest number of preventable crashes per month were examined. The schedules for all operators were also examined for comparison. Operators involved in preventable collisions were examined in more detail.

Information from the operator schedule data included the beginning and ending of duty time, the hours worked each day, and any split hours. The data collected included 222 collision occurrences and a general population of 677.

Preventable collisions were examined by time of day. The fewest preventable collisions, approximately 1 percent, occurred between midnight and 4:00 a.m. The smaller number of routes in operation during this time period lessens exposure. Preventable accidents were more likely to occur between 1:00 and 7:00 p.m., with 50 percent occurring in that period. Preventable collisions were most likely from 1:00 to 3:00 p.m., with 26 percent occurring in that period.

The data on preventable collisions were examined by day of the week. Approximately 81 percent of preventable collisions occurred on weekdays. The largest number of preventable collisions, 18 percent of the total, occurred on Wednesdays. Saturdays accounted for 14 percent of the preventable collisions, reflecting the operation of shuttle service for evening special events. The lowest number of preventable collisions, 5 percent, occurred on Sundays, reflecting limited services and less regular traffic.

The combined agency averages involved in preventable collisions were calculated. On the basis of the 222 collision occurrences, the average weekly driving hours for nonsplit and split shifts were 49.8 and 57.3, respectively. The average daily driving hours for nonsplit and split shifts were 9.8 and 11, respectively.

Collision occurrences versus exposure for daily and weekly schedules without split schedules and with split schedules were examined. Collision occurrences were higher for split shifts with more than 12 hours of daily driving and more than 60 hours of weekly driving. A sharp increase was observed after 50 hours of driving per week. A spike was observed for driving more than 10 hours per day.

The study led to a number of conclusions. First, sleep time for bus operators is reduced by working long hours. Split work shifts were found to be associated with fewer hours of sleep. Second, collision occurrences increase with longer driving and working hours. Higher rates were found for drivers with split work schedules.

Several recommendations were made. The first focused on the minimum rest period. The current regulation does not afford drivers an opportunity to sleep a minimum of 8 hours. As a result, a minimum of a 10-hour rest period was recommended. In terms of split schedules, the study recommended that schedules be optimized to minimize the length of splits. Analysis shows that drivers who drive more than 10 hours per day are overrepresented in collision occurrences. The maximum of 12 hours used in the draft Florida Department of Transportation rule is greater than the federal maximum of 10 hours. The study recommends a reduction to a 10-hour maximum per 24-hour period.

The analysis identified an overrepresentation in collision occurrences for more than 5 hours of driving in 7 consecutive days, with a spike of overrepresentation at more than 60 hours per week. The 72 hours used in Florida is greater than the federal maximum of 60/70 hours for 7/8 consecutive days. The study recommends reducing the Florida rule to a 60-hour maximum for 7 consecutive days.

A final recommendation was to change the terminology from rest period to time off duty. The objective of time off duty is to afford drivers with an opportunity to sleep for 8 hours. Using the term "time off duty" better reflects this objective.

PANEL ON BEST PRACTICES AND LESSONS LEARNED

Michael Glikin, Moderator

• *Brenda Himrich*

My background is in industrial hygiene, which focuses on evaluating and assessing hazards and developing plans to mitigate them. While industrial hygiene focuses primarily on chemicals, the principles and approaches with regard to transit fatigue are similar. We are trying to bring good science to good management practices to address fatigue in the transit industry.

Metro Transit serves the Minneapolis–St. Paul, Minnesota, metropolitan area. Metro Transit operates 123 bus routes, one light rail transit (LRT) line, and one commuter rail line. A second LRT line is under construction, a third is in preliminary engineering, and a fourth is in the long-range planning stage. Metro Transit has 885 buses and approximately 1,200 bus and rail operators.

My involvement in operator fatigue issues began 10 years ago, when I became manager of bus system safety. I was told to figure out the fatigue issue. At that time, the primary available resource was the Transportation Safety Institute (TSI). I attended one of the TSI courses. Metro Transit safety staff also attended the TSI courses and became certified fatigue awareness trainers.

In Minnesota, there are no rules or regulations concerning hours of service for public transit bus operators. Metro Transit and other public transit agencies in the state are self-regulating for bus operators. The LRT and commuter rail operators are covered under other regulations. Similar situations exist in many other states.

There was interest at Metro Transit in identifying how to self-regulate in a responsible manner. TSI provided assistance. The first training session included the Amalgamated Transit Union (ATU) board of directors and the Metro Transit management team. The commitment to fatigue training and addressing fatigue issues began at the top at both the agency and the labor union. Training was provided to other managers next, followed by all of the bus operators. Maintenance personnel, who also have fatigue issues, were not trained at that time.

The training session covered many of the topics mentioned by speakers this morning. A point stressed in the training was that operators would not lose their jobs because of sleep disorders. Obtaining treatment for a healthier, happier, and more productive life was emphasized. This message proved important to the operators, many of whom provided positive feedback to the training. Several operators reported to us that they went to the doctor after the training and were diagnosed with a sleep problem and that the recommended treatments were helping them. Metro Transit provided the tools for bus operators to take responsibility for their alertness at work. There is a good deal of misinformation about sleep disorders. Providing accurate information on both sleep disorders and treatments is critical.

Another outcome of the training was a change in the union contract language. The work schedule for bus operators was 16 hours. After the training, the work schedule was reduced to 14 hours. It has recently been changed back to 16 hours, but now all work time is included. There is a rule for an 8-hour break after 16 hours of work, but drivers can request that the break be waived and that they continue to drive. This rule creates the theoretical possibility that a bus operator could work 32 hours. However, since there is little service after midnight and not much demand for overtime, this situation has a low risk of occurring.

Metro Transit operates extra service during the Minnesota State Fair, and drivers sometimes request a waiver to break time during the fair. Transit supervisors are trained in fatigue awareness and will question and talk to drivers who appear to be fatigued. Most drivers are good at self-regulation and respond positively when a supervisor talks with them. There are still concerns with split shift schedules and fatigue, however. These schedules appear to be the most challenging to manage.

Changes were also made in the extra board drivers. Previously, drivers were on call for 24 hours. Drivers did not know when they might be called for work, when their break would be, or when they would be called to work again. An a.m. and p.m. extra board driver plan was implemented to help address this issue.

Metro Transit uses the HASTUS computer scheduling system, which provides a good tool for developing bus operator schedules. The agency has also gone to a 24-hour clock starting at midnight for tracking the number of hours a driver can work. Previously, a rotating 24-hour period was used. Now, all drivers use a midnight-to-midnight 24-hour clock. This change allows use of HASTUS to provide warnings when a driver works more than 16 hours in a 24-hour day.

New training was provided for investigating accidents. The work history of drivers involved in accidents is examined, including any fatigue-related issues. It is often difficult to determine whether fatigue was involved unless a driver falls asleep. We have had accidents in which a bus operator and an LRT operator appear to have fallen asleep.

Metro Transit continues to face challenges related to fatigue awareness and fatigue countermeasures. Winter weather, including snow, ice, and cold temperatures, provides an extra challenge. The longer hours of darkness in the winter, which occur during the morning and afternoon peak hours, present another challenge. What drivers do when they are not at work, including sleep, is a personal thing. Transit agencies cannot tell drivers what to do. Even having conversations about sleep deprivation and fatigue is not easy. Ongoing conversations are key for both drivers and the agency. Split shifts and pick work continue to be concerns. Drivers at the bottom of the pick order may have difficulty scheduling enough work and breaks.

The University of Minnesota conducted a study of bus operator health. The study examined diet, nutrition, exercise, weight, body mass, and other health-related factors. The study found that most drivers gained 20 pounds or more during their first year of employment. This study supports the need for providing drivers with information on good eating habits, health, and sleeping.

• *Tony Abdallah*

My comments focus on the experience at New York City Transit (NYCT) with regard to fatigue awareness and fatigue management. In the early 1990s, a research study was conducted by NYCT to examine whether there was a correlation between hours worked and accidents. No correlation was identified. The study recommended that employees have at least 8 hours off between work shifts, with account taken of commute time.

Other recommendations were that while train operators, conductors, and tower operators work scheduled shifts of less than 10 hours per day, they be restricted to working not more than 16 hours a day, excluding time between assignments when overtime is required. The study further recommended that employees be restricted to working not more than 6 consecutive days, which was already in application at NYCT.

Hours of service were revised in September 1996 to limit the number of hours worked to 16 consecutive hours, inclusive of time between assignments. The restriction on the number of consecutive workdays was unchanged at 6 days.

The NYCT rules require supervisors to monitor employees' unscheduled overtime greater than 2 hours and ascertain that the employee has a minimum of 8 hours between tours. Weekly evaluations are conducted to assess high levels of overtime. Violations must be tracked and addressed.

In October 1996, NYCT Subways developed a fatigue awareness training program. Employees are educated on the causes of fatigue, as well as strategies to prevent it. Training was provided to all Rapid Transit Operations employees at the time. New employees receive this training on hiring as part of their induction.

In January 2009, the American Public Transportation Association (APTA) published a standard for train operator (TO) hours-of-service requirements. They state that TOs shall not be assigned a shift that has an overall elapsed time, from start to finish, of more than 16 hours, with no more than 14 hours of work in aggregate. The requirements further state that there shall be a minimum of 10 hours off between shifts.

All NYCT employees are required to obtain agency approval before engaging in secondary employment. The potential for fatigue is considered in the review of applications for dual employment. The work hours of the proposed secondary employment are evaluated to ensure that there is adequate rest time between the employee's NYCT work shift and the secondary employment work shift.

When employees are involved in collisions, derailments, or other serious accidents, their previous work shifts are evaluated to determine whether fatigue may have been a factor in the accident. Records for the prior 30 days are examined as part of this analysis. NYCT continues to evaluate the feasibility of implementing a standard consistent with the APTA standard for TO hours of work. The maximum of 16 consecutive hours of work, inclusive of time between assignments, is being reviewed. Other regulations are also being explored. For example, naps during breaks are not allowed, but consideration is being given to allowing TOs to put their heads down and close their eyes for a few minutes at the end of the line.

Safety is the critical focus at NYCT. As other speakers have noted, benchmarking is an important element of the overall approach.

• *James Bradford*

My comments highlight current practices at Connecticut Transit (CTTransit) as part of normal operations that help manage, mitigate, and even prevent fatigue from being a factor in many accidents and incidents. CTTransit has approximately 560 bus operators. While CTTransit is a smaller system, we face many of the same issues related to fatigue and safety that larger systems face.

Our approach toward managing fatigue makes use of simple, straightforward practices that transit systems of any size can implement. It is hard to measure fatigue's total negative impact unless managers are proactive and operators are open and honest about their state of being. We rely on education, communication, and simple awareness tactics to promote "good-sense" practices among operators, supervisors, and managers.

At CTTransit, we focus on the four categories of education, detection, management, and follow-up to address and mitigate fatigue. While we do not have all the answers, our practices and policies provide good approaches for addressing fatigue-related problems.

Education is the first tool we use to address fatigue. A fit-for-duty class is part of training for new operators. The signs of fatigue, such as yawning, blurred vision, slow reactions, and poor concentration, are covered, along with tips on proper sleep and nutrition. The Transit Ambassador program focuses on managing stress and the workday. Tips on wellness and other hot issues are provided through the CTTransit newsletter, mailbox stuffers, notices, and other mechanisms. The annual health and wellness fair provides opportunities for all CTTransit employees to obtain information on a variety of topics. Services such as blood pressure checks, flu shots, body fat composition tests, and glucose tests are provided. Information on stopping smoking, healthy eating, and good nutrition is provided. Medical providers, health groups, and local hiking and biking clubs participate. Child care tips, child travel safety advice, and financial health planning information are provided.

The second tool is detection. Warning signs are monitored, including the required biannual medical card physicals, prescription lists, and new medical ailments, such as sleep apnea. CTTransit doctors review and advise operators on medical questions. Operators are required to go through retraining if they have been out more than 30 days. We conduct accident analysis and review, coaching for operators after accidents, and visual checks. We monitor appearance and provide direct communication with regard to any issues. We follow up on any complaints received from riders and the public related to erratic driving, head nods, missed stops, and near misses. Every complaint of possible driver fatigue is taken seriously and investigated. We conduct accident trend analyses.

Management is the third tool. CTTransit uses daily safety messages to promote fatigue awareness. In the interest of safety as it pertains to adequate periods of rest, CTTransit's labor agreement with ATU has maintained a provision that allows "early report" operators who return to the garage after 11:00 p.m. to defer their starting time the next morning if their next scheduled report time is before 10:40 a.m. This provision, called driver's clock, allows an operator to acquire sufficient rest while still reporting early enough the next day to complete a full day's work.

CTTransit has a policy on outside employment. We know that many employees may need additional income and may try to work an additional job, including leveraging their commercial driver's license with another driving job. The CTTransit policy requires all operators to disclose any additional employment they may have. Outside employment is in no way to affect their job performance or duties. Employees who are out on illness are not to engage in other work during that period of absence. If they do have another driving job, they are only allowed to work it on their days off, on vacation, or on holidays. Operators are required to report all driving work by filling out a log sheet. Failure to disclose additional employment may result in disciplinary actions, including discharge.

CTTransit's medical disqualification policy allows us to disqualify employees if they are no longer medically capable of performing their expected job duties, if they fail a required drug or alcohol test, or if they lose any licensing that is required as a condition of their employment. "Medically" means that the decision to disqualify will normally be based on a doctor's written opinion as to the individual's ability to perform all of the duties required of employment fully and safely.

In addition, managers and supervisors follow up on previous issues or concerns. As I mentioned, CTTransit has ongoing health and wellness promotions, including facility workout centers, blood pressure nurses, and safety and health committees.

The final tool is follow-up. Ongoing communication, including discussion of any barriers to optimum performance with operators, is a key element of this tool. We use onboard video to verify complaints and detect warning signs of problems. CTTransit offers an employee assistance program for stress management or general counseling. There are also follow-ups on previous problem operators, fitness-for-duty-tests, and retraining for any operator with absences of more than 30 days.

• *Brian Dwyer*

The Massachusetts Bay Transportation Authority (MBTA) is the fifth-largest transit property in the United States. It serves 1.3 million trips each weekday. MBTA has more than 6,000 employees and serves 175 member cities and towns within a 3,200–square mile area with more than 4.6 million residents.

A major train crash occurred in 2008. The operator of one of the trains was killed, and many passengers were injured. The National Transportation Safety Board (NTSB) investigated the crash. NTSB is an independent federal agency charged by Congress with investigating significant accidents and issuing safety recommendations aimed at preventing future accidents.

The NTSB Report Synopsis of July 14, 2009, included the following summary of the crash and the probable cause (*1*). On May 28, 2008, at about 5:51 p.m., Westbound Train No. 3681 was stopped at a red signal west of Waban on MBTA's Green Line D branch. At this time, Westbound Train No. 3667, traveling at about 38 mph, struck the rear end of Train No. 3681. Train No. 3667 had failed to stop at a signal that warned of the presence of Train No. 3681 and had failed to proceed at a restricted speed. The probable cause was determined to be the failure of the operator of the striking train to comply with the controlling signal indication, likely as a result of becoming disengaged from her environment consistent with experiencing an episode of microsleep.

Among NTSB's conclusions was that the operator of the striking train was at a high risk for having undiagnosed sleep apnea and that she may have been chronically fatigued as a result of the condition. NTSB further concluded that MBTA continues to have an inadequate fatigue awareness program for educating train operators about the risks of fatigue and an inadequate program for identifying and addressing potential sleep disorders for its train operators.

Six of the NTSB recommendations addressed fatigue, including the following three (*1*):

- R-01-27: Ensure that your fatigue educational awareness program includes the risks posed by sleeping disorders, the indicators and symptoms of such disorders, and the available means of detecting and treating them.
- R-09-10: Review your medical history and physical examination forms and modify them as necessary to ensure that they elicit specific information about any previous diagnosis of obstructive sleep apnea or other sleep disorders and about the presence or specific risk factors for such disorders.
- R-09-11: Establish a program to identify operators who are at high risk for obstructive sleep apnea or other disorders and require that such operators be appropriately evaluated and treated.

MBTA responded to all of the NTSB recommendations. On May 17, 2002, NTSB accepted MBTA's fatigue awareness program. NTSB reviewed the program and reclassified it as unacceptable in July 2009. MBTA took a number of actions to improve the fatigue awareness program.

The 30-minute fatigue awareness program was incorporated into many operations and occupational health services training programs, including new-hire orientation, annual recertification, and right-of-way classes. The program addresses the causes of fatigue, the effects of fatigue, fatigue countermeasures, individual responsibilities, and notification procedures. A fatigue awareness tool kit is distributed in all fatigue awareness training. It includes information on fatigue awareness, drowsy driver warning signs, and detection and treatment of sleep disorders. The Massachusetts Department of Public Utilities and MBTA's Safety Department are monitoring the effectiveness of the program as committed to in the corrective action plan.

MBTA addressed R-09-10, focusing on medical history and examinations for sleep apnea. Previously, all employees and applicants were required to complete a medical history form that required a list of any present medical conditions and medications. All applicants who disclosed a history of sleep apnea or a sleep disorder as a medical condition were required to provide documentation before hiring that they complied with their recommended treatment protocols. Employees were required to document compliance with treatment protocols. If they were noncompliant, they were disqualified from work until they could document compliance. They would be monitored for compliance throughout their employment.

The medical history and physical examination forms were reviewed and updated as appropriate in response to NTSB's recommendation. A sleep disorder questionnaire is used by Medical Operations to identify employees for possible sleep disorders. The screening includes a sleep apnea questionnaire and the Epworth sleepiness scale. Screenings take place at preemployment physicals, annual and biannual physical exams, and return-to-work physicals. All postaccident, reasonable suspicion, and drug and alcohol testing includes this screening. Employees who are suspected of having a sleep disorder are required to be evaluated and must produce medical documentation of treatment compliance. The Massachusetts Department of Public Utilities and the MBTA Safety Department will be monitoring the effectiveness of the program as committed to in the corrective action plan.

MTBA addressed R-09-11, which focused on identifying operators at risk for sleeping disorders. Previously, supervisors conducted checks in which they were required to assess each operator's fitness for duty when he or she reported for work. This practice has been praised by NTSB. The clinic has added a sleep disorder questionnaire as a component of all physical examinations. That screening includes a sleep apnea questionnaire and the Epworth sleepiness scale. It can be used to open a dialogue with employees about their sleep habits and to determine a potential sleep disorder. Supervisory staff attend fitness-for-duty training classes. The classes are designed to teach supervisory staff to recognize signs, symptoms, and issues involving the physical and mental health of employees and how and why to request a fitness-for-duty examination. MBTA will continue to explore strategies for reducing fatigue, including schedule changes.

MBTA was able to comply with all of the NTSB recommendations. NTSB classifies the recommendation as "closed—acceptable action." MBTA was the first rail system to adopt the APTA Work Hour Standards. Supervisory fitness-for-duty training has been added.

Reference

1. *Railroad Accident Report: Collision Between Two Massachusetts Bay Transportation Authority Green Line Trains, Newton, Massachusetts, May 28, 2008.* NTSB/RAR-09/02 PB2009-916302 National Transportation Safety Board, Washington, D.C., July 14, 2009. www.ntsb.gov/doclib/reports/2009/RAR0902.pdf.

• *James Dougherty*

I appreciate the opportunity to provide an overview of fatigue management and mitigation at the Washington Metropolitan Area Transit Authority (WMATA), which was created in 1967 by an Interstate Compact, signed by the District of Columbia, Virginia, and Maryland. The WMATA service area covers 1,500 square miles and serves 3.5 million people.

The Metrorail system is 106 miles long and includes 86 stations. Metro has 1,130 rail cars. The Metro bus system includes 319 bus routes on 174 lines. Metro has 1,400 buses, 12,227 stops, and 2,398 shelters. MetroAccess is the paratransit service, which is operated with 600 vehicles. Metro serves approximately 1 million riders daily and has more than 10,000 employees.

Fatigue is an issue in public transit, as it is in every industry. There are no regulations for public transit with regard to fatigue. The industry is working toward policies and guidance, however. Scarce resources at most public transit agencies contribute to the problem. Fatigue issues may affect the safe operation of transit services and the personal health of drivers and other personnel.

Fatigue may be caused by many factors, including night work and lack of sleep due to sleep disorders such as sleep apnea. Other factors influencing fatigue are work requirements, personal demands, and personal choices.

Work-related reasons for fatigue may include the mandated employment hours and voluntary overtime to increase pay or retirement benefits. Other work-related factors are maintaining a second job and the time and stress of commuting.

A number of personal demands and choices may contribute to fatigue. Education, continuing education, and training may add hours to an individual's schedule. Family demands, such as those related to children and parents, may influence fatigue. Health care, errands, and entertainment may cause fatigue in employees.

Fatigue is a major issue for all public transit modes and for operators, maintenance personnel, and other workers. To reduce service disruptions, much of Metro's maintenance activities are conducted during off-peak periods, including nighttime.

These schedules result in maintenance personnel working long hours. The Federal Transit Administration, APTA, state safety oversight agencies, and transit agencies are all working to establish guidelines related to fatigue.

Metro continues to improve training and procedures and to explore new approaches to fatigue-related issues. Medical screening and testing procedures have been revised to improve examination of sleep disorders, such as sleep apnea. Employee training has been updated. A safety hotline and a safety committee provide additional opportunities for identifying and addressing fatigue-related issues. Biomathematical models, including the Fatigue Avoidance Scheduling Tool (FAST) and the Fatigue Audit Interdyne (FAID) are being reviewed for potential use. The new Federal Railroad Administration (FRA) rule, which is effective October 15, 2011, includes Regulation 49 CFR 228 concerning hours of service.

Metro and other transit agencies face numerous challenges in addressing fatigue issues. Limited financial resources are a concern. Accomplishing necessary work, including provision of service during all operating hours and maintenance of a state of good repair, places burdens on operators and maintenance personnel. Metro is hiring skilled employees to help address this issue. New employee training is also being implemented. The participation of unions, along with collective bargaining buy-in, is critical to successful efforts.

PANEL ON LABOR PERSPECTIVE ON FATIGUE MANAGEMENT INITIATIVES

Ed Watt, Moderator

- *Bruce Hamilton*

I began driving for Greyhound in 1971, so I worked during the period of deregulation of the over-the-road motor coach industry. The establishment of the Interstate Commerce Commission (ICC) in 1935 was the result of a chaotic situation in the motor coach industry in the 1920s and 1930s. There was stiff competition between operators. Wages were low, vehicles were not maintained, and safety was compromised. As a result, there were numerous accidents involving motor coaches, and public safety was at risk.

ICC and the related regulations were established to bring order to the industry and improve safety. Businesses were required to apply for permission to operate service, and ICC regulated fares, routes, and stops. This approach brought order to and improved safety in the industry. It was in place for approximately 45 years before the movement toward deregulation in the late 1970s.

Deregulation has resulted in numerous small carriers entering the market. Today, there are approximately 4,000 over-the-road bus lines in the United States, with an average fleet of five to six buses. Many motor coach companies consist of one driver and one bus. An ultracompetitive environment exists today, similar to the situation in the 1930s.

A number of major crashes involving over-the-road motor coaches have occurred this year. A crash in March 2011 in the Bronx resulted in numerous fatalities, as did one in Virginia over the Memorial Day weekend. There were other, less serious crashes throughout the year. Driver fatigue appears to be a common element in these crashes. Previous NTSB studies have identified driver fatigue as the most important cause of traffic fatalities involving intercity buses.

ATU has been examining issues related to driver fatigue for many years. As noted by speakers this morning, the economics associated with the over-the-road motor coach industry are a key factor. The federal Fair Labor Standards Act, which was also approved by Congress in the 1930s, includes provisions related to overtime. They do not apply to over-the-road bus drivers. Only about 15 percent of workers in the United States are not covered by the overtime provisions of the act. I am not sure why over-the-road bus drivers are included in the 15 percent. Employers in the over-the-road motor coach industry have an incentive to maximize the number of hours that their employees work. This situation leads to long work hours, which lead to fatigue, which leads to crashes, which lead to fatalities.

Adding over-the-road motor coach operators to the groups covered by the overtime requirements should be the first step in addressing this issue. The overtime situation should be rectified before dealing with the hours-of-service issue. ATU is working to have this change made as the beginning point of addressing the fatigue and safety concerns associated with the motor coach industry. Addressing the economic situation of motor coach operators is also a key element.

At Greyhound, ATU has negotiated 9 hours off duty, rather than 8 hours, after on-duty hours. The Greyhound contract includes a "16-hour mile," which stipulates that an operator cannot be assigned to a piece of work if it is known that a total of 16 hours will be required from the time the operator reports to the time the work is completed. This stipulation is in response to the 15 hours in the FMCSA guidelines.

One suggestion for research is to expand and update the studies conducted by Dr. Belzer examining the economic situation of motor coach operators and truck drivers. A better understanding of the components of the over-the-road motor coach industry is needed as a first step in identifying approaches to addressing work-related fatigue and improving safety. A case can be made that reregulation of the industry is needed to improve operators' work conditions and public safety.

Examining the sleeping facilities and conditions of motor coach operators when they are on the road would also be beneficial. There is anecdotal evidence that adequate facilities are woefully lacking. The best way to address over-the-road motor coach safety is to ensure that drivers are able to obtain a full night's sleep.

• *James Stem*

Fatigue is a major safety issue for all transit employees. The operational definition of fatigue from the 1998 U.S. Department of Transportation (DOT) Human Factors Coordinating Committee is as follows: "Fatigue is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness. Fatigue is more than sleepiness and its effects are more than falling asleep."

The Sleep, Activity, Fatigue, and Task Effectiveness model provides one approach to the analysis of fatigue. It is a biomathematical model based on 12 years of modeling experience and investment by the U.S. Department of Defense and U.S. DOT. It has been validated against laboratory and simulator measures of fatigue. It is used by the U.S. Department of Defense as the common war fighter fatigue model. It has been independently compared with six models from around the world and judged to be at least as good as any other model available. It is the only model that considers the long-term effects of sleep restriction.

There are a number of ways to mitigate fatigue. Examples include providing adequate notice of operator scheduling and providing predictable schedules and defined break periods based on human physiology. Other approaches are providing predictable time off with assigned work and rest schedules and employee education that uses medical science. The building blocks of human performance have been identified in various studies.

As noted on the NTSB website in an article titled "Addressing Human Fatigue" (*1*), airplanes, trains, trucks, buses, and ships are complex machines that require the full attention of the operator, maintenance personnel, and other individuals performing safety-critical functions. The cognitive impairments of these individuals that result from fatigue due to insufficient or poor-quality sleep are critical factors to consider in improving transportation safety. Operators of transportation vehicles need to have sufficient off-duty time to obtain adequate sleep. Duty schedules are only part of the equation, however. Even when an individual has enough time to rest, medical conditions, living environments, and personal choices can affect the ability to obtain quality sleep.

NTSB has investigated many accidents over the years in all transportation modes in which fatigue was cited as the probable cause or a contributing factor. Human fatigue is subtle. At any given point, the traveling public could be at risk because the professional pilots, vessel captains, motor coach drivers, or truck drivers with whom or near whom they are traveling—or the individuals responsible for maintaining the vehicles—do not realize until too late that they cannot safely complete their duties because of fatigue. To make matters worse, people frequently are not aware of or may deny ability impairments caused by fatigue. Just because a driver is not yawning or falling asleep does not necessarily mean that he or she is not fatigued (*1*).

NTSB has made many recommendations on human fatigue and its relationship to operational safety. NTSB has issued more than 180 safety recommendations to address the problem of human fatigue in all modes of transportation since its creation (*1*).

Continued research on the manifestations of fatigue will help in further identifying mechanisms that can counter and ultimately eliminate fatigue. Such research needs to recognize the unique aspects of fatigue associated with each mode of transportation, such as the effect of crossing multiple time zones on international flights or being required to work during periods of the day when circadian rhythms increase the risk of fatigue (*1*).

Fatigue-countering mechanisms must include science-based, data-driven hours-of-service limits, particularly for professional drivers, pilots, mechanics, and air traffic controllers. The medical oversight system must recognize the dangers of sleep-related medical impairments, such as obstructive sleep apnea, and incorporate mechanisms for identifying and treating affected individuals (*1*).

In "Addressing Human Fatigue," NTSB also points out that employers play a key role in addressing fatigue-related issues. Employers should establish science-based fatigue management systems that involve all parties—employees, management, unions, and interest groups—in developing environments to help identify the factors that cause fatigue. Employers should also monitor operations to detect the presence of fatigue before it becomes a problem. Because "powering through" fatigue is not an acceptable option, fatigue management systems need to allow individuals to acknowledge fatigue without jeopardizing their employment (*1*).

The Federal Transit Administration has an important oversight role to play in addressing fatigue. Transit systems operate throughout the country but are especially important in major urban areas, including those along the East Coast. More than 90 percent of passenger rail operations use freight tracks. The commuter rail systems are in operation in major urban areas. Advanced technology can be used to assist with fatigue countermeasures.

The Fair Labor Standards Act addresses employment hours. Many employees work long hours by choice because they are not eligible for overtime. The motivation is extra income. Bus drivers may try to work long hours for a number of reasons. Examples of these factors include employer demands, the desire to increase their income, and the instability of the bus workforce. Many drivers are immigrant Americans with concerns over their jobs.

Partnerships involving federal agencies, local transit systems, unions, operators, and other groups are needed to address fatigue in public transportation. All groups must work together to ensure the safe operation of transit services and other transportation modes. These partnerships can begin with the individuals involved in this conference.

Reference

1. Addressing Human Fatigue. National Transportation Safety Board, Washington, D.C. www.ntsb.gov/safety/mwl-1.html

• *Larry Hanley*

ATU was formed in 1892 to address the poor working conditions of streetcar operators. At the time, horses pulling streetcars in the United States and Canada were limited to 4 hours of work, while operators had to work 12 hours. The trolley companies did not respond to ATU's requests for changes in operators' work hours. ATU worked in individual states to pass legislation addressing streetcar operators' work hours. Only after operators froze to death because there were no vestibules for operators did the issue began to be addressed. An ATU vice president was one of the individuals who died.

That was the situation when ATU was established in 1892. Unfortunately, the same lack of insight into the working conditions of the people who operate transit services exists today. The conditions may have changed, but the mentality has not changed much. Many transit agencies rely on federal regulations and laws as the maximum level of effort needed for their operations. These agencies focus only on complying with federal requirements.

There are gaps in federal laws, regulations, and guidelines associated with transit operator hours of service and related work conditions. I worked in Delaware for 3 years. The state-operated transit system, Delaware Transit Corporation (DART), had a policy of forced overtime for bus drivers. The overtime policy resulted in some drivers working the extra list, which had them reporting to work at 5:00 a.m. and not leaving until midnight. These schedules were approved by management. A woman paratransit driver in her 70s suffered from exhaustion after working 14 straight days and had to be taken off her bus and transported to a hospital in an ambulance. This situation was obviously not good for DART operators, DART riders, or the traveling public. The union brought this issue to DART management and the Delaware Secretary of Transportation. There was no response. The union next went to Republican members of the state legislature, who held hearings. Representatives from DART did not present an accurate picture of this labor practice related to overtime at the hearings.

Most transit systems now use computers to schedule transit operators' work hours. One of the issues with computer scheduling is the lack of a check on the reasonableness of the schedule. Agencies seek the cheapest and the most efficient schedules, regardless of the effects on transit operators. I know of schedules that provide only 4 minutes of layover time for drivers at the end of a route. To ensure that everything goes right and a bus stays on schedule throughout the trip, which rarely happens, 4 minutes of recovery time is not enough.

Schedules routinely require drivers to be behind the wheel for just under 6 hours at a time. There are no rules concerning provision of bathroom breaks for bus drivers. Some drivers do not drink enough liquids to keep hydrated because they are concerned about not being able to take a bathroom break. This is a major health concern, which can contribute to dehydration, kidney disease, and other long-term health consequences.

The situation for bus and commuter train operators has declined in my lifetime. Driving a bus under normal conditions is almost impossible. At the same time, there has been downward pressure on wages. As agencies put pressure on drivers for lower wages, drivers are more likely to have second jobs.

What has happened in the over-the-road motor coach industry is a scandal. People are dying on our roadways because of downward pressure on wages and the fatigue that results from drivers working long hours without adequate breaks and sleep opportunities. Deregulation has made the motor coach industry unsafe. Congress and the industry are ignoring this problem despite the recent crashes and fatalities.

Data from NTSB indicate that only 6 percent of the fatalities in the over-the-road motor coach industry are due to distracted driving, while 74 percent are due to driver fatigue, equipment failure, and driver health problems. While most Greyhound drivers, approximately 70 percent, I believe, have company health care, most of the people who drive over-the-road coaches are not covered by employer-provided health care programs.

As was mentioned, bus operators are not covered by the overtime provisions of the Fair Labor Standards Act. As a result, it is cheaper for agencies and companies to work drivers longer than 40 hours. Every hour after 40 hours worked is cheaper than the first 40 hours. Fatigue is a major result of drivers working long hours.

All of these conditions contribute to driver fatigue and health problems, safety concerns, and fatalities. More women in the driving workforce have helped address some of these issues, but a woman driver was killed when she went to use a bathroom and forgot to set the brake and was hit by the bus. We need to address the core issues and deal with the key economic concerns. It is ultimately about money and power.

- *André Jones, Sr.*

I agree with the comments made by other speakers. I will personalize my remarks by providing a glimpse of a typical day for a bus operator, which is what I was until I took my current position 13 months ago.

My day began at 2:54 a.m. I got off work at 11:49 a.m. I lived 1 hour away from my district. From 11:49 a.m. to 4:00 p.m., I worked as a union representative. At 4:00 p.m., I left my district to pick up my children. From 5:00 to 7:00 p.m. I cooked dinner and helped my children with their homework and other activities. Many nights I did not go to sleep until 10:00 p.m., just to get up at 2:54 a.m. and begin the same routine again. I worked this schedule 5 days a week.

The Southeastern Pennsylvania Transportation Authority, where I work, has a 14-hour property-to-property rule. This rule means that operators can only work 14 hours from the time the bus leaves the property. Operators stretch this rule to work overtime for additional income, however. To address fatigue, we need to address this underlying economic situation.

A partnership is needed among the transit authorities, operators, unions, and government agencies to address these underlying issues, fatigue, and safety. Emphasizing the importance of rest and sleep is critical, but operators will not heed this message if they do not have a living wage. I know drivers who work extra hours for financial reasons even though they know they are sacrificing needed sleep and their overall health. Nothing replenishes sleep but sleep.

Education is important for all groups. A culture change is also needed by all these groups. All the partners need a better understanding of the basic issues and must work together to ensure a reasonable and safe work environment for operators, which in turn leads to safe operation of transit services.

ENHANCING TRANSPORTATION SAFETY: THE IMPORTANCE OF MANAGING FATIGUE

Mark Rosekind

My comments focus on the mission and responsibilities of NTSB, the role fatigue plays in accidents, and methods for mitigating fatigue and improving safety.

NTSB's mission is determining the probable cause of transportation accidents and making recommendations to prevent their recurrence. In addition, in 1996, Congress gave the NTSB responsibility for providing transportation disaster assistance. This assistance has been provided in aviation since 1996 and now has been extended to rail.

NTSB is responsible for investigating aviation, highway, rail, marine, pipeline, and hazardous material accidents. There are typically 2,000 domestic aviation accidents each year. All domestic aviation accidents are investigated by NTSB.

NTSB was created in 1967 as an independent federal agency. Since that time, it has conducted more than 130,000 accident investigations and has made more than 13,000 safety recommendations to more than 2,500 organizations. NTSB does not have any regulatory or enforcement power. NTSB has an 82 percent acceptance rate for its recommendations, however. Some have suggested that NTSB would not be doing its job if the acceptance rate were 100 percent. That is, NTSB would not be making recommendations that push the envelope if there were 100 percent acceptance.

Approximately 39 percent of NTSB recommendations focus on aviation, followed by marine at 17 percent. Railroads and highways each represent 16 percent of the total recommendations. Recommendations related to pipelines represent 9 percent, and intermodal recommendations represent 2 percent.

While the major product of NTSB is safety recommendations, it also acts as the moral compass and industry conscience. It is interesting to see how on the one hand organizations dislike being the target of an NTSB investigation, while on the other hand the recommendations are often used to obtain funds for needed safety improvements. NTSB findings, recommendations, and reports often become the impetus of change and funding for improvements. Some of the changes take a long time before they are implemented.

One of the issues with the "Swiss cheese" accident–safety model or other models is that the holes in the Swiss cheese can align—rendering the successive layers of defense barriers and safeguards ineffective. In addition, a situation may be above the cheese and bypass all the layers. These situations result in accidents, which NTSB investigates.

There are two key reasons for investigating fatigue in public transit. The first relates to the challenges of living in a 24/7 global society. Humans are not built to operate around the clock. Humans are programmed for sleep. Sleep is a vital physiological requirement. We have a clock in our brain that tells us to be awake during the day and asleep at night. There is a risk in changing this pattern. The second is that fatigue is a safety risk. I think the realization that fatigue is a safety risk is part of the culture change that has occurred in the transportation industry. The bigger challenge we face is how to address fatigue issues. Safety is the key issue and economic, quality-of-life, and other concerns should be discussed in the context of safety.

We know that there is no single solution to fatigue. We know that addressing fatigue is complex and contentious. It is harder than telling everyone to get 8 hours of sleep. Addressing fatigue is complex because of physiological, economic, organizational, and other issues. It is also contentious because it affects the economics of individuals, agencies, and businesses.

Fatigue has been on the NTSB "most wanted" list since 1990. NTSB has made approximately 200 recommendations related to fatigue since 1967. Fatigue has been found to be a probable or contributing cause to accidents in all modes of transportation. The recommendations have addressed multiple solutions with regard to the complex problem of fatigue. They have focused on scheduling policies and practices, education, organizational strategies, and the raising of awareness. Other recommendations have addressed healthy sleep, vehicle and environmental strategies, and research and evaluation.

Education is the foundation for addressing fatigue in all transportation modes. Sleep—not rest—is the key. Development of a fatigue education and countermeasures training program is critical. Education is needed for all groups—operators, schedulers, maintenance personnel, management, unions, and families. Information on the use of all elements, from detection to mitigation strategies, is needed. It is also critical that this information be reviewed and updated on an ongoing basis. The integrity and accuracy of the science must be checked and updated.

There is a difference between fatigue awareness and fatigue education. Education is the foundation of any fatigue effort. Education should address broad and applied content. It should cover the basics on the amount of sleep people need, circadian rhythm, sleep debts, and other elements. Other topics of basic education include how fatigue affects performance, how to minimize fatigue risks, countermeasures to combat fatigue, and policies to support tired drivers. Education should provide information that people can use and act on.

Scheduling policies and practices were found to contribute to a bus crash in Victoria, Texas, which occurred at 4:00 a.m., the window of circadian low. The driver was on an inverted schedule of working at night and sleeping during the day. NTSB's ruling focused on establishing scientifically based hours of service regulations. Elements that should be addressed include rotating schedules, extended duty days, schedule inversion (day sleep and night work), scheduling irregularity and unpredictability, and opportunity for 8 hours of uninterrupted sleep.

Driver fatigue was found to contribute to the motor coach crash in Mexican Hat, Utah, in January 2008, in which the motor coach made a 360-degree rollover, killed nine people, and ejected 50 of 52 passengers. The driver was diagnosed and treated for sleep apnea. He was not using his continuous positive airway pressure machine because of sinus problems and altitude.

Obtaining healthy sleep is critical in addressing fatigue. Disseminating guidance for identifying and treating obstructive sleep apnea and other sleep disorders is a key step in addressing transit operator fatigue. Ensuring that drivers with apnea are effectively treated before granting unrestricted medical certification is also important. Having a written contingency plan to accommodate drivers impaired by fatigue or illness is important.

Organizational strategies for addressing fatigue are critical. Examples of organizational strategies are improving drivers' rest facilities, reviewing log book violations for driver safety assessments, implementing nonpunitive fatigue call-in policies, and providing backup drivers when needed.

Advanced technologies and other elements can contribute to addressing vehicle and environmental factors. Rumble strips on roadways are used in many areas to alert drivers that they are veering off the roadway. In-vehicle technologies to reduce fatigue-related accidents include electronic onboard recorders, lane detection systems, and collision avoidance systems.

NTSB recommendations related to fatigue management systems have been made. One recommendation is to develop guidance based on empirical and scientific evidence for operators to establish fatigue management systems. A second is to develop and use a methodology that will continually assess the effectiveness of fatigue management systems.

There are good examples of fatigue risk management systems in the aviation industry that may be of use in the transit industry. *Fatigue Risk Management Systems: Implementation Guide for Operators* and *Fatigue Risk Management Systems: Manual for Regulators*, both developed by the International Air Transport Association, the International Civil Aviation Organization, and the International Federation of Airline Pilots' Associations, are two examples.

Fatigue management programs should use a comprehensive approach and include multiple components. They should be science-based, and they should be continuously evaluated and updated. Fatigue management programs should complement hours-of-service regulations.

The lack of accidents does not necessarily equal safe operation. In summary, key elements of managing fatigue include developing knowledge, tools, and programs; implementing education programs, fatigue risk management systems, and policies; and continuously improving, evaluating, enhancing, and integrating all the elements. Remember, managing fatigue is critical to safety.

WORK SCHEDULES AND SLEEP PATTERNS OF TRAIN AND ENGINE SERVICE WORKERS IN PASSENGER SERVICE

Judith Gertler

My presentation focuses on a recent study conducted for FRA that examines the work schedules and sleep patterns of train and engine service workers in passenger rail operations. I will cover the objectives of the project and the survey procedure and describe the characteristics of respondents, their job characteristics, and their sleep patterns. I will close by discussing the analysis of their on-the-job effectiveness and the main study conclusions.

The study had two objectives. The first was to design and conduct a survey to collect work schedule and sleep data from passenger train and engine (T&E) service employees. The second was to analyze the data to characterize the work and sleep patterns of the respondents and to identify work schedule–related fatigue issues. The study used a background survey and 2-week daily logs to collect data.

The survey was distributed to actively working passenger T&E employees who were members of the Brotherhood of Locomotive and Engineer Trainmen (BLET) and the United Transportation Union (UTU). BLET has approximately 1,510 members in passenger service, and UTU has some 5,665 members. A total of 1,275 surveys were distributed to members of the two unions. The number distributed to each union was proportional to its total number of qualifying members. A total of 269 individuals returned both the survey and the daily log. Thirteen respondents were disqualified because of errors in recording data or because the individual was not in fact a passenger T&E employee. The remaining 256 surveys and logs were analyzed.

The characteristics of the respondents were examined as part of the analysis. Males accounted for 91 percent of the respondents. A total of 67 percent of the respondents reported working straight through shifts, with the remainder split almost evenly between split assignments (17 percent) and the extra board (16 percent). The mean of the respondents' total reported years of passenger T&E experience was 15.7, and the median was 13.7. The mean years of employment with the current employer was 13.2, and the median was 11.3. These results indicate that group members worked in a different railroad job before working a T&E position.

The majority of respondents, 71 percent, were between the ages of 40 and 59. The detailed age breakdown is as follows: 36 percent were between 50 and 59, 35 percent were between 40 and 49, 21 percent were between 30 and 39, 5 percent were 60 or over, and 3 percent were between 20 and 29. The average age was 47 years, which is typical of railroad employees in general.

The survey included questions on diagnosed sleep disorders and treatments. A total of 6.6 percent of the respondents indicated they had been diagnosed with a sleep disorder, and 82.4 percent of these individuals reported that they were receiving treatment. Fifteen respondents indicated that they have sleep apnea, and 14 of the individuals reported receiving treatment. These responses are slightly higher than the reported norm for U.S. working male adults, which is 4 percent.

Respondents were asked about receiving fatigue-related education. Some reported exposure to more than one type of educational material. Exposure to brochures was reported by 23 percent of the respondents, 19 percent indicated that they had received a briefing, and 13 percent reported viewing a videotape. A total of 44 percent of the respondents indicated that they had not been exposed to any fatigue education. This result indicates that there are opportunities for more fatigue education for this population of transit employees.

The survey included a series of questions on job characteristics. Respondents were asked about their guaranteed rest days, and the results were examined by the type of schedule. Two consecutive days of rest per week were reported by 80 percent of the straight through workers and 71 percent of the split assignment workers but only by 41.5 percent of the extra board workers. Among straight through workers, 11 percent reported 2 guaranteed rest days per week, and 6 percent reported 1 day per week. Less than 1 percent reported no rest days per week. For the remaining split assignment workers, 17 percent reported 2 rest days per week, 7 percent reported 1 rest day per week, 5 percent reported other rest days, and none reported no rest days. Among extra board workers, 41.5 percent reported 1 guaranteed rest day per week, and 15 percent reported no guaranteed rest days. The extra board workers had the highest percentage of no guaranteed rest days. The differences by type of schedule were statistically significant.

A more detailed analysis of the total hours worked in a 2-week period for those respondents with 14 days of log book data was conducted. The total hours of work reported were examined by the 25th percentile, the median, and the 75th percentile. Individuals working straight through schedules worked the greatest number of hours and those on split assignment the least. For individuals reporting a straight through schedule, the median reported hours worked in a 2-week period was 89 hours 20 minutes, and the 75th percentile was 104 hours 26 minutes. This means that a quarter of the straight through workers worked 24 or more hours of overtime in the 2-week period of the study. For individuals working a split assignment, the mean was 77 hours 10 minutes in a 2-week period, and the 75th percentile was 92 hours 29 minutes. For individuals working the extra board, the median hours worked in a 2-week period was 81 hours 5 minutes, and the 75th percentile was 99 hours 40 minutes. Overall, split assignment T&E personnel worked less overtime than did those on other schedules.

Break location was of interest because employees are more likely to be able to rest if they are off the train. The majority of respondents, 77 percent, reported that their break location was off the train, 19 percent responded that it was on the train, and 4 percent did not report a location. The total daily break time by schedule type was also examined. Overall, approximately 40 percent of breaks were less than 1 hour. Respondents with straight through schedules had a mean of 1 hour 46 minutes of total break time per day and 55 percent of days with breaks. Respondents on split assignment schedules had a mean of 1 hour 24 minutes and 11 percent of days with breaks. Respondents working the extra board schedule had a mean of 1 hour 48 minutes and 39 percent of days with breaks. The lower levels of days with breaks and the lower mean break time for split assignment workers may relate to the nature of their schedule, which provides a break of several hours in the day, referred to as interim release.

Respondents were asked to report their sleep patterns in the log. The following definitions were used in analyzing the log book data:

- Workdays have at least one work start time logged in a calendar day.
- Rest days have no work starts occurring in a calendar day. Primary sleep for a calendar day is the longest sleep period ending on that day.

For example, Respondent A went to sleep on Day 1 at 11:00 p.m. and awoke at 6:00 a.m. on Day 2. This sleep period is assigned to Day 2. In a second example, Respondent A went to work at 8:00 p.m. on Day 2 and got off work at 8:00 a.m. on Day 3. Respondent A did not work for the rest of Day 3 after getting off work. In this example, Day 2 is a workday and Day 3 is a rest day. The sleep period in the first example ends on Day 2, a workday, and is therefore classified as workday sleep.

The total daily sleep by type of day and work schedule was examined. Total daily sleep includes the primary, usually nighttime, sleep plus any supplementary sleep periods or naps. Workers on straight through schedules reported 7 hours 7 minutes of sleep on workdays and 7 hours 50 minutes of sleep on rest days. Workers on split assignment schedules reported 7 hours 26 minutes of sleep on workdays and 7 hours 43 minutes of sleep on rest days. Extra board workers reported 7 hours 17 minutes of sleep on workdays and 7 hours 15 minutes of sleep on rest days. These results indicate that straight through workers get the least amount of sleep on workdays but make up for their sleep debt by getting close to 8 hours of sleep on rest days. Extra board workers get a little more than 7 hours of sleep on both workdays and rest days.

A more detailed analysis was conducted of the primary sleep period for workdays and rest days. Straight through workers reported 6 hours 53 minutes of primary sleep on workdays and 7 hours 41 minutes of sleep on rest days. Split assignment workers reported 6 hours 16 minutes of primary sleep on workdays and 7 hours 37 minutes on rest days. Extra board workers reported 6 hours 59 minutes of sleep on workdays and 7 hours 3 minutes of sleep on rest days. Comparison of the primary sleep of split assignment workers (6 hours 16 minutes) with their total sleep for workdays (7 hours 26 minutes) indicates that this group has supplementary sleep periods during the day, most likely during their midday break time. In contrast, for both the straight through and the extra board groups, there was little difference between total daily sleep and primary sleep. The split assignment group had a median of 1.8 daily sleep periods, which is consistent with their supplementary sleep periods.

The daily sleep hours on workdays from the survey results were compared with those for adults in the United States as reported in the National Science Foundation's 2009 Sleep in America Poll. Overall, this group of railroad employees is comparable with U.S. adults. The passenger T&E survey respondents had higher percentages of 6 to less than 7 hours and 7 to less than 8 hours of sleep than did the overall population. They also had lower percentages of less than 6 hours of sleep than the overall population, indicating that they may be slightly less sleep-deprived than other working adults.

The prevalence of supplementary sleep during the workday could be determined from the daily logs. Ten percent of the respondents reported sleep opportunities on breaks, and 65 percent reported sleep opportunities during interim release. The respondents were asked about employer-provided sleeping arrangements at away-from-home terminals or interim release points. Quiet rooms were the most commonly reported type of arrangement, noted by 68 percent of the respondents, followed by sleeping accommodations with 23 percent. No accommodations were reported by only 7 percent of the respondents.

In conclusion, the study found a slightly higher rate of sleep apnea among passenger T&E employees than U.S. working adults, probably because of the increase in public awareness in recent years. The survey results indicated that commuter rail operators need to provide more fatigue education to passenger rail T&E employees. The results further indicated that workers on split assignment have shorter primary sleep hours on workdays but appear to compensate with naps. Workday sleep hours for passenger rail T&E employees are similar to those of U.S. adults. On the basis of FAST effectiveness scores, passenger rail T&E employees do not appear to have a fatigue problem; 2.4 percent of straight through and 1.0 percent of extra board work time are at risk with scores of less than or equal to 70.

Complete reference information for this study, which is available at http://www.fra.dot.gov, is as follows:

Gertler, J., and A. DiFiore. *Work Schedules and Sleep Patterns of Railroad Train and Engine Service Employees in Passenger Operations*. Report DOT/FRA/ORD-11/05. Federal Railroad Administration, Washington, D.C., 2011.

NEW HOURS-OF-SERVICE REGULATIONS FOR COMMUTER RAIL EMPLOYEES

Thomas Raslear

The Rail Safety Improvement Act of 2008 [Section 108(e)] provides authority to FRA to issue hours-of-service rules for train employees engaged in commuter and intercity passenger rail transportation. This is the first time such authority has been granted. Other FRA hours-of-service rules have been by statute. The act provides that "regulations . . . shall consider scientific and medical research related to fatigue and fatigue abatement. . . ."

The Railroad Safety Advisory Committee (RSAC) provides a forum for developing consensus recommendations to the FRA Administrator on rulemaking. RSAC includes representation from all FRA's stakeholder groups, including railroads, labor organizations, manufacturers, suppliers, and other parties. RSAC formed the Passenger Hours of Service Working Group. The first meeting of the working group was in June 2009. The group expressed unanimous agreement on the proposed rule at its September 2010 meeting. RSAC unanimously accepted the proposed rule.

The new regulation, which is contained in 49 CFR 228, Subpart F, addresses the hours of service of railroad employees. It includes substantive regulations for train employees providing commuter and intercity rail passenger transportation. The regulation was published in the *Federal Register* on August 12, 2011 (Vol. 76, No. 156, pp. 50360–50401), and is effective October 15, 2011.

The first key provision of the regulation addresses limitations on time on duty in a single tour and mandatory off-duty periods. Time on duty in a single tour is limited to 12 consecutive hours, or 12 nonconsecutive hours if broken by interim release of at least 4 hours (split shift). Mandatory off-duty periods are 8 consecutive hours, or 10 hours if the time on duty is equal to 12 hours.

The second key provision of the regulation addresses limitations on consecutive duty tours. Consecutive duty tours are limited to 6 consecutive days that include at least one "Type 2" assignment—those including time on duty between 8:00 p.m. and 4:00 a.m. Employees working Type 2 assignments must have 24 hours off duty at their home terminal. Employees working 13 or more days in a 14-day period must have 2 consecutive days off duty at their home terminal. There are no cumulative limits on time on duty.

The third key provision of the regulation addresses the use of fatigue science. Type 2 schedules must be analyzed with an FRA-approved validated biomathematical fatigue model. The FAST and the FAID tools are two examples of these models. The analysis determines fatigue risk. Any identified excess risk of fatigue requires action.

The fourth key provision of the regulation relates to Type 2 schedules with excess risk of fatigue. These schedules must be mitigated through a fatigue management plan, which is subject to FRA review or documentation that mitigation is not possible and that the schedule is operationally necessary. The plan requires FRA approval.

Fatigue risk depends not only on the hours per day an employee is permitted to work or the required off-duty time between periods of work but also on the time of day of work and sleep, consecutive time on duty, schedule rotation, and consecutive days of work. Individual factors, including age and medical conditions, also influence fatigue risk.

Human performance is adversely affected by fatigue. Vigilance, reaction time, lapses, cognitive throughput, alertness, and a tendency to fall asleep may all be influenced by fatigue. Changes in performance increase the probability of errors, and accidents are more likely to occur. There is more recovery from errors when fatigue is diminished.

Fatigue models use work schedules to predict changes in human performance and fatigue. The models consider circadian rhythm and sleep opportunities. They are supported by extensive laboratory studies. The models allow quantification of a complex process that involves multiple variables. FRA has used accident data to demonstrate that the risk of a human factors–related accident is related to fatigue scores for FAST and FAID.

These studies indicate that there is a significant correlation between human factor accident risk and FAST scores. No significant relationship was found between non–human factor accident risk and FAST scores. FAST scores range from 0, which is the most fatigued, to 100, which reflects no fatigue. An elevated risk of human factor accidents occurs at any FAST score of less than 90. A FAST score of 90 or greater typically reflects individuals who work from 9:00 a.m. to 5:00 p.m. 5 days a week and get approximately 8 hours of sleep per night.

The risk of human factor accidents increases by 21 percent at FAST scores of 70 or below. The risk level is statistically greater than chance or neutral and the mean risk for non–human factor accidents. Approximately 23 percent of accidents occurred at FAST scores of 70 or below. Accidents that might be expected of a fatigued train crew were overrepresented at FAST scores of 70 or below.

Fatigue has an economic cost. The average total cost of human factor accidents at FAST scores of 70 or below is three times the average cost of all accidents and four times the cost of all accidents at FAST scores greater than or equal to 90, when fatigue is not involved. There is an exponential increase in cost at FAST scores equal to or less than 90. Schedules exceeding the fatigue threshold require mitigation or justification as operationally necessary.

The following resources may be of use in examining these models in more detail:

1. Validation and calibration of fatigue models:
   – http://www.fra.dot.gov/downloads/Research/ord0804.pdf.
   – http://www.fra.dot.gov/rpd/downloads/TR_Procedures_or_Validation_and_Calibration_final.pdf.

2. Work–rest diary studies
   – Passenger T&E: http://www.fra.dot.gov/rpd/downloads/TR_Work_Schedules_and_Sleep_Patterns_final.pdf.
   – T&E: http://www.fra.dot.gov/downloads/Research/ord0922.pdf.
   – Dispatchers: http://www.fra.dot.gov/downloads/Research/ord0711.pdf.
   – Signalmen: http://www.fra.dot.gov/downloads/Research/ord0619.pdf.
   – Maintenance of way: http://www.fra.dot.gov/downloads/Research/ord0625.pdf.

3. Economics of fatigue: http://www.fra.dot.gov/rpd/downloads/TR_Economic_Analysis_of_Rail_Accidents_and_Effectiveness_final.pdf.

Topics for Future Research

Individual participants identified a number of research needs and outreach activities to help address fatigue issues in transit operations. The following topics were suggested during the discussion. None of the suggestions below should be interpreted as representing a consensus of the conference participants as a whole, the planning committee, or the Transportation Research Board.

- Develop a best practice synthesis documenting examples of fatigue mitigation and fatigue management policies, programs, and activities in use by public transit agencies throughout the country.
- Examine and summarize approaches, tools, and techniques used in other transportation industries that may have applications in public transit. The trucking, railroad, over-the-road motor coach, aviation, and marine industries could be investigated.
- Update *TCRP Report 81: Toolbox for Transit Operator Fatigue*, which was published in 2002.
- Identify and document best practices and case studies of developing and maintaining a fatigue awareness and a fatigue management culture at transit agencies involving all key stakeholders. The stakeholders include operators, union representatives, management personnel, medical support services, and other groups.
- Conduct research on the causes of fatigue in public transit. Assess potential sleep issues, stress concerns, and economic factors associated with operating public transit service. Economic factors associated with operator scheduling, compensation, work hours, and other factors would be included in the analysis. The project would build on the realization that fatigue is a complex issue with many causes. It would identify potential methods, programs, and technologies for addressing and mitigating these concerns. A pilot program could be developed and implemented to test these approaches.
- Develop a methodology for establishing a baseline for fatigue in transit operations that can be used by individual agencies. Pilot test the methodology with selected agencies. A more extensive project could develop a national baseline by using the methodology.
- Develop methodologies for conducting before-and-after assessments of new fatigue awareness and fatigue management programs for use by transit agencies. Pilot test the methodology, and document case study examples.
- Conduct workshops, outreach, and training for transit agencies on best practices. These efforts could be coordinated with the American Public Transportation Association, the Community Transportation Association of America, the Federal Transit Administration, and other groups.

APPENDIX A

Conference Agenda

WEDNESDAY, OCTOBER 12, 2011

Keck 100

8:30 a.m.	**Welcome** Robert E. Skinner, Jr. *Executive Director, Transportation Research Board*
	Conference Overview Judith Gertler, *QinetiQ North America, Inc.* *Chair, Conference Committee*
8:45–11:30 a.m.	**Fatigue in Other Transportation Modes**
8:45 a.m.	**Union Pacific Railroad Fatigue Management Program** Jacqualyn Keenan, *Union Pacific Railroad*
9:15 a.m.	**Greyhound Fatigue Management Initiatives** Alan Smith, *Greyhound Lines, Inc.*
9:45 a.m.	**Fatigue and Accidents** Rick Narvell, *National Transportation Safety Board*
10:15 a.m.	**Economic Drivers of Fatigue in the Trucking Industry** Michael Belzer, *Wayne State University*
10:45 a.m.	*Break*
11:00 a.m.	**Health Effects of Fatigue** Thomas Balkin, *Walter Reed Army Institute of Research*
11:30 a.m.–4:45 p.m.	**Fatigue Issues and Initiatives in Transit**

11:30 a.m.	**Relationship Between Operator Schedule and Fatigue** Thobias Sando, *University of North Florida*
Noon–1:00 p.m.	*Lunch*
1:00 p.m.	**Best Practices and Lessons Learned** Michael Glikin, *New York City Transit (Moderator)* Brenda Himrich, *Metro Transit Minneapolis* Tony Abdallah, *New York City Transit Department of Subways* James Bradford, *Connecticut Transit* Brian Dwyer, *Massachusetts Bay Transportation Authority* James Dougherty, *Washington Metropolitan Area Transit Authority*
2:00 p.m.	**Labor Perspective on Fatigue Management Initiatives** Edward Watt, *Transport Workers Union of America (Moderator)* Bruce Hamilton, *Amalgamated Transit Union, Local 1700* James Stem, *United Transportation Union* Larry Hanley, *Amalgamated Transit Union* André Jones, Sr., *Transport Workers Union of America, Local 234*
3:00 p.m.	*Break*
3:15 p.m.	**Enhancing Transportation Safety: The Importance of Managing Fatigue** Mark Rosekind, *National Transportation Safety Board*
3:45 p.m.	**Work Schedules and Sleep Patterns of Train and Engine Service Workers in Passenger Service** Judith Gertler, *QinetiQ North America, Inc.*
4:15 p.m.	**New Hours-of-Service Regulations for Commuter Rail Employees** Thomas Raslear, *Federal Railroad Administration*
4:45 p.m.	**Wrap-Up and Identification of Research Topics for Next Day**
5:00–6:00 p.m.	*Reception*

THURSDAY, OCTOBER 13, 2011

Breakout sessions in Keck 100, 101, and 206

8:00–9:00 a.m.	*Breakfast*
9:00 a.m.–noon	**Development of Research Problem Statements**
Noon	*Meeting adjourns*
Noon–1:30 p.m.	**Planning Committee Meeting** *(members only)*

APPENDIX B
Participants

Tony Abdallah, *New York City Transit*

Albert Alvarez, *Federal Motor Carrier Safety Administration*

Thomas Balkin, *Walter Reed Army Institute of Research*

Michael Belzer, *Wayne State University*

James Bradford, *Connecticut Transit*

Kirsten Brownstein, *Transport Workers Union, American Federation of Labor Congress of Industrial Organizations*

Roy Wei-Shun Chen, *Federal Transit Administration*

Dennis Collins, *National Transportation Safety Board*

Grady Cothen, *self-employed*

James Dougherty, *Washington Metropolitan Area Transit Authority*

Brian Dwyer, *Massachusetts Bay Transportation Authority*

Lawrence Fleischer, *Burlington Northern Santa Fe Railway*

Judith Gertler, *QinetiQ North America*

Michael Glikin, *New York City Transit*

Edward Grandi, *American Sleep Apnea Association*

Theresa Hallquist, *Federal Motor Carrier Safety Administration*

Bruce Hamilton, *Amalgamated Transit Union, Greyhound*

Larry Hanley, *Amalgamated Transit Union*

Jeffrey Hickman, *Virginia Tech Transportation Institute*

Brenda Himrich, *Metro Transit (Minnesota)*

PARTICIPANTS

Heidi Howarth, *Volpe National Transportation Systems Center*

Mark Johnson, *Transport Workers Union*

André Jones, Sr., *Transport Workers Union of America, Local 234*

Albert Kaye, *Fulcrum Corporation*

Jackie Keenan, *Union Pacific Railroad*

Stephen Klejst, *National Transportation Safety Board*

Ronald Knipling, *Safety for the Long Haul*

Vijay Kohli, *Fulcrum Corporation*

Rafael Marshall, *National Transportation Safety Board*

Levern McElveen, *Federal Transit Administration*

David Money, *Liberty Mutual Group*

Rick Narvell, *National Transportation Safety Board*

Karen Philbrick, *Mineta Transportation Institute*

Jana Price, *National Transportation Safety Board*

Thomas Raslear, *Federal Railroad Administration*

Roger Rosa, *National Institute for Occupational Safety and Health*

Jennifer Rosales, *Transportation Research Board*

Mark Rosekind, *National Transportation Safety Board*

Jeffrey M. Rosenberg, *Amalgamated Transit Union*

Thobias Sando, *University of North Florida*

Robert E. Skinner, Jr., *Transportation Research Board*

Alan Smith, *Greyhound Lines, Inc.*

Gwen Chisholm Smith, *Transportation Research Board*

James Stem, *United Transportation Union*

Pierre Thiffault, *Transport Canada*

Katherine Turnbull, *Texas A&M Transportation Institute*

Martin Walker, *Federal Motor Carrier Safety Administration*

Ed Watt, *Transport Workers Union*

Victor Wiley, *Florida Department of Transportation*

Patricia Willis, *CSX Transportation*

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