Transit Advisory Committee for Safety (TRACS) 14-02 Report

Establishing a Fatigue Management Program for the Bus and Rail Transit Industry

7/30/2015

Contents

Executive Summary

On October 28th and 29th, 2014, the Federal Transit Administration (FTA) Acting Administrator tasked the Transit Advisory Committee for Safety (TRACS) with developing recommendations for FTA on the elements that should comprise a Safety Management System (SMS) approach to a fatigue management program.

TRACS Representatives with backgrounds in state safety oversight agencies, state and local transportation agencies, labor unions, research organizations, and national transportation associations worked together to create recommendations for FTA to manage transit worker fatigue and prevent fatigue-related incidents. These recommendations address each aspect of the SMS approach, including policy, risk management, safety promotion, and safety assurance. The report begins by introducing the issue of transit worker fatigue, the aspects of a fatigue risk management system, and the SMS approach and its connections to this report. It then presents TRACS' recommendations regarding the components of a successful fatigue management program, including hours of service (HOS), shift scheduling, fatigue prevention and awareness training, fitness-for-duty medical evaluations and screenings, work and vehicle environment design, safety culture, incident investigation, and data collection. Each section includes an introduction, a description of recommendations, and a table analyzing how the section relates to each SMS pillar. Some sections also include a list of relevant definitions.

TRACS denotes its strongest recommendations with suggestions that FTA require transit agencies to conduct certain activities. For example, TRACS recommends that FTA develop a federal regulation mandating minimum HOS requirements that reflect National Sleep Foundation research stating that individuals need 7 to 9 hours of sleep to function properly.[1] The recommended regulation, including covered employees, an implementation plan, exemptions, and maximum on-duty hours, duty tour length, and consecutive working days, is discussed in detail in the HOS section. If FTA must prioritize the recommendations in this report, TRACS advises that FTA prioritize the federal regulation regarding HOS.

TRACS also recommends that FTA require transit agencies to:

- Provide mandatory fatigue awareness training for all safety-sensitive personnel and develop or adopt tools and resources to educate at-risk workers about frequently-occurring medical conditions that may result in worker fatigue;
- Mandate that safety-sensitive employees and applicants see a qualified medical health care provider to determine whether the employee is at risk for sleep disorders—including, at minimum, sleep apnea; that those found at risk see a specialist for further evaluation and therapy; and that safety-sensitive employees with confirmed sleep

[1] http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need.

disorders demonstrate compliance with the treatment plan at intervals of no more than 1 year; and
- Collect and track fatigue performance measures to evaluate the success of their fatigue risk management system (FRMS).

In addition to proposed requirements, TRACS also includes several recommendations that FTA develop and publicize best practices for transit agencies to manage transit worker fatigue and prevent fatigue-related incidents. Best practices discussed in this report include providing optional education/training for the families of safety-sensitive employees; preparing peer trainers to deliver training in tandem with subject matter experts; and enabling employees to meet with sleep professionals to identify personal strategies for addressing fatigue. FTA could advance these and other best practices by:

- Designing best practice programs for agencies to provide continued support for all employees at risk for, or confirmed with, sleep disorders beyond mandatory fatigue management training;
- Producing case studies and an FRMS guidebook that highlight best practices for developing safety cultures that facilitate fatigue management in large and small rail transit and bus agencies; and
- Developing best practices and protocol templates for investigating whether fatigue was a contributing factor in incidents or accidents and incorporating this fatigue assessment protocol into certification courses for accident investigation.

TRACS does not expect every transit agency to adopt all the best practices described in this report or in the materials FTA develops. Rather, transit agencies should conduct analyses to determine the best combination of effective risk control strategies to adopt initially and then phase in others as possible.

Finally, TRACS recommends that FTA conduct further research in several areas. These recommendations include:

- Studying the before and after effects of the HOS requirements and alternative policies;
- Determining how shift scheduling tools can be successfully used in transit settings;
- Researching national and international design standards for bus and rail operator compartment areas, identifying design elements that have been proven to reduce fatigue, coordinating with bus and rail car manufacturers to discuss incorporating these designs, and working with the American Public Transportation Association (APTA) to incorporate these designs into the Standard Bus Procurements Guidelines and Light Rail Vehicle Request for Proposals (RFP) Procurement Guidelines;
- Collecting and analyzing data from a spectrum of large and small rail transit and bus-only properties and conducting hazard analyses to determine precursors of fatigue-related incidents, including but not limited to the relationship between compensation

and accidents, the lack of recovery time at the end of a trip, the effects of lack of adequate bathroom and break facilities for operators, and the effects of operator cognitive overload;

- Piloting a program in which FTA measures the baseline fatigue-related incidents and behaviors regarding fatigue in a select number of agencies, these agencies then develop and implement a collaborative labor-management FRMS program, and FTA evaluates any changes in behaviors and fatigue-related incidents to determine which aspects of the FRMS programs were most successful; and
- Identifying which data collected during fatigue-related incident investigations to include in a national safety database as a source for national trend analysis.

Together, the recommendations in this report represent a comprehensive review of the strategies available to FTA and transit agencies to manage transit worker fatigue and prevent fatigue-related incidents. By following these recommendations, FTA can promote transit agencies' use of the SMS approach to address the serious challenges presented by fatigue in the transit industry, thereby ensuring safer conditions for both transit workers and passengers.

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FTA Administrator's Tasking 14-02 to TRACS

"Develop recommendations for Federal Transit Administration (FTA) on the key elements that should comprise a Safety Management System (SMS) approach to a fatigue management program. Identify the major organizational and behavioral challenges that may be faced in addressing transit employee fatigue, leveraging lessons learned from other modal organizations in implementing their strategies."

Issues to be considered include but are not limited to:

1. Recommend operational definitions and a methodology for assessing likelihood that fatigue was a contributing cause to accidents, incidents, and near-misses, understanding that economic and work organization factors may have a substantial contribution to fatigue.

2. Identify possible root causes and likely prevalence of fatigue within each mode of public transportation to properly understand the scope of the problem.

3. Review recent hours of service recommendations from the National Transportation Safety Board (NTSB) to recommend relevant safety measures and strategies for inclusion in guidance for rulemaking and development of fatigue risk management plans.

4. Recommend minimum performance-based safety standards for public transportation work schedules, including workload-induced fatigue, and staffing not already regulated by the Federal Railroad Administration (FRA), the Federal Motor Carrier Safety Administration (FMCSA), or the U.S. Coast Guard (USCG), drawn from best practices and safety standards developed by the public transportation industry.

5. Review available policies, training materials, and related tools for staff and managers on fatigue, assess its impact and applicability to the transit workforce and identify possible gaps in what is available, what is working, and what is needed. Consider scheduling policies and practices, awareness and education, organizational strategies, as well as vehicle and environmental strategies.

6. Identify and evaluate potential outreach and enforcement tools, including methods to encourage and optimize safety at the Transit agency level. Fatigue risk management and culture change should be priority considerations.

7. Define the role of a nonpunitive, close call reporting system or other safety reporting in baselining and monitoring fatigue-related safety performance in a risk-based safety management system.

Introduction

Definition and Background

Fatigue presents a complex challenge for bus and rail transit agencies. Due to its many environmental, personal, physical, and psychological components, the nature of fatigue itself is subject to debate. For the purpose of this report, the TRACS operational definition of fatigue is "a physical and/or mental state resulting from prolonged physical and/or mental exertion or insufficient quantity and/or quality of sleep or rest in which an individual's motor skills, coordination, mood, reasoning, and/or reaction are degraded from their normal function and execution."

All modes of public transportation must address the effects of fatigue on safety. Despite well-documented incidents of fatigue noted among transportation operators, fatigue risk in the transportation sector remains a significant challenge.[2] Not surprisingly, several decades of research have consistently found that unmitigated fatigue negatively impacts alertness, attention, reaction time, emotions, judgment, decision-making, and a variety of other cognitive processes.[3]As stated in Transport Canada's report Fatigue Management Plans: Requirements and Assessment Guidelines, "There is no doubt that fatigue has a detrimental impact on human performance and safety."[4] Fatigue of operators and other employees responsible for the movement of vehicles poses especially significant safety risks because even a momentary lapse of situational awareness or slightly slowed reaction time at the wrong moment can cause fatal accidents. Whether acute or chronic, unmitigated fatigue impinges upon a transit operator's ability to selectively attend to changing cognitive landscapes throughout the work period, potentially compromising an operator's ability to make real-time safety decisions and appropriately execute related safety-critical tasks.

Many bus and rail transit accidents and near-misses stem from fatigue. According to a 2012 National Sleep Foundation (NSF) poll, 10 percent of bus drivers and 26 percent of passenger and freight train operators say sleepiness impacts their job performance at least once a week.[5] Over the course of their careers, fatigue has caused 12 percent of bus drivers and 18 percent of train operators to experience a "near miss" at work and 7 percent of bus drivers and 9 percent of train operators to make a serious error. While there is no national data on the percentage of bus and rail transit accidents caused by fatigue, a 1995 NTSB report showed that fatigue played a significant role in 31 percent of commercial vehicle crashes.[6] Train operators and bus drivers experience similar levels of near misses and serious errors at work due to fatigue, which suggests that fatigue likely causes or contributes to about a third of bus and rail transit accidents.[7]

Identifying the causes of fatigue and strategies to address them has important safety implications for U.S. bus and rail transit agencies. By implementing a collection of policies,

[2] Commercial Transportation Operator Fatigue Management Reference, 2003.
[3] Folkard & Monk, 1979; Costa, 1991; Wright & Czeisler, 2001; Popkin, Howarth & Morrow, 2010; Lim & Dinges, 2010.
[4] Transport Canada, Fatigue Management Plans: Requirements and Assessment Guidelines, September 1, 2010, Rev. March 1, 2011, p. 4.
[5] NSF, Planes, Trains, Automobiles and Sleep. 2012. p. 64.
[6] NTSB, Factors that Affect Fatigue in Heavy Truck Accidents, Volume 2: Case Summaries, January 1995, p. v.
[7] NSF, Planes, Trains, Automobiles and Sleep. 2012. p. 64.

training tools, and communications, safety assurance, and hazard identification strategies as part of a fatigue management program organized around safety-culture change, these agencies could likely reduce the number of bus and rail transit accidents each year.

Causes of Fatigue in Public Transportation

Multiple factors contribute to the development of fatigue. These include:

- A transit worker's sleep/wake history;
- The time of day and length of time a transit worker has slept in the preceding days;
- Circadian rhythms, which influence fluctuating periods of alertness and fatigue across the 24-hour day, as shown in Figure 1;
- Task-related factors, such as low and high task work environments and monotonous off-peak and high stress peak commute work activities;
- Environmental factors, such as temperature and humidity;
- Personal characteristics including age and physical health;
- Behavioral patterns of transit workers (leisure activities, family patterns, secondary jobs/businesses, habits).

For instance, long commutes, which are monotonous and decrease the time available for sleep, as well as early morning shifts, which fall during a circadian dip in alertness, are associated with shortened sleep and excessive daytime sleepiness and fatigue.[8] Increased stress can also lead to difficulty obtaining adequate levels of sleep.

[8] 2000 Census Data.

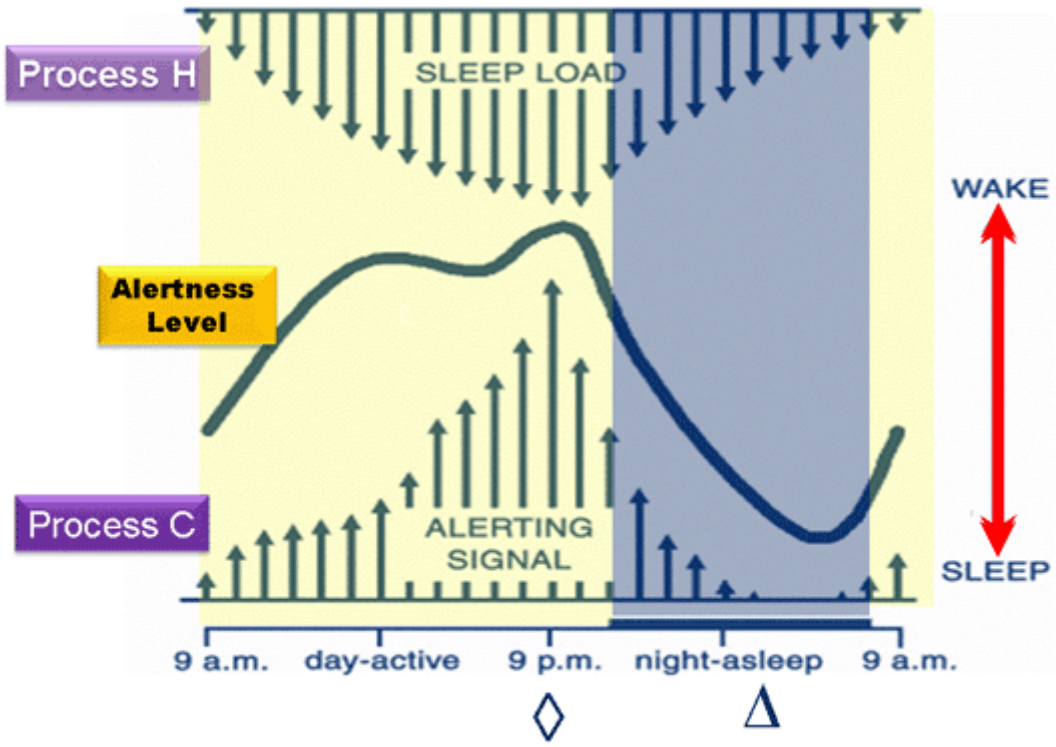

Figure 1. "A schematic representation of the 'opponent process' model. The model consists of the alternation of wakefulness and sleep which results from the interaction of two processes, homeostatic (H) and circadian (C)." *(Source: Medscape, Expert Column: Etiology and Prevalence of Sleep/Wake Cycle Disorders)*

Most adults age 26 to 64 need 7 to 9 hours of sleep every day to perform optimally and better manage their health, while those 65 and over need 7 to 8 hours.[9] However, a variety of factors can prevent someone from sleeping an adequate number of hours, even when he or she has sufficient time to do so. In the bus and rail transit industry, for instance, workers often work shifts at irregular times, such as late at night or early in the morning. Although many agencies require a minimum of 8 to 12 hours off between shifts to allow adequate time for sleep, circadian rhythms, obstructive sleep apnea (OSA), and other environmental, physiological, and behavioral factors can make it difficult for workers to fall asleep between 8 AM and noon and between 5 PM and 9 PM, interfering with their ability to achieve 7 to 9 hours of sleep.[10]

While transit agencies can provide input into shift scheduling and hours-of-service regulations, transit workers experience fatigue due to many factors other than hours spent sleeping or at work. The following section describes the way in which fatigue risk management systems seek to address these other factors.

[9] http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need.
[10] Figure 1, Medscape, Expert Column: Etiology and Prevalence of Sleep/Wake Cycle Disorders.

Aspects of a Fatigue Risk Management System

A Fatigue Risk Management System (FRMS) has been defined by the International Civil Aviation Organization (ICAO) as *"a data-driven means of continuously monitoring and maintaining fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness".*[11] A successful FRMS is:

Science based	Supported by established peer-reviewed science
Data driven	Decisions based on collection and objective analysis of data
Cooperative	Designed together by all stakeholders
Fully implemented	Systemwide use of tools, systems, policies, procedures
Integrated	Built into corporate safety and health management systems
Continuously improved	Progressively reduces risk using feedback, evaluation, and modification
Owned[12]	Responsibility accepted by senior corporate leadership

FRMS is broader and more flexible than hours-of-service regulations alone, consisting of many policies and means to address the multiple components of, and contributors to, fatigue. These tools can be continuously improved and adapted within the local context. The American College of Occupational and Environmental Medicine (ACOEM) recommends "five defenses" against fatigue as part of any FRMS.[13] The risk control strategies recommended by the Committee in this letter report are structured according to the ACOEM framework:

1. Balance between workload and staffing;
2. Shift scheduling;
3. Employee fatigue training and sleep disorder management, including considerations of medications and psychological problems that may contribute to inadequate sleep;
4. Workplace environment design; and
5. Individual fatigue monitoring and mitigation.

[11] http://www.skybrary.aero/index.php/File:FRMS.png.
[12] Evolution of Fatigue Risk Management Systems: The "Tipping Point" of Employee Fatigue Mitigation, Martin Moore-Ede, M.D., Ph.D., Circadian White Paper.
[13] ACOEM Guidance Statement, Fatigue Risk Management in the Workplace, Journal of Occupational and Environmental Medicine (JOEM), Volume 54, Number 2, February 2012, p. 236.

Each of these strategies defends against different and overlapping causes of fatigue. Workload staffing balance, for instance, helps address last-minute schedule changes without requiring employees to report early, stay late, and work extra shifts and overtime, all of which could prevent employees from obtaining adequate sleep.

Other than ensuring adequate staff to cover last-minute scheduling changes, agencies can use hours of service (HOS) policies and shift scheduling to address the following scheduling-related causes of fatigue:

- Inadequate time between shifts to allow for sleeping, commuting, eating, etc.;
- Excessive shift length;
- Employees consistently working at night and not maximizing daytime sleep;
- Shift rotation preventing transit workers from adjusting to a wake-sleep cycle routine;
- Dual employment resulting in work when the person should be sleeping; and
- Personnel working excessive consecutive days.

Competency-based employee fatigue training and tools teach scheduling managers the need to allow for adequate sleep by accounting for commute time and other personal needs between shifts. Training and tools also help employees learn the importance of obtaining adequate sleep between shifts by working with their families to better manage family schedules to support shift work recovery time, controlling their sleep environment, eating well and exercising, and securing testing for sleep disorders.

Adjusting work-environment design can ensure that work and vehicle temperature, humidity, vibration, and sound either do not induce fatigue, or do so to a lesser degree. This aspect of an FRMS also involves providing work breaks and making provisions so that employees can secure rest during off-duty time in split shifts. Modifying the work and vehicle environment design can also address several physical and stress-related contributors to transit operator fatigue by, for instance, reducing the force needed to operate the brakes or steering and/or by protecting the operator from assault.

Finally, agencies can ensure that coworkers and supervisors understand the signs of excess fatigue and have the skills to tactfully discuss observations with potentially fatigued employees or implement other actions to combat fatigue. While this tactic will not work in all instances, as fatigued individuals may seek to appear alert when in the presence of supervisors or peers, it is useful as a last line of defense. Individual fatigue monitoring and mitigation also require agencies to create a nonpunitive safety culture that leads to a change in the operators' and management's behavior, thereby supporting transit workers who report they are unable to complete their shifts due to fatigue. For this change to occur, an agency must adopt the appropriate communications and feedback processes to allow such a safety culture of trust to develop.

Applying Safety Management System Principles to Fatigue Management Programs

Safety Management Systems (SMS) are collections of policies, processes, and communications that ensure a formalized, proactive approach to safety risk management.[14] An FRMS is one example of an SMS. SMS principles emphasize the need for leadership and organizational culture to effectively implement and continuously improve safety policies, rules, and processes.

SMS includes four main pillars: SMS policies and procedures, risk management, safety assurance, and safety promotion. These pillars are described in further detail in Figure 2.

The Safety Management Maturity Model describes the process through which an SMS matures as an agency, tailors it to the complexity of the local environment, and iteratively improves it through the learning and implementation process. This model addresses the reality that implementing safety tactics like fatigue management programs requires sustained systemic change. The five levels of maturity are shown in Figure 3. They are:

1. **Reactive Response**: Safety processes are undocumented and undergo dynamic change in reaction to accidents or near-misses;
2. **Regulatory Compliance**: Agencies implement repeatable safety processes but adhere to them due to outside demands rather than internal goals;
3. **Hazard Analysis Program**: Safety policies and processes are defined, documented, and tracked for improvement over time. The organization also uses a standard process to identify and understand hazards across the agency and devotes time and resources to reviewing and correcting safety issues;
4. **Management Accountability Systems**: Organizations use a risk-based approach to manage hazards and monitor safety performance and accountability and enforce regulations and policies; and
5. **Safety Culture in Action**: Agencies integrate safety as a core value and strategic business driver, involve every employee in achieving safety, and aim to continually improve safety performance.

When implementing fatigue management programs, agencies typically progress from lower to higher stages of development. In the following section, each potential component of a fatigue management program will be evaluated through the SMS framework. Discussing the strategies in the context of the four SMS pillars and the Safety Management Maturity Model will guide considerations of the tools' effectiveness at managing transit worker fatigue and the stage at which a policy or tool may be best implemented in an agency's fatigue management program.

[14] TRACS 10-01 Report: Implementing Safety Management System Principles in Transit Agencies.

Figure 2. The Four Pillars of Safety Management Systems (SMS). *(Source: TRACS 12-02 Report, pp. i, 12)*

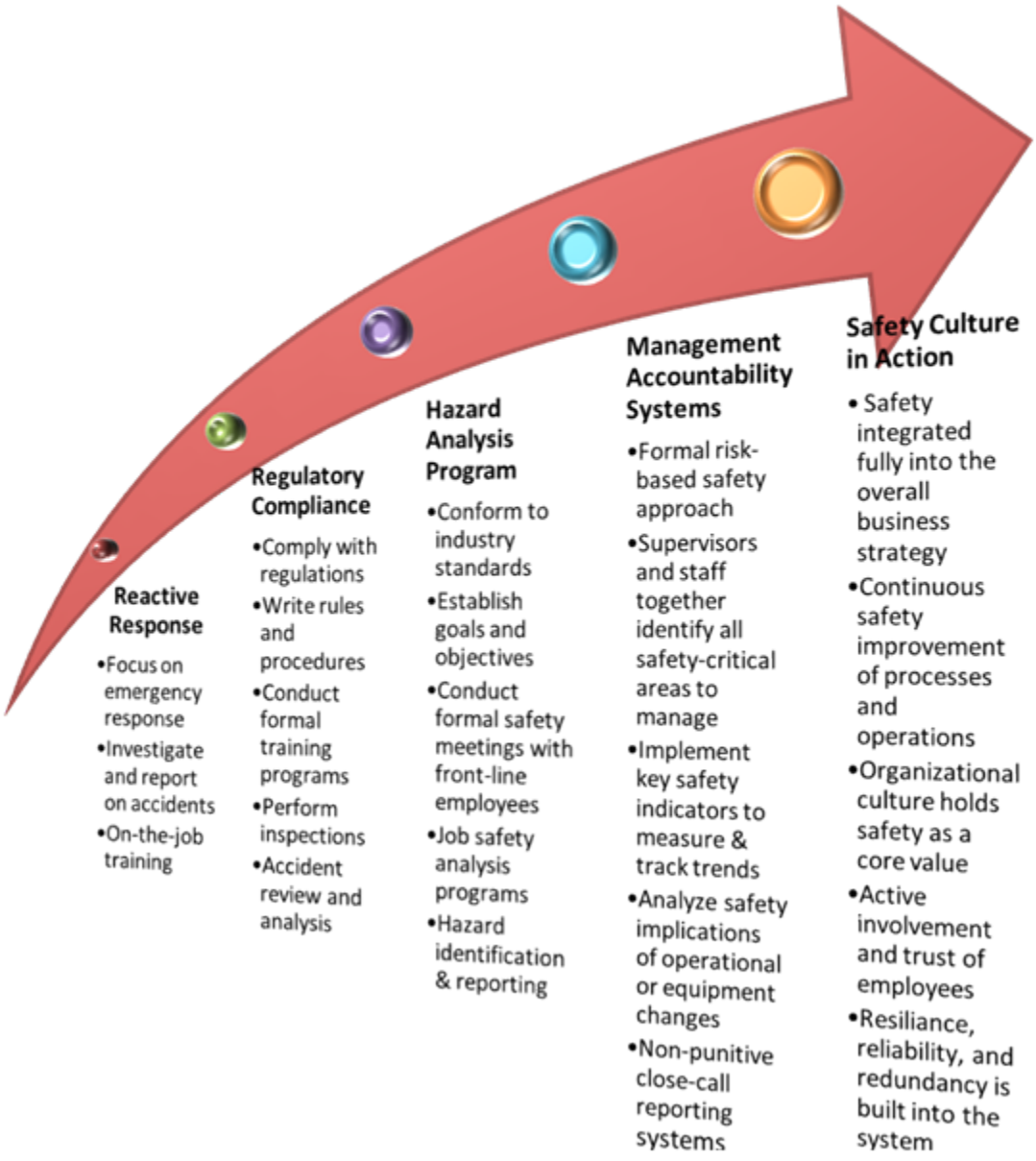

Figure 3. Safety Management Maturity Model[15]

[15] TRACS 10-01 Report, p. 13, Adapted from the APTA Safety Management Maturity Model.

Components of a Successful Fatigue Management Program

Scheduling Policies and Practices and Balance between Workload and Staffing

Hours of Service (HOS)

Hours-of-service (HOS) rulemaking and fatigue risk management more broadly have received increased attention by U.S. Department of Transportation (DOT) agencies since the 1980s. During this period, transit operations have also strived to meet an increasing demand for safe, accessible public transportation. Yet, inherently demanding transit operator schedules can, at times, place undue strain on managing transit operator fatigue. The problem is further complicated by complex issues affecting operations, earnings, health and well-being, and how people spend their time off. Schedules and related HOS regulations provide a key component in the context of a broader fatigue risk-management framework.

HOS rulemaking considerations face an ongoing tension between achieving optimal safety and meeting desired service goals as well as a broad range of employee preferences. No HOS policy is likely to fully eliminate demanding schedules at all times, but a well-crafted HOS strategy could help reduce the degree to which a schedule impedes an operator's alertness across the work period, as well as during the commute to and from work. HOS rules would *better distribute* risk in a way that lower levels of fatigue risk are spread more equitably across employees. This will significantly reduce risk among those employees facing the most challenging schedules, either on paper or in practice, through excessive unscheduled overtime or constantly rotating shifts. Such considerations further suggest the importance of a collaborative change-management process accompanying HOS discussions, as labor/management understanding, consensus, and buy-in foster sustainable safety gains.

It is important to establish performance outcomes for any hours of service changes to operations. Ideally, these would extend beyond baseline and single post-implementation assessment to include ongoing evaluation using predictive analytics as new data is continually captured. Integration with close-call programs such as those used in the aviation and railroad industries, for example, could provide further opportunities for evaluation and modification over time.

The implementation of recommended changes is important to consider. For example, if a 30-minute rest period were integrated into a work schedule specifically to encourage napping/resting, the extent to which one's environment supported such efforts could significantly impact effectiveness. Factors specific to the organization, environment, and individual employees can be effectively included in HOS discussions and policy formulation. The more transparent the variables and decision points are, the greater the likelihood of a successful HOS initiative.

Indeed, any HOS considerations require a well-informed balancing of not only safety concerns but also operational, financial, legal, individual, and cultural issues impacted by change. Variables such as size and scope of operation, staffing levels, impacted crafts, collective

bargaining agreements, seasonal changes, environmental conditions, and other human and operational factors can impact HOS considerations:[16]

Recommendations

- **Federal regulation based on fatigue science:** FTA should develop a scientifically based federal regulation mandating minimum HOS requirements[17] based upon circadian rhythms and human sleep and rest requirements, such as those that reflect National Sleep Foundation research, which states that individuals need 7 to 9 hours of sleep to function properly.[18] The minimum HOS requirements should also take into account the need for social interaction, commute time, and time to prepare for sleep and work in order to establish predictable work and rest schedules.

- **The TRACS Committee feels strongly that HOS is a fundamental, initial pillar of an SMS framework and should be implemented by FTA as soon as possible. (See TRACS draft Recommended Safety Standard for Hours of Service in Appendix A.)**

- **Covered employees:** The regulation should initially apply to employees that are involved with moving revenue and maintenance equipment, including bus and rail operators, dispatchers, conductors, and controllers.

- **Maximum on-duty hours and minimum off-duty hours:** FTA should implement a regulation that sets a maximum of 12 on-duty hours over a maximum duty tour of 14 hours, including any period(s) of interim release, with a minimum of 10 consecutive hours off-duty between shifts. While agencies must not exceed these maximum and minimum limits, they should consider providing additional off-duty time and ensure that shift schedules allow for 7-9 hours of sleep between shifts while also accommodating time spent commuting and preparing for sleep and work. Agencies should provide an environment conducive to napping during interim off-duty time or shorten the maximum duty tour to 12 hours. These requirements apply to every service day, which is defined by the 24-hour period starting when a shift begins, regardless of whether the shift goes beyond a calendar day.

- **Consecutive days:** FTA should set a maximum of 6 consecutive working days. Bus and rail transit agencies, in collaboration with employees and their representatives, should apply a fatigue risk management system approach to select and implement patterns of work duty and off-duty periods that best minimize fatigue while meeting operational requirements. Agencies should also establish rules, protections, and reporting policies for emergency situations that may necessitate waivers of these recommendations. This

[16] See DOT Safety Council Work Product: Current and Next Generation Fatigue Models (October 2014, DOT-VNTSC-OST-14-01, Authors: Lehrer & Popkin) for a systems-based model of fatigue inputs integrating scheduling with other system variables.
[17] This recommendation concurs with the National Transportation Safety Board's Safety Recommendation R-15-019 issued after the investigation of the March 24, 2014 Chicago Transit Authority Accident at O'Hare Station. See Appendix C for a list of all fatigue-related recommendations related to the March 24th accident.
[18] http://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need.

requirement would help prevent fatigue from accumulating over an extended period of consecutive work days.

The TRACS Committee also gave significant consideration to the issue of whether or not FTA should require a maximum number of on-duty hours over the 6 consecutive working days, and if so what that number should be. The discussion was extensive and included consideration of many benefits and drawbacks to regulating this aspect of an HOS Policy.

In response to the workgroup's request, the Volpe Center fatigue experts assisting the workgroup offered the following rationale for a 60-hour maximum in 6 days: The rationale for the 60 on-duty hour maximum is that both physiological and sociological recovery needs to take place. A 10h on average work day allows for 7 hours of sleep, 2 hour commute and 5 hours of social interaction (eating, showering, family time, etc.), which is the minimum necessary to keep from building up a sleep deficit. The goal is to keep from going into deficit mode. Having one day off a week also helps, especially with social recovery.

Clearly, establishing a maximum number of hours over 6 consecutive working days will ensure that employees have sufficient time to obtain rest, sleep, and eat meals as well as have time to engage in family and social interactions and other personal activities without impinging on sleep time.

Safety concerns were expressed about implementing a 60-hour maximum over 6 days. Larger agencies will likely have to hire and train new and part-time employees in order to achieve the staffing levels necessary to operate under a maximum hours regulation. One transit agency expressed concern that large numbers of inexperienced employees would pose a safety hazard and that agencies that do not increase staffing levels sufficiently will require overtime from employees who would not otherwise seek it.

During consideration of the issue of HOS in general, and the specific discussion of maximum hours over the 6-day period, TRACS members agreed that occupational research indicates that the rate of on-the-job injuries increases as the number of hours worked increases to 12 hours or more.

> "After adjusting for those factors, working in jobs with overtime schedules was associated with a 61 percent higher injury hazard rate compared to jobs without overtime. Working at least 12 hours per day was associated with a 37 percent increased hazard rate and working at least 60 hours per week was associated with a 23 percent increased hazard rate. A strong dose-response effect was observed, with the injury rate (per 100 accumulated worker-years in a particular schedule) increasing in correspondence to the number of hours per day (or per week) in the workers' customary schedule."[19]

19 The Impact of Overtime and Long Work Hours on Occupational Injuries and Illnesses: New Evidence from the United States. AE Dembe, J B Erickson, R G Delbos, S M Banks. Occup Environ Med 2005;62:9 588-597.

Discussions also included anecdotal evidence from one transit agency that implemented a 60-hour maximum. Despite initial operator resistance to give up overtime, employees have now embraced the limitations and cite an overall increase in quality of life.

Consideration was given to whether 60 hours was an appropriate maximum requirement. While the Committee is recommending a maximum of 12 on-duty hours a day, many Committee members felt that 72 hours (12-hour maximum per day over 6 days) was too many hours for an employee to safely work over 6 days. Some workgroup members pointed out that even this analysis was conservative, and did not consider commonly occurring factors such as nightshifts, circadian rhythm disruption, and critical individual differences. Adding just individual differences for needed sleep, the rationale would mean a 10-hour on average work day, which allows for 9 hours of sleep, a 2-hour commute, and 3 hours of social interaction (eating, showering, family time, etc.). A not uncommon 3-hour commute would mean a 10-hour on average work day, which allows for 9 hours of sleep, a 3-hour commute, and 2 hours of social interaction (eating, showering, family time, etc.). Without the 60-hour maximum requirement, the limit would be 72 hours, and could result in all-night duty-tours of 14 hours, with 12 hours on-duty each duty-tour. With a 2-hour commute there isn't even time for 9 hours of sleep.

The 60-hour limit was originally based on a survey of HOS requirements for other modes (e.g., FMCSA). The TRACS Committee generally agreed that comparison to other modes was not necessarily equivalent, and some members felt the research did not yet support 60 hours, or any particular maximum number of hours, over the 6 consecutive days.

While Committee members agreed on the general concept of decreasing safety as work hours increase, and reached consensus on the issue of limiting to 6 the number of consecutive work days, the Committee did not reach consensus on the issue of including a maximum number of hours over 6 days in the HOS Safety Standard.

Despite the lack of consensus, many members of the Committee advocate that FTA should conduct the necessary research to establish an appropriate required maximum number of hours and include such a requirement in the Hours of Service regulation. Implementation of HOS requirements, as reflected in the proposed safety standard in Appendix A, **should not**, however, be delayed to complete this research. It was agreed that the maximum number of hours over 6 consecutive days must be a requirement because agencies are unlikely to adopt it as a recommendation or best practice.

Recommendations

In conducting this research, the FTA should consider, at a minimum, the following:

- Evaluating the fatigue factors that are specific to the transit industry as well as general fatigue factors;
- Evaluating the economic relationships between overtime, fatigue, and risk;

- Assessing realistically the sleep individuals need, including a reasonable inclusion of individual differences. For example, only accounting for 7 hours of sleep in a requirement would leave out most individuals; i.e., those needing 8 or 9 hours according to the fatigue research;
- Evaluating the time requirements for commute times, social, and familial needs, night shifts, and circadian rhythm factors;
- Evaluating actual hours of "seat or drive" time (the hours when an employee is physically operating the revenue or maintenance vehicle) in more depth beyond evaluating schedules alone through measuring bus movements and individual driving requirements; and
- Determining the differences between urban and rural transit environments, and large and small transit agencies, and how these differences impact fatigue.

- **Implementation plan:** After an initial implementation phase, the effectiveness of the regulation should be reviewed. If deemed effective, the HOS regulation may be extended to other safety-sensitive employees, including track maintenance employees, right-of-way and signal inspectors, and supervisors. The HOS regulation may be modified or adapted based on the specific requirements or safety impact of a particular role. FTA should set a 5-year implementation period for the initial phase to enable transit agencies and their unions to revise labor agreements to meet the HOS regulation. Oversight agencies will have the responsibility for developing an implementation plan for their state and setting maximum times for phasing in the policy. The oversight agencies will monitor their state's transit agencies for compliance. The 5-year implementation period will also allow FTA to prepare to review and evaluate agencies' FRMS. TRACS has previously stated that States are allowed to adopt regulations where FTA has not and are allowed to adopt more strict regulations where FTA has adopted regulations provided that the state has recognized and documented due process procedures for rule promulgation and that it is possible to comply with both federal and state regulations at the same time.[20] FTA should evaluate the initial 5-year phase to inform further expansion of the program.

- **Exemptions:** After implementing the HOS requirements, FTA should allow transit agencies to apply for exemption from these HOS requirements if they conduct fatigue analyses to demonstrate that their HOS policies, developed through a management-labor partnership, reflect current scientific research on fatigue and scheduling in the transit industry. Affected labor organizations and state safety oversight agencies must be allowed input into the exemption process and such input must be weighed by FTA in consideration of an agency's application for exemption. FTA needs to develop a process for exemptions and determine the fatigue analyses necessary to secure an exemption, as well as for agencies to collect data they can use in an exemption process. FTA should review and approve any exemptions and share the results with all transit agencies for their use. Exemptions granted should be temporary in nature, for a specific period of

[20] TRACS 10-02 Report: Characteristics of an Ideal State Safety Oversight Organization.

time, after which the agency should be required to reapply for a renewal of the exemption.

Extreme Circumstances: TRACS recommends that the regulation allow the Agency, in good faith, to temporarily suspend HOS requirements for the safety and/or protection of its employees and/or the public under extreme circumstances. Extreme circumstances affecting the safety and/or protection of employees and the public may warrant temporary suspension of HOS requirements. Transit Agencies shall include provisions in their HOS policies that address the type and degree of extreme circumstances during which an exception to the HOS requirement may be made. The Agency shall define how such situations will be identified, by whom, and what level of exception will be made. The FTA and oversight agency retain enforcement authority for misuse of this provision.

- **Evaluations:** FTA and/or transit agencies should study the before-and-after effects of the HOS requirements and alternative policies.

HOS Definitions

Duty Tour: *The elapsed period from the time the employee initially reports for work to the time the employee is finally released from duty. The duty tour may include one or more interim periods of release.*

Off-Duty Time: *Time during which an employee is free to leave the workplace, commute between work and home, engage in personal activities, and obtain rest. Off-duty time includes interim periods of release of one hour or greater, mandatory off-duty periods, days off, vacation days, and other periods not defined as "on-duty time."*

On-Duty Time: *Time actually spent in the service of the transportation agency, whether or not compensated, including time performing safety-critical tasks and other tasks, time "standing by" to perform duties when instructed, and work breaks or interim periods of less than one hour. On-duty time can include drive or seat time as well as in station time, breaks between runs, and other incidental tasks and duties. On-duty time does not include any interim period of release of one hour or greater. On-duty time includes time spent in transportation to and from a work location, but does not include travel time to/from home to work or work to home. On-duty time includes time devoted to training.*

Connection to SMS Pillars

SMS Pillar	HOS
Safety Policies and Procedures	Develop HOS policies.
Safety Risk Management	The HOS-related root causes of fatigue are HOS policies that do not provide employees with adequate time to consistently obtain a sufficient number of hours of sleep every service day and to recover from consecutive work days with a day off.
Safety Assurance	FTA will adopt a regulation, and oversight agencies will monitor their state's transit agencies for compliance and reporting.
Safety Promotion	Labor/management collaborative revision of labor agreements to enable the agency to implement the HOS regulation described in this section.

Shift Scheduling

Shift scheduling is an essential part of managing fatigue, and a scientific approach to scheduling shifts should incorporate circadian sleep science. Fatigue training for shift schedulers is critical and the use of scheduling planning and analysis tools can allow for decisions based on objective data analysis.

It is essential that employees who create work schedules understand the many factors that impact fatigue and the best ways to mitigate the impacts of those factors when creating work schedules. Schedulers must understand the underlying issues of fatigue science, including sleep and rest requirements, the impacts of circadian rhythms and predictable work and rest periods. Schedules must also be written so as to allow a reasonable balance between time on task and breaks for recovery, food, and bathroom use. Training in these fundamental principles will give work schedulers the foundation they need to create schedules that will minimize the fatigue risk factors under the control of the Agency.

Current work scheduling planning and analysis tools offer important insights and have the potential to decrease fatigue as a component of an overall comprehensive fatigue risk management system. If interpreted properly, and as a part of a comprehensive system, planning and analysis tools can be used to:

- Evaluate and assist in planning work schedules;
- Support hours of service regulations;
- Assess risk of fatigue associated with various work shifts at the group level;

- Predict changes in performance based on schedules and other variables;
- Make overtime work shift decisions;
- Provide employee schedule history to assist in accident investigations.

While scheduling tools can be adapted to the specific circumstances of a work shift, many tools do not account for individual differences or differentiate between chronic or task-specific fatigue risk or psychological and social factors which can influence sleep/wake behavior. The broader range of personal and organizational fatigue risk factors (see Appendix F) can serve as a complement to the key defenses of an FRMS identified in the Guidance Statement (Volume 54, Number 2, dated February 2012) published by ACOEM.[21]

Many current tools,[22] including biomathematical models such as the Fatigue Audit InterDyne (FAID) fatigue assessment and Fatigue Avoidance Scheduling Tool (FAST), aim to predict fatigue based on the underlying physiology of fatigue and related effects on human performance. Inputs typically rely on time of day, sleep history, and workload, and may include electroencephalography (EEG) recordings, paper schedules, work-rest and sleep-wake logs, and time clocks. Though elements of actionable output emerge from such tools, no one model optimally captures risk.

Training and education are imperative to ensure that tools are used and interpreted properly to provide management and labor with actionable data, further strengthening rapport through collaborative problem solving.

Recommendations

TRACS recommends that FTA determine the appropriate training for work schedulers and require transit agencies to provide the necessary training to their work schedulers.[23] TRACS also recommends that FTA fund further research, including independent validation efforts, to determine how shift scheduling tools can be successfully used in transit settings.[24] While transit agencies have extensive experience with shift scheduling, an independent analysis and recommendation can help facilitate mediations between labor and management and achieve a resulting policy that minimizes fatigue. Upon completion of this research, FTA should revisit this recommendation as to implementation of such a policy.

For more information about shift scheduling planning and analysis tools, please see Appendix B.

[21] ACOEM Guidance Statement, Fatigue Risk Management in the Workplace, Journal of Occupational and Environmental Medicine (JOEM), Volume 54, Number 2, February 2012.
[22] Text appears in DOT Safety Council Work Product: Current and Next Generation Fatigue Models (October 2014, DOT-VNTSC-OST-14-01, Authors: Lehrer & Popkin).
[23] These recommendation concur with the National Transportation Safety Board's Safety Recommendation R-15-020 and R-15-021 issued after the investigation of the March 24, 2014 Chicago Transit Authority Accident at O'Hare Station. See Appendix C for a list of all fatigue-related recommendations related to the March 24th accident.
[24] This recommendation supports the National Transportation Safety Board's Safety Recommendation R-15-018 issued after the investigation of the March 24, 2014 Chicago Transit Authority Accident at O'Hare Station. See Appendix C for a list of all fatigue-related recommendations related to the March 24th accident.

SMS Pillar	Shift Scheduling
Safety Policies and Procedures	Develop, justify, and understand the impacts of safety policies and procedures for: • Shift scheduling and extra board calling • Emergency work scheduling • Napping policies • Marking-off and bidding (accepting) schedules (management and labor negotiated rules)
Safety Risk Management	Hazard analysis What-if scenarios for optimizing opportunities for rest within an operational context Support development/implementation of a schema for data collection and accident trend analysis (for compliance check – see below) The shift scheduling-related root causes of fatigue include: • Night shifts for operators who do not maximize daytime sleep • Rotating shifts that prevent a regular sleep schedule • Dual employment that interferes with time for sleep (there have been cross-government efforts to develop a training/ credential program for schedulers and FTA should participate in these efforts)
Safety Assurance	Establish a procedure for assessing the effectiveness of work scheduling planning and analysis tools Determine that schedules are in compliance with parameters and rules set and agreed to Verify underlying scheduling rules match current science and understanding of fatigue manifestation Understand impact of FRMS changes and new hazard mitigations
Safety Promotion	Communications and educational tool for culture change Tailored feedback for particular workers to support their working shifts Labor participation is instrumental to the success of such tools and is important in acquiring workforce-specific characteristics of individual properties.

Employee Fatigue Training and Sleep Disorder Management

Fatigue Prevention and Awareness Training

Fatigue in the workplace is an unsafe condition that, like other risk factors, must be managed and mitigated. This is particularly important for transit workers who operate and maintain our nation's rail, transit, bus, and paratransit systems. Management of workplace fatigue requires an understanding of its root causes and the development of strategies and countermeasures to reduce and prevent fatigue. FTA should require all transit agencies to develop or adopt available educational and support tools and resources to educate at-risk workers about frequently occurring medical and other conditions that may result in worker fatigue. Agencies should include such training modules in new hire and recurrent worker safety training, as presented below.

Benefits of Training

Fatigue prevention and awareness training can improve employee and public well-being and safety and has the potential to reduce the cost of transit operations. Employee fatigue can manifest itself directly in operating costs due to lost productivity, increased absenteeism, greater turnover, reduced morale, accidents, and unnecessary wear and tear on equipment.

Who Should Receive Training?

Safety-sensitive personnel should receive mandatory fatigue awareness training that stresses the impact of fatigue on employee performance, safety, and well-being.

Recommendations

Examples of personnel who should receive mandatory education/training:

- Bus operators
- Train operators
- Conductors
- Tower operators
- Starters
- Inspectors
- Yard persons
- Shift schedulers (emergency and routine schedulers)
- Maintenance-of-way employees
- Signal and electric traction employees
- Mechanical department employees
- Dispatchers
- Supervisors

Examples of groups who could benefit from optional education/training:

- Spouse/partner
    - Family/social life segment
- Children

- A take-home activity/training module is recommended for children (e.g., coloring book activity that provides a message)

When Should Training be Provided?

Recommended training schedule:

- At date of hire
- When applicable regulations or policies change
- At targeted intervals TBD by individual property, periodic refreshers (target: 1 to 3 years), supplemented by:
  - Periodic newsletters/pamphlets/A-V materials
  - Blogs and social media

Fatigue Countermeasure Program: Resources for Consideration

If possible, a qualified individual on the property could deliver training in tandem with a subject matter expert who has successfully delivered fatigue risk management training to relevant audiences such as transit operators. A trained and qualified peer trainer could further help as a means to establish credibility with the message and facilitate buy-in by rank and file employees. Agencies could provide "train the trainer" sessions to enable peer training. If that type of face-to-face training can't be accommodated, multimedia resources can work. Resources for consideration and use as a best practice are listed alphabetically in Appendix D.

Connection to SMS Pillars

Effective fatigue prevention and awareness training strategies must be scalable and sufficiently flexible for adoption by transit operations of various sizes and complexities. However, regardless of scalability, fatigue management training strategies will share common traits and adherence to the four pillars of Safety Management Systems (SMS).

SMS Pillar	Employee Fatigue Training and Sleep Disorder Management
Safety Policies and Procedures	Develop policies related to implementing competency-based employee training about fatigue, and train employees about fatigue-related policies.
Safety Risk Management	Understand the root causes of fatigue, both internal and external, and develop training programs to raise awareness and mitigate/manage the risks.
Safety Assurance	Develop training objectives and standardized training modules/materials. Develop metrics for measuring the effectiveness of training and outcomes and for identifying necessary training program improvements. Utilize “peer” instructors who have been trained in the principles of adult learning and adult teaching techniques.
Safety Promotion	Labor/management cooperation and collaboration must be the cornerstone of a fatigue mitigation and training program. Top-down support and buy-in for the program must come from the leadership of both labor and management.

Fitness-for-Duty Medical Evaluations and Screenings

Fitness-for-duty screening is used to determine an employee's ability to perform their job in a way that maintains the safety and health of the employee, coworkers, agency property, and the public at large. For the purpose of this report, fitness for duty refers only to screening for sleep disorders—at minimum, for obstructive sleep apnea (OSA), because of its prevalence in the general population and among transportation workers. OSA is characterized by a blocked or partially blocked airway passage during sleep. In affected individuals, breathing stops (or is restricted) and restarts dozens, even hundreds, of times during each sleep period. Even though most people with OSA do not remember waking repeatedly, it is extremely disrupting and can lead to marked fatigue. The most widely used treatments are positive airway pressure (PAP) machines, of which the continuous positive airway pressure (CPAP) machine is the most common.[25]

Medical evaluations to screen for OSA are generally conducted in two steps: first, a determination is made regarding whether an individual is likely at risk[26]; if a person is at risk, then a follow-up overnight sleep study using polysomnography allows specialists to confirm diagnosis and disease severity.

Recommendations

- **Screening current safety-sensitive employees for sleep disorders:** FTA should require bus and rail transit agencies to have all safety-sensitive employees see a qualified medical health-care provider if, based on the results of an appropriate screening process, such screening indicates that the employee is at risk for sleep disorders, at minimum, sleep apnea.[27] If, based on the screening results, the agency's medical examiner determines the employee may be at risk for sleep disorders, the medical examiner will direct such employee to see a qualified medical health-care provider. Should the qualified medical health-care provider detect risk factors for a sleep disorder that are likely to interfere with the individual's ability to effectively conduct his or her safety-sensitive tasks, the employee must be referred to a specialist for further evaluation and therapy. The medical examiner used by the transit agency should review the findings of the fatigue screening and any further studies and then, based on a framework agreed upon by the affected labor organizations and the agency, determine fitness for duty and any follow-up actions. Screening and any associated medical evaluations should be periodic, not to exceed two years, consistent with DOT policy for the frequency of medical evaluations. These policies should be jointly developed and implemented by agreement in partnership with labor organizations at the agency level.

  Extensive sleep evaluation studies can be an economic burden for both employees and transit agencies. . Additionally, leaving the cost burden on the employee could create an incentive to hide the condition; therefore, employees should not solely bear the cost.

[25] http://www.sleepapnea.org/treat/treatment-options.html.
[26] This determination could be made using a validated methodology used properly such as the Berlin Questionnaire (in Appendix E), BMI cutoffs (FMCSA's expert panel recommended greater than or equal to 33kg/m^2) and/or a clinical evaluation (evaluation of symptoms and other risk factors and conditions known to be associated with a high risk of OSA).
[27] See footnote 26. "Qualified medical health care provider" is defined in the text box below.

Given that fatigue is a safety issue and ensuring safety is considered a cost of providing service, FTA should consider the economic burden on both employees and agencies when crafting the regulation. FTA should encourage agencies, employees, and labor organizations to address the payment for sleep evaluation studies during the collective bargaining process. Where collective bargaining is not successful in addressing payment issues for sleep evaluation and/or where agency employees do not have collective bargaining rights, TRACS strongly recommends FTA establish a procedure to assist employees and employers in addressing this important issue. The committee also recommends the FTA provide grant funding opportunities to assist in covering these safety costs.

- **Compliance with treatment:** Bus and rail transit agencies should provide a temporary certification of up to 90 days for safety-sensitive employees deemed at risk for a sleep disorder by a qualified medical health-care provider, unless the employee is determined by that health-care provider to pose an imminent safety risk. Within the 90-day period, at-risk, safety-sensitive employees should be required to complete a sleep study, either in a sleep lab or through home testing, conducted by a qualified medical health care provider. The employee would then provide the agency with documentation from the sleep specialist indicating compliance with any prescribed treatment plan.

  FTA should require that bus and rail transit agencies require safety-sensitive employees with confirmed sleep disorders to self-certify that they are in compliance with the treatment plan at intervals of no more than 1 year. Unless determined to be an imminent safety threat, employees found out of compliance should receive 30 days to come into compliance with treatment.

  To preempt and address any scheduling problems or other concerns, transit agencies should involve their medical directors, legal experts, labor organizations, and others as appropriate, as early as possible in the implementation of screening and compliance certification.

- **Screening applicants for sleep apnea:** FTA should also consider requiring bus and rail transit agencies to screen for sleep disorders, and, at minimum, sleep apnea, in otherwise qualified applicants that the agency may be interested in hiring for safety-sensitive positions. If the results of the initial screening indicate risk factors for a sleep disorder, agencies should allow a medical hold for a period as determined appropriate by the hiring agency, for at-risk applicants to provide documentation from a follow-up sleep study in a sleep lab or through home testing. The documentation should disconfirm a sleep disorder or demonstrate 30-day compliance with treatment, including self-certification. Applicants would be responsible for completing the sleep studies and treatment on their own and not be hired if they do not produce the necessary documentation.

- **Voluntary, confidential wellness program:** FTA should evaluate and design best-practice programs for agencies to provide continued support for all employees at risk

for, or confirmed with, sleep disorders beyond mandatory fatigue management training. Best practices may include providing employees the opportunity to meet periodically with a sleep professional or a trained, occupational health nurse to identify personal strategies (consistent with any treatment prescribed by the employee's qualified medical health care provider) for addressing sleep disorders and fatigue.

Fitness-for-Duty Definitions

Compliance with treatment:
*Meets the minimum uniform treatment protocols required by the qualified medical health-care provide**r.** The uniform minimum treatment protocol requirements will vary by sleep disorder.*

***Screening** means sleep disorder evaluation conducted by a qualified medical health-care provider. The medical examiner used by the transit agency must review the findings of the fatigue screening and, based on a framework agreed upon by the affected labor organizations and the agency, determine fitness for duty and any follow-up actions.*

***Qualified medical health-care provider** means a board-certified health-care professional medically trained and qualified to screen, diagnose, and treat sleep disorders. This health-care professional should be accredited by the American Academy of Sleep Medicine (AASM). According to the AASM, "the AASM Standards for Accreditation ensure that sleep medicine providers display and maintain proficiency in areas such as testing procedures and policies, patient safety and follow-up, and physician and staff training." The following links can help transit agencies and employees locate AASM-accredited health-care professionals:*

- *http://www.aasmnet.org/*
- *http://www.sleepeducation.com/find-a-center*

***Treatment** means screening, diagnosis, and follow-up care prescribed by a qualified medical health-care provider that meets the minimum uniform treatment protocols required by the transit agency.*

*For purpose of these recommendations, **Safety Sensitive** primarily applies to employees that are involved with moving revenue and maintenance equipment or structures, including bus and rail operators, conductors, and controllers. Some transit agencies have also included a larger subset of employees to receive sleep disorder screening, including maintenance-of-way workers, station personnel, and transit police officers.*

Connection to SMS Pillars

SMS Pillar	Fitness-for-Duty Medical Evaluations and Screenings
Safety Policies and Procedures	Develop policies and procedures related to screening employees for sleep disorders and providing support for these employees.
Safety Risk Management	Screening employees for sleep disorders and requiring treatment greatly reduces the risk for fatigue-related incidents.
Safety Assurance	Require employees identified as at-risk for sleep disorders to provide proof of getting screened and completing treatment.
Safety Promotion	Agencies can promote safety by helping employees trust that those identified with sleep disorders will not lose their jobs, provided they adequately treat the disorder. Agencies should make sure to continue focusing on safety culture and other policies in this document as means of safety promotion, as well.

Work and Vehicle Environment Design

The recommendations in this section are based on one of the key defenses of an FRMS identified in the Guidance Statement (Volume 54, Number 2, dated February 2012) published by ACOEM. While the Guidance Statement is useful for this section in that it recommended work environment design as an important defense against fatigue, many of the operational countermeasures in the publication, such as brightly lit work areas, sound in the form of noise, music, or conversation, rotation of task parameters, and workplace temperature, may actually create unsafe conditions when applied to transportation. In transit, operators do not typically operate buses and trains with brightly lit bus compartment areas or train cab interiors. Almost all transit agencies discourage or prohibit the use of music or "unnecessary conversation" with transit operators while they are operating transit vehicles. Moreover, because transit agencies do not have the option to vary tasks of a bus or train operator, implementing the task parameter defense described in the publication is not practical. Therefore, this section will suggest other, more transportation-appropriate strategies for mitigating fatigue in workplace design.

Modifying the work and vehicle environment design can address several physical and stress-related contributors to transit operator fatigue. One such physical contribution to fatigue for bus operators is the sheer physical force required to operate the vehicle. The American Public Transportation Association (APTA) Standard Bus Procurement Guidelines, for example, allow power steering effort as high as 70 lbs. fully turned. With a large steering wheel and up to 7 turns lock to lock, this presents a fatigue risk factor for operators making hundreds of turns per shift. Similarly, power brakes are specified with effort up to 75 lbs. With the usual shift consisting of hours of starts and stops in rapid sequence, this significantly adds to operator fatigue and injuries. The industry standard air-ride seats expose operators to approximately 50 percent more whole body vibration than available design alternatives despite the well-documented high rate of back injury.[28] In each case, simple, available engineering solutions could alleviate or at least mitigate operator fatigue and injuries.

The high-stress nature of the bus transit operator's job compounds the physical and psychological fatigue due to the inherent conflict between the great amount of decision making required, coupled with negligible decision-making authority. Drivers reporting the highest levels of workload demand minus job control have been shown to have the highest levels of on-the-job elevations of stress hormones.[29] One such stressor is the fear of assault. TCRP Synthesis 93 noted that a 2005 survey of transit operators found 36 percent had been physically assaulted and 55 percent had experienced verbal threats.[30] Workplace design changes such as the provision of functional security barriers can reduce these sources of highly elevated stress and its impact on fatigue.

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[28] Blood, Ryan P., Jack Dennerlein, Charlotte Lewis, Patrik Rynell, and Peter W. Johnson. 2011. "Evaluating Whole-Body Vibration Reduction by Comparison of Active and Passive Suspension Seats in Semi-Trucks." Proceedings of the Human Factors and Ergonomics Society Annual Meeting 55 (1): 1750–1754. doi:10.1177/1071181311551363.

[29] Carrère, S., Evans, G. W., Palsane, M. N. and Rivas, M. 1991. Job Strain and Occupational Stress Among Urban Public Transit Operators. Journal of Occupational Psychology, 64: 305–316.

[30] Nakanishi, Yuko J, Fleming, William C, Transportation Research Board. Front Matter. *TCRP Synthesis 93: Practices to Protect Bus Operators from Passenger Assault*. Washington, DC: National Academies Press, 2011.

The scale of transit operators' physical and emotional task-based risk is well documented. A National Institute for Occupational Safety and Health study from 2011, examining more than 214,000 workers found that local and interurban passenger transit employees suffered the highest rates of hypertension, depression, cardiovascular disease, and diabetes.[31] A stratified random sample of urban motor coach operators in California found that 80.5 percent had current back or neck pain.[32] Compounding these numbers, a recent review of 27 papers on bus operator well-being noted that the actual rates of disease related to bus operator work could be higher if those who left the occupation for health reasons were included in the analysis. Pain, ill health, high stress, and depression all contribute strongly to fatigue. An SMS approach to altering the design of the transit operator workplace could substantially reduce the risk of these problems.

There has been little research into operator workstation design despite the clear psychological and physical hazards which contribute to occupational stress and fatigue. TRACS offers the following recommendations to resolve that problem.

Recommendations

FTA should complete the following steps and establish requirements that will reduce stress and fatigue for transit vehicle operators.

1. Research the best-practice design standards for bus and rail operator compartment areas, both on a national as well as international level, and identify design elements that have been proven to reduce fatigue by addressing the physical demands described above. Ideally, this would involve convening an expert task group comprised of varying perspectives across the transit fatigue community, such as labor, management, federal regulators, researchers, and industry.
2. Work with bus and rail car manufacturers to discuss incorporating technology already available for personal vehicles such as driver drowsiness alert systems, lane departure systems, etc., that provide real-time alerts in the driver's compartment areas prior to the driver realizing that he or she is becoming fatigued.
3. Fund demonstration projects of the new technologies described in Recommendation No. 1 on transit buses and rail vehicles to determine the efficacy of such features.
4. Work with APTA on updating the Standard Bus Procurement Guidelines and Light Rail Vehicle Request for Proposals (RFP) Procurement Guidelines to incorporate features proven to be effective, based on the results of the demonstration projects, as "standard" features.

[31] Bushnell, P.T., Li, J., & Landen, D. 2011. Group Medical Claims as a Source of Information on Worker Health and Potentially Work-Related Diseases. J Occup Environ Med, 53 (12), 1430-1441. doi: 10.1097/JOM.0b013e3182363bbe.
[32] Anderson, R., The Back Pain of Bus Drivers – Prevalence in an Urban Area of California. Spine 17:1481, 1992.

Connection to SMS Pillars

SMS Pillar	Work and Vehicle Environment Design
Safety Policies and Procedures	Develop policies that require buses, rail cars, stations, and other environments in which safety-sensitive transit employees work to incorporate designs that address common contributors to fatigue.
Safety Risk Management	Addressing the environmental factors that contribute to operator fatigue will reduce the risk of fatigue-related incidents.
Safety Assurance	Funding demonstration projects of fatigue-mitigating designs on transit buses and rail vehicles will test the effectiveness of these designs in reducing fatigue-related incidents. Research findings from these demonstrations should lead to design requirements tied to funding for vehicle procurement.
Safety Promotion	Demonstrating the success of fatigue-mitigating work environment designs will encourage other agencies to adopt similar vehicle designs and show employees that agency management prioritizes the mitigation of fatigue. Labor and management should cooperate to develop potential work and vehicle environment designs that could mitigate fatigue.

Individual Fatigue Monitoring and Mitigation

Safety Culture

A successful FRMS requires the shared commitment of management and labor. Developing a successful fatigue safety culture will provide the framework necessary to help transit agencies ensure that employees and all levels of management prioritize the mitigation of fatigue risk to safety, wellness, and operational performance. All other FRMS initiatives discussed in this report are affected directly or indirectly by the quality of an agency's fatigue safety culture. The FTA TRACS report on SMS defines safety culture as "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that can determine the commitment to and the style and proficiency of an organization's safety management system."[33] Safety culture also consists of the following elements: [34]

- A **reporting** culture: an organizational climate in which people are prepared to report their errors and near-misses.
- A **learning** culture: the willingness and the competence to draw the right conclusions from its safety information system, and the will to implement reforms, including major reforms, when their need is indicated.
- A **just** culture: an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information—and in which they achieve consensus in distinguishing between acceptable and unacceptable behavior.
- A **flexible** culture: takes a number of forms, but in many cases it involves shifting from the conventional hierarchical mode to a flatter professional structure, where control passes to task experts in real time, and then reverts back to the traditional bureaucratic mode once the emergency has passed. Such adaptability is an essential feature of the crisis-prepared organization and, as before, depends crucially on mutual respect—in this case, respect for the skills, experience, and abilities of the workforce and the first line supervisors. This requires a major training investment on the part of the organization.

Together, these four subcomponents "interact to create an informed culture," which equates to a safety culture:

- An ***informed*** culture: one in which those who manage and operate the system have current knowledge about the human, technical, organizational, and environmental factors—and the interactions within and among them—that determine the safety of the system as a whole.

An ideal FRMS would incorporate all components. Employees must ***report*** their fatigue without fear of punishment. Agencies must ***learn*** from and continuously improve their programs. All members of the organization must feel they are treated ***justly*** in fatigue management decisions that affect their lives. Agencies need to develop and implement a reliable but ***flexible*** operation that accommodates employees who cannot work due to fatigue and that can adjust to short-duration emergencies without causing employees to become fatigued. Employees must be

[33] Transit Rail Advisory Committee for Safety. 2011. *Implementing Safety Management System Principles in Rail Transit Agencies*. Washington DC: Federal Transit Administration, p. 10.
[34] Reason, J. (1997). *Managing the Risks of Organizational Accidents*, Ashgate Publishing, Burlington, VT, pp. 195-196.

allowed good faith refusal of overtime if fatigued. Agencies must be ***informed*** about those variables that predict fatigue, monitor, and collect data needed for fatigue prediction, and operate the system accordingly to reduce fatigue risk. While many transit agencies deal with employee availability issues and the impact of staff shortages on an agency's ability to operate, safety must remain the driving concern when developing a nonpunitive safety culture.

Developing each component of a safety culture requires time. The SMS maturity model[35] suggests that agencies, both management and labor, can begin by adopting HOS policies and fatigue training programs. They can then identify all fatigue precursors and set shared fatigue-related safety goals, and finally establish a system through which employees feel comfortable self-reporting fatigue. At this stage, management and employees will trust each other and hold the mitigation of fatigue as a core value, while the agency's practices will accommodate employees who cannot work due to fatigue.

Recommendations

TRACS provides the following recommendations for FTA to encourage the development of fatigue-related safety cultures in bus and rail transit agencies:

- **Safety goals:** FTA should set safety goals related to fatigue in the National Public Transportation Safety Plan. TRACS recommends that bus and rail transit agencies reflect those fatigue-related safety goals in their agency safety plans.

- **Data collection and hazard analysis:** FTA should collect data from a spectrum of large and small rail transit and bus-only properties and conduct hazard analyses to determine precursors of fatigue-related incidents. To further strengthen this process, a joint labor/management working group can be convened within and among properties to gather multiple perspectives, insights, and recommendations.

- **Metrics:** Based on the data collection and hazard analyses, FTA should define metrics for a successful safety culture in regard to fatigue. This step should include a pilot program in which FTA measures baseline fatigue-related incidents and on-the-job behaviors that may increase fatigue in a select number of agencies. The agencies would then develop and implement a collaborative labor-management FRMS program. Finally, FTA would evaluate any changes in behaviors and fatigue-related incidents to determine which aspects of the FRMS programs were most successful. Existing safety culture scales may be helpful as beginning points for adaptation to create a fatigue safety culture survey scale.[36]

  In addition to the incident investigations discussed in the next section, agencies should conduct internal investigations and evaluations to determine if fatigue is becoming a problem for the organization or for individual employees. Agencies could track health incidents, sickness, turnover, Employee Assistance Program (EAP) use, and other factors

[35] TRACS 10-01 Report, p. 13, Adapted from the APTA Safety Management Maturity Model.
[36] See, for example, Parker, D., Lawrie, M., and Hudson, P. 2006. A Framework for Understanding the Development of Organizational Safety Culture. *Safety Science*, 44(6), 551-562.

to understand if the safety culture and FRMS is successfully addressing the problem of fatigue.

- **Case studies:** After FTA identifies best practices for developing a safety culture in regard to fatigue; it should develop case studies highlighting those best practices for both large and small rail transit and bus properties.

- **Guidebook:** FTA should create an FRMS guidebook that teaches bus and rail transit agencies of all sizes to develop a successful safety culture in regard to fatigue. TRACS anticipates that this guidebook will include information on communication strategies that will establish trust between labor unions and transit agencies.

Connection to SMS Pillars

SMS Pillar	Safety Culture
Safety Policies and Procedures	Ensure that the agency has an expressed policy of fatigue management, and has procedures to implement it.
Safety Risk Management	Identify, assess, and implement remedies to possible uses of any HOS rules and fatigue management systems that might undermine trust and employee willingness to engage in other trust-related safety systems such as close-call reporting.
Safety Assurance	Surveys, focus groups, and individual supervisor/operator contact, all of which inquire into behaviors and information about employee acceptance and voluntariness in fatigue management. Safety culture surveys developed for transit tap into fatigue and shift scheduling issues.
Safety Promotion	Agencies can promote safety through training on fatigue management, the use of data and interviews, and many forms of communication about the agency's purpose, goals, and values.

Incident Investigation

Fatigue should be considered as a potential underlying factor in virtually all accidents or injuries where human error played a role in the incident. The objective of the incident investigation is to identify if any of the root causes of fatigue were present and if they contributed to the incident.

The information obtained by a transit agency during the incident investigation will be used to:

- Determine if fatigue was a causal or likely contributing factor in the incident being investigated;
- Investigate all potential root causes of fatigue in an incident and assess or estimate the likelihood of each in contributing to the fatigue, or to the likelihood of fatigue;
- Ensure that the fatigue-related root causes that have been identified in the incident being investigated are appropriately resolved;
- Assess the use of available technologies that are capable of overriding the actions of a fatigued operator;
- Determine if the agency is complying with internal and external standards with regard to their fatigue management program;
- Determine if the agency's current fatigue management programs and practices are effective; and
- Identify any commonalities among incidents and determine if there are any systemwide improvements that can be made to prevent future occurrences.

TRACS recommends that oversight agencies and transit agencies incorporate the following practices into safety investigations of incidents and accidents to determine if fatigue is a causal or related factor. These suggested protocols are scalable for different size properties and, as needed, different modes of transit.

Fatigue Investigation

The first step in the investigation process is to evaluate the incident and determine if the incident is the type in which fatigue may have played a role.[37] Examples of the types of incidents in which fatigue may have played a role are:

- Derailments
  - Over-speed derailments
- Collisions
  - Train versus train, fixed object, transit worker, pedestrian, or other vehicle
  - Bus versus bus, fixed object, transit worker, pedestrian, or other vehicle
- Near miss/close call incidents
  - Incursion into an out-of-service track
  - Incursion into a work zone
  - Excessive speed through a work zone or adjacent to a work zone
  - Switch run-through
  - Signal run-through

[37] Transportation Safety Institute, Advanced Rail Investigation, Module 10 – Human Factors.

- Signal violation
- Operational errors such as over/under shooting stations, opening train doors on the wrong side, opening train doors outside of the station, etc.

Initial Assessment of Fatigue

Agencies should establish two factors before concluding that operator fatigue contributed to an accident. First, the agency should determine whether the operator was likely fatigued based on sleep lengths, sleep disturbances, circadian factors, time awake, and/or medical issues. Second, if it is determined that the operator was likely fatigued, the agency should evaluate information concerning the operator's performance, behaviors, and appearance at the time of the accident to determine whether they were consistent with the effects of fatigue.

TRACS recommends that agencies answer the following questions when investigating incidents in which fatigue may have played a role. If the answer to any of these questions suggests that fatigue may have contributed to the incident, then agencies should investigate the operators' and other safety-sensitive employees' fatigue involved in the incident in depth.

- Does the 72-hour history suggest a sleep debt? If the operator was averaging less than 7 hours of sleep per night, s/he may have been fatigued.
- What time of day did the occurrence take place? Did the incident occur during times of reduced alertness?
- Was the operator's normal circadian rhythm disrupted? E.g. was the operator working at a time when s/he was normally sleeping, had the operator's schedule recently changed, and/or was the operator working a forward/backward rotating, on-call, or split shift schedule?
- How many hours had it been since awakening? If the operator was awake for more than 16 hours, s/he may have been fatigued.
- Is sleep disorder likely? Has the operator been diagnosed with a condition that could lead to excessive sleepiness?

In-Depth Collection of Fatigue-Related Data and the Determination of Fatigue as a Causal Factor through Interviews and Documentation Analysis

The following outlines the data that agencies should try to obtain if the initial assessment indicates that the operator may have been fatigued.[38] For the questions regarding medical history and drug use, agencies should work with their legal and medical staff to ensure that data collection practices do not violate the Health Insurance Portability and Accountability Act (HIPAA).

- Activities in the last 72 hours
    - When was the last time the operator worked before the incident?
    - When did the operator work during the three days previous? What other activities was the operator engaged in during this period?

[38] National Transportation Safety Board Methodology for Investigating Operator Fatigue in a Transportation Accident, Version 2.0 6/2/06.

- When did the operator go to sleep the previous night?
- When did the operator wake and did s/he feel well rested?
- Was the operator's sleep pattern different or disrupted in the days leading to this incident?
- What is the operator's normal work schedule? When are his/her days off, vacations? When was his/her last vacation?
- Describe the operator's activities on the day of the accident up to the accident. Any work breaks? Any naps (when, where, length, why)?
- Did the operator suffer from circadian issues due to recently rotating, inverted or variable work/sleep schedules?
- Did the operator engage in dual employment?

- Life changes/environmental issues that may have affected the operator's ability to sleep
  - Did the operator have major changes in his/her health that affect sleep in the past year?
  - Have there been major changes in the operator's financial situation?
  - Have there been major changes in the operator's personal life (e.g., separation, divorce, birth, death)?
  - Have there been changes in the health of the operator's immediate family or close friends? Any deaths?
  - Were there factors in the operator's environment (e.g., noise, light, phone calls, etc.) that interfered with his/her sleep?
  - Did the operator indicate that s/he was fatigued in the recent past?

- Medical/Drugs
  - Does the operator have difficulty falling asleep or staying asleep?
  - Did the operator take prescription or nonprescription medicine? What, how often? When was the last time that the operator took the medicine before the incident? (Medical or pharmacy records can be used.)
  - Did the operator's toxicological results indicate the presence of substances that may affect sleep or alertness?
  - Was the operator ever tested for a sleep disorder?
  - Has the operator ever told a doctor about how s/he sleeps? If so, why, when, and what was the result?

- Complexity or difficulty of work assignment on the day of the incident
  - Was the work affected by the weather or other environmental factors?
  - Were there excessive noise or temperature variations in the work environment?
  - Was the work monotonous (as may be the case in automated environments)?

- Training
  - Has the operator received fatigue awareness training in proper sleep, diet, eating patterns, exercise, sleep environment and sleep disorder symptoms?

Once the presence of fatigue has been identified using the above considerations, agencies should make a separate determination about whether the fatigue was causal to the incident. Even if fatigue was not causal, agencies should document the presence of fatigue and the circumstances that gave rise to it to identify potential safety improvements.

When reviewing the circumstances of the accident to determine if the operator's performance was likely the result of fatigue, agencies should examine whether the operator:

- skipped or overlooked steps,
- made mistakes or judgment errors,
- had difficulty paying or dividing attention,
- did not make expected control inputs (e.g., steering, braking, or throttle adjustments),
- focused on one task to the exclusion of more important information,
- was unresponsive or had delayed responses to stimuli,
- had difficulty making decisions or was slow to do so, and/or
- had difficulty changing plans or otherwise adapting behavior to accommodate new or changing information.

Agencies can use these signs to link the operator's fatigue to the cause of the incident. Note that fatigue can lead to unfocused performance, delayed reaction time, and otherwise poor human performance. Consequently, an operator does not have to have fallen asleep for fatigue to have caused or contributed to the incident. Agencies should use the knowledge derived to address shortcoming in the FRMS and take steps to prevent future fatigue-related incidents.

Of course, falling asleep—or experiencing a micro-sleep—could be the cause of an incident. A micro-sleep is a brief, involuntary episode of sleep that may involve nodding of the head or drooping or closed eyelids. Video of the operator during the incident and/or eyewitness descriptions of the operator during the incident may demonstrate whether an operator fell asleep or experienced a micro-sleep. An operator may also report experiencing micro-sleeps or diminished alertness, but people do not always remember and report such experiences. Further, the lack of urgently required pre-incident control inputs may strongly imply that the operator fell asleep or was micro sleeping, particularly if loss of consciousness for medical reasons can be ruled out or deemed improbable.

Recommendations

- FTA should establish minimum requirements for investigating the possible role of fatigue in incident investigations.
- FTA should develop best-practice protocol templates for close call, incident, and accident investigation that include fatigue assessment.
- FTA should incorporate the fatigue assessment protocol recommended in this section into its certification courses for accident investigation.
- The FTA and the transit industry should identify which data collected during fatigue-related incidents or accidents to include in a national safety database as a source for national trend analysis.

- For those accidents or incidents already reported to the National Transit Database, information should be included indicating whether or not the incident was fatigue related, if possible.

Resources

- DOT Safety Council Work Product: Phase I: Assessment of Organizational Capabilities to Identify Contributory and Causal Fatigue Effects in Accident Investigations (October 2014, DOT-VNTSC-OST-14-01, Authors: Gabree, Johnson, & Comperatore)

Connection to SMS Pillars

SMS Pillar	Incident Investigation
Safety Policies and Procedures	Develop incident investigation procedures to determine whether fatigue contributed to an incident or accident.
Safety Risk Management	After determining that fatigue has contributed to an incident or accident, bus and rail transit agencies should identify potential safety improvements to reduce the risk of future fatigue-related incidents.
Safety Assurance	Tracking trends related to fatigue-related incidents or accidents could demonstrate the success of incident investigations in reducing the risk of these incidents. For possible fatigue-related accident investigations, agency reports should document the fatigue inquiry performed.
Safety Promotion	Develop best practices for investigating whether fatigue was a contributing factor in incidents or accidents. Incorporate the recommended fatigue assessment protocol in FTA certification courses for accident investigation.

Data Collection

Collecting data on fatigue performance measures can help transit agencies determine whether an FRMS is successfully reducing fatigue among safety-sensitive employees. Although regularly gathering and analyzing data on fatigue performance measures will incur additional staff, technology, IT, and time costs, the ability to track trends in these variables before and after implementing an FRMS provides agencies with a crucial tool for identifying which aspects of an FRMS to adjust and improve as well as for sharing lessons about what's working well.

Recommendations

FTA should require transit agencies to collect and track data on fatigue performance measures over the course of several years to evaluate the success of their FRMS. Although the changes in these metrics may not fully stem from implementation of the FRMS, trends across variables can nonetheless help indicate program success in reducing fatigue among safety-sensitive employees. FTA should consider recommending that transit agencies begin by collecting objective data that they do not need to request from employees (such as incident rates), and then collect more subjective or personal data from employees to add nuance if needed. Transit agencies should ensure confidentiality around any personal data, such as medical history and any sleep disorders. Involving legal and medical staff and collaborating with labor representatives can help transit agencies ensure their data collection policies respect their employees' confidentiality needs and rights. FTA should also consider which government entity will own each type of data. The data could remain with the local transit agency or be compiled at the state or federal level. Data ownership has important implications for employee privacy, and FTA should consider which data is most useful for analysis at each level of government and then ensure confidentiality around those metrics.

The recommended performance measures are presented in

Table 1. A more detailed list of potential performance measures related to fatigue is included in Appendix F. Each transit agency also has its own performance goals and metrics and should consider tracking the changes in these metrics before and after implementing the FRMS to evaluate the program's contribution to meeting the agency's goals. Hence, the combination of performance metrics that transit agencies choose to evaluate the success of the FRMS will vary at least in part based on the agency's location, size, and other circumstances. TRACS does not recommend that FTA collect data for all the performance measures listed here or in the appendix, but rather that FTA ensure that transit agencies are collecting this data to measure the success of their FRMS. The entity that should own and maintain data on each performance measure is listed in the second column of the table below.

Table 1. Recommended FRMS Performance Measures

Performance Measure	Who Owns and Maintains the Data
Incident rates, including accident, injury, error, and close call rates due primarily to fatigue factors	FTA
Employee wellness, including employee satisfaction, sick days, absenteeism, and turnover rate among safety-sensitive staff	Transit Agency
Employee and management feedback on training and other FRMS components	Transit Agency
Percent of safety-sensitive employees receiving training and treatment for sleep disorders	Transit Agency
Percent of night-shift safety-sensitive employees taking preemptive naps in the afternoons and/or evenings before their shifts	Transit Agency
Percent of split-shift safety-sensitive employees taking a rest break/nap during the split in their shifts	Transit Agency
Vibration and sound levels in bus and rail cabs	Transit Agency

Conclusion

Transit worker fatigue remains a serious problem for the country's transit industry. FTA can address this challenge by promoting an SMS approach to preventing fatigue-related incidents. This approach includes developing and adopting an HOS regulation; implementing requirements related to fatigue training, fitness-for-duty medical evaluations and screenings for sleep disorders including at a minimum sleep apnea and FRMS performance management; publicizing best practices for developing a safety culture and conducting incident investigations; and conducting further research on shift-scheduling tools, design standards that reduce fatigue, the most successful aspects of FRMS programs, and fatigue data to include in a national safety database. By developing these requirements, best practices, and research studies, FTA can support transit agencies and workers in jointly managing fatigue and preventing fatigue-related incidents.

Appendices

Appendix A: Recommended Safety Standard for Hours of Service

A. Overview

a. Scope

This standard applies to transit agency operations that are not governed by more restrictive Federal or State Hours of Service requirements. This standard does not apply to Commuter Railroads when operating on the general railroad system of transportation regulated by the Federal Railroad Administration (FRA).

b. Purpose

Operating rules are created to promote safe and reliable transit operations. Compliance is necessary to achieve this objective. This safety standard sets forth the requirements for each Agency to implement an Hours of Service (HOS) program in order to create the conditions that minimize the impact of fatigue on job performance.

B. Definitions

a. Agency: Transit agency, including bus and/or fixed guideway systems.

b. **Covered Employees:** Employees that operate a revenue service vehicle, including when not in revenue service; operate a nonrevenue service vehicle and/or maintenance equipment; or control dispatch or movement of a revenue service or maintenance vehicle. This definition includes but is not limited to all bus and rail vehicle operators, dispatchers, conductors, and controllers.

c. Hours of Service (HOS): Safety standards governing the number of hours a Covered Employee may work, including required rest periods.

d. **Duty Tour:** The elapsed period from the time the Covered Employee initially reports for duty to the time the Covered Employee is finally released from duty. The Duty Tour may include one or more interim Off-Duty Time periods. Interim Off-Duty Time periods are included when considering the maximum allowed Duty Tour within a Service Day.

e. Off-Duty Time: Means any a period of release of one hour or greater during which the Covered Employee is not on duty, required to be in readiness to work, or under

any responsibility to perform work. During Off-Duty Time, a Covered Employee is free to leave the workplace, commute between work and home, engage in personal activities, or obtain rest. For Off-Duty time to be counted in a split shift, employees must be provided with a reasonable environment in which to get rest if they choose. Off-Duty Time includes mandatory off-duty periods, days off, vacation days, and other periods not defined as On-Duty Time.

f. **On-Duty Time:** Time actually spent in the service of the transportation agency, whether or not compensated, including time performing safety-critical tasks and other tasks, time "standing by" to perform duties when instructed, and work breaks or interim periods of less than one hour. On-duty time can include drive or seat time as well as in station time, breaks between runs, and other incidental tasks and duties. On-duty time does not include any interim period of release of one hour or greater. On-duty time includes time spent in transportation to and from a work location, but does not include travel time to/from home to work or work to home. On-duty time includes time devoted to training.

g. Service Day: The 24-hour period starting when a shift begins, regardless of whether the shift goes beyond a calendar day.

C. General requirements

a. Minimum Requirement

All Agencies shall develop, implement, and adhere to procedures governing HOS requirements that meet or exceed these requirements.

b. Employee Applicability

HOS requirements shall apply to all Covered Employees. Agencies may choose to expand the scope of this standard to apply to other categories of employees.

c. Scheduling

Covered Employees shall not be required or permitted to work in violation of HOS requirements unless the procedures for extreme circumstances described in Section J are followed.

d. Shift Assignments

The Agency shall not assign work to a Covered Employee that would violate HOS requirements.

e. Responsibility of Covered Employees

The Agency shall define the Covered Employees' responsibilities concerning HOS in the Rulebook or other appropriate documents.

D. Maximum "Duty Tour"

The Agency shall not require or permit a Covered Employee to work a Duty Tour that has an overall elapsed time from start to finish greater than 14 hours within a **Service** Day.

E. Maximum "On-Duty Time"

The Agency shall not require or permit a Covered Employee to have more than 12 hours On-Duty Time during a Duty Tour.

F. Minimum Rest Period

The Agency shall require a minimum 10 hours of Off-Duty Time between Duty Tours.

G. Consecutive Working Service Days

The Agency shall not require or permit a Covered Employee to work for more than six consecutive working Service Days.

H. Record keeping

a. Requirement to Record Shift Times

The Agency shall maintain a record of hours worked by all Covered Employees, including shift start and end times and dates and any Off-Duty Time during split-shifts. The Agency shall retain such records for three years.

b. Requirement to Maintain Records

The Agency shall maintain such records as shall provide for verification of compliance with HOS requirements.

I. HOS Compliance Program

a. Verification of Compliance

The Agency shall develop a review process to verify and ensure its compliance with HOS requirements.

J. Extreme Circumstances

Under extreme circumstances, the Agency may, in good faith, temporarily suspend HOS requirements for the safety and/or protection of its employees and/or the public. Extreme

circumstances affecting the safety and/or protection of employees and the public may warrant temporary suspension of HOS requirements. The Agency shall include provisions in its HOS policy that address the type and degree of extreme circumstances during which an exception to the HOS requirement may be made. The Agency shall define how such situations will be identified, by whom, and what level of exception will be made. All exceptions shall be reported to the FTA and the applicable state oversight agency. The FTA and oversight agency retain enforcement authority for misuse of this provision.

Appendix B: Shift Scheduling Planning and Analysis Tools

Table 2. Stakeholder Input Regarding Fatigue Models *(Source: "Current and Next Generation Fatigue Models"[39] p. 6)*

Purpose	Effectiveness & Best Aspects	Limitations	Other Problems
For what purposes are biomathematical models currently being used? • Evaluate and plan work schedules • Assess risk of fatigue associated with various work shifts at the group (not individual) level; measure degree of 'hazard exposure', defined as accident risk • Predict changes in performance based on schedules and other variables • Make overtime work shift decisions • Investigate accidents • Conduct audits	*What have users found particularly useful?* • A starting point for risk management and scheduling • Useful when consistent with existing regulations and laws • When bought into by users, not just management and regulators *Regarding current models, what stands out?* • Types and quality of outputs, e.g., report summaries • User-friendly interfaces • Ability to enhance fatigue risk management systems (FRMS)	*What are the limitations of current models? What are some concerns about misuse?* <u>Validation/Calibration</u> • Not all models are validated[40] • Accurate data hard to obtain, resulting in inaccurate predictions to build and use models • Not calibrated for specific industries once in use <u>Group/Individual</u> • Unable to assess individual fitness-for-duty • Psychological and social factors influence sleep/wake behavior, in addition to circadian and work scheduling factors; the former are not incorporated into existing models • Cognitive performance does not equal task performance Other • Perceived by some as 'magic bullet' or firm threshold • Only one element of larger FRMS • Difficulties with time-zone changes • Lack of batch review	*What other challenges and concerns do users have?* <u>Acceptance/Implementation</u> • Not accepted by all industries, unions; need agreement between management and employees that fatigue mitigation is desirable, that while there are costs to mitigating fatigue, the benefits outweigh the costs • May be difficult to use: time, cost, skill, motivation; training may be limited or costly • After implemented, may not be used well; may be misused, unintentionally or otherwise <u>Standards</u> • May be relied upon more than intended or justified • Differences of opinion re: risk/performance; where to draw the line? • The 'mean' becomes the standard; deviations not sufficiently acknowledged • Conflict of Interest • Developers' financial interest in selling their models

[39] DOT Safety Council Work Product: Current and Next Generation Fatigue Models (October 2014, DOT-VNTSC-OST-14-01, Authors: Lehrer & Popkin).

[40] Validation means determining that the output of a biomathematical model of human fatigue and performance actually measures human fatigue and performance. The model must be consistent with currently established science in the area of human performance, sleep, and fatigue, the model output has a statistically significant relationship with the risk of a human factors (HF) accident caused by fatigue, and the model output does not have such a relationship with nonhuman factors (NHF) accident risk. (From Procedures for Validation and Calibration of Human Fatigue Models: The Fatigue Audit InterDyne Tool, FRA, November, 2010.)

Appendix C: National Transportation Safety Board (NTSB) Safety Recommendations Following the Investigation of the March 24, 2014 Chicago Transit Authority Accident at O'Hare Station

	NTSB Recommendation
R-15-018	Develop a work scheduling program for rail transit agencies that incorporates fatigue science—such as validated biomathematical models of fatigue—and provides for the management of personnel fatigue risks, and implement the program through the state safety oversight program. (R-15-018)
R-15-019	Establish (through the state safety oversight program) scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements. (R-15-019)
R-15-020	Identify the necessary training and certification needs for work schedulers in the rail transit industry and require the transit agencies—through the state safety oversight program—to provide additional training or certification for their work schedulers. (R-15-020)
R-15-021	Require (through the state safety oversight program) rail transit employees who develop work schedules to complete initial and recurrent training based on current fatigue science to identify and mitigate work schedule risks that contribute to operator fatigue. (R-15-021)

Appendix D: Employee Fatigue Training and Sleep Disorder Management References

DOT Safety Council Work Product: Preliminary Communications Concepts for Addressing Operator Fatigue and Drowsy Driving (October 2014, DOT-VNTSC-OST-14-xx, Authors: Lehrer & Popkin *in draft form as of 2.5.15*)

- This document provides a framework for communicating with targeted audience groups about the risks of fatigue and drowsy driving. The discussion includes a potential methodology to apply to a future strategic communications effort as well as probable communications goals, audience groups, and strategies that should be considered for such a campaign. Finally, the report includes sample tactical elements that demonstrate current Safety Council discussion within the area of communications. (verbatim abstract)

MTA New York City Transit "Operations Training: Fatigue Awareness Training Manual" (Revised August 2014)

- This training manual defines fatigue, alertness, circadian rhythms, sleep principles, and related topics and includes recommendations for lifestyle adjustments and sleep optimization.

Office of the Assistant Secretary for Research and Technology Transportation Safety Institute (TSI): Transit Safety and Security Division (http://www.rita.dot.gov/tsi/about/transit_safety)

- Fatigue and Sleep Apnea Awareness for Transit Employees (Online Course)
    - The Federal Transit Administration sponsors all training activities provided by the Transit Safety and Security Division. All costs, other than a small materials fee (which covers the cost for textbooks, classroom supplies, printing and shipping), are waived for all transit system employee.

TCRP Report 81 "Toolbox for Transit Operator Fatigue" (http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_81.pdf)

- "This report documents principles, techniques, and strategies that are used in the development of fatigue-mitigation plans. The Toolbox includes a "how to" component on the design, implementation, and evaluation of fatigue-mitigation plans. The fatigue-mitigation plans may be used by senior managers, operations managers, safety officials, medical personnel, risk managers, human resource personnel, policymakers, and legal advisors." (page 5)

Appendix E: Berlin Questionnaire

Scoring Berlin questionnaire
Source: http://www.sleepapnea.org/assets/files/pdf/Berlin%20Questionnaire.pdf
Adapted from: Table 2 from Netzer, et al., 1999. (Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. Ann Intern Med. 1999 Oct 5;131(7):485-91).

The questionnaire consists of 3 categories related to the risk of having sleep apnea. Patients can be classified into High Risk or Low Risk based on their responses to the individual items and their overall scores in the symptom categories.

Categories and scoring:
Category 1: items 1, 2, 3, 4, 5.
Item 1: if '**Yes**', assign **1 point**
Item 2: if '**c**' or '**d**' is the response, assign **1 point**
Item 3: if '**a**' or '**b**' is the response, assign **1 point**
Item 4: if '**a**' is the response, assign **1 point**
Item 5: if '**a**' or '**b**' is the response, assign **2 points**

Add points. Category 1 is positive if the total score is 2 or more points
Category 2: items 6, 7, 8 (item 9 should be noted separately).
Item 6: if '**a**' or '**b**' is the response, assign **1 point**
Item 7: if '**a**' or '**b**' is the response, assign **1 point**
Item 8: if '**a**' is the response, assign **1 point**

Add points. Category 2 is positive if the total score is 2 or more points
Category 3 is positive if the answer to item 10 is 'Yes' OR if the BMI of the patient is greater than 30kg/m2.
(BMI must be calculated. BMI is defined as weight (kg) divided by height (m) squared, i.e., kg/m2).

High Risk: if there are 2 or more Categories where the score is positive
Low Risk: if there is only 1 or no Categories where the score is positive

Additional question: Item 9 should be noted separately.

BERLIN QUESTIONNAIRE

Height (m) _____ Weight (kg)_____ Age_____ Male / Female

Please choose the correct response to each question.

CATEGORY 1

1. **Do you snore?**

_ a. Yes
_ b. No
_ c. Don't know

If you snore:

2. **Your snoring is:**

_ a. Slightly louder than breathing
_ b. As loud as talking
_ c. Louder than talking
_ d. Very loud – can be heard in adjacent rooms

3. **How often do you snore**

_ a. Nearly every day
_ b. 3-4 times a week
_ c. 1-2 times a week
_ d. 1-2 times a month
_ e. Never or nearly never

4. **Has your snoring ever bothered other people?**

_ a. Yes
_ b. No
_ c. Don't Know

5. **Has anyone noticed that you quit breathing during your sleep?**

_ a. Nearly every day
_ b. 3-4 times a week
_ c. 1-2 times a week
_ d. 1-2 times a month
_ e. Never or nearly never

CATEGORY 2

6. **How often do you feel tired or fatigued after your sleep?**

_ a. Nearly every day
_ b. 3-4 times a week
_ c. 1-2 times a week
_ d. 1-2 times a month
_ e. Never or nearly never

7. **During your waking time, do you feel tired, fatigued or not up to par?**

_ a. Nearly every day
_ b. 3-4 times a week
_ c. 1-2 times a week
_ d. 1-2 times a month
_ e. Never or nearly never

8. **Have you ever nodded off or fallen asleep while driving a vehicle?**

_ a. Yes
_ b. No

If yes:

9. **How often does this occur?**

_ a. Nearly every day
_ b. 3-4 times a week
_ c. 1-2 times a week
_ d. 1-2 times a month
_ e. Never or nearly never

CATEGORY 3

10. **Do you have high blood pressure?**

_ Yes
_ No
_ Don't know

Appendix F: Fatigue Data to Consider when Creating and Evaluating an FRMS

The following variables and sub-variables represent a sample of the factors that could be measured to evaluate the success of an FRMS.[41] Many of these variables could also be considered when creating FRMS policies.

Variable and Sub-variable Attributes
Fatigue Risk Management System
Fatigue risk management policy
Fatigue management training and education for employees and management
Fatigue analysis and reporting system
Fatigue monitoring and mitigation for operating crews and others
Incident reporting/investigation process
Performance evaluation/auditing
Physiological Drivers
Circadian alertness/time of day
Homeostatic sleep pressure/hours awake
Sleep inertia/fatigue upon wakening
Chronotype: Lark/Owl/Flexible
Predisposed sleep need
Sleep debt
Sleep debt to need ratio
Schedule dynamics
Guidance documents
HOS regulations
Core schedule
Shift duration/operating period
Shift duty period including operating time plus additional duty time
Shift duty period impacted by number of work segments and time of day
Maximum hours in year or month
Maximum hours in week or x consecutive days
Maximum consecutive days
Maximum hours in day or watch
Minimum hours off duty in day, watch, week
Minimum hours at home terminal after x consecutive days
Number of work segments in specified time period based on transport vehicle weight
Speed of shift rotation

[41] This table has been modified from the following source: Lehrer, A.M. & Popkin, S.M. HOS Framework Checklist Tool and Compendium (draft under review). Volpe National Transportation Systems Center, U.S. Department of Transportation Safety Council, Office of the Secretary of Transportation, 2014.

Variable and Sub-variable Attributes
Direction of shift rotation or fixed shift schedule
Average commute (duration, distance, conditions; mode: active/operator, single driver, carpool driver, motorcycle, bicycle; passive/deadhead, carpool passenger, service (e.g., taxi), public transportation; route comfort (e.g., highway vs. stop & go), route variability, road conditions, rest opportunity
Schedule-related management criteria (e.g., 24/7)
Start time
Sleep/nap opportunity prior to scheduled start times
Sleep/nap actual rest prior to scheduled start times
Hours awake at shift start
Hours awake at end of shift
Rest breaks within shifts: rules, timing, duration, quality, quantity
Recovery time between shifts
Shift transition frequency, change in start time and/or hours
Days off between shift transitions
Policies, practices, procedures indirectly impacting schedule
Seasonal changes to schedule
Built in overtime; desired vs. actual, variability over time
Forecasted overtime
Unanticipated overtime: voluntary/required
Unplanned additional changes to work schedule
Planned changes to work schedule
Unknown schedule (JIT, unanticipated and/or emergent schedules (e.g., reserve, day-of-operations)
Schedule selection process
Employee and management schedule satisfaction
Staffing
Staffing levels : staff to plan, built in relief, coverage of vacations, holidays, sick/personal days, etc.
Staff tenure, retention, turnover
Number of work crews
Training: knowledge, skills, abilities
Job-related classes, coursework, certifications
Cross training
Specific training on coping with shiftwork stress
Safety culture
Managers' Scheduling Certification program
Task Demands
Attentional task demands: vigilance, decision making, precision, quality/quantity; imposed cognitive load; task-related stress
Physical task demands: intensity, duration, frequency, weight lifted, movement vs sedentary, sitting/standing/change in positioning, repetitive movements
Task control

Variable and Sub-variable Attributes
Task support
Task rotation
Seasonal changes to tasking
Safety (metrics; e.g., accidents/errors, near-accidents/errors, reportables, lost work days…)
Productivity metrics
Socio-economic dimensions
Spouse/partner support
Coworker/supervisory support
Organizational support
Social network/support outside family/work
Family responsibilities/child care/elder care
Socio-Economic Status (SES)/financial health
Moonlighting
Union presence
Rapport
Morale
Environmental/ergonomic variables
Lighting: ambient worksite and task lighting
Temperature/humidity
Color
Vibration
Sound/Noise
Aroma
Air quality/ventilation
Chemicals
Ease of access to work equipment/consoles/dashboards
Break rooms
Chair(s): quality/adjustability
Sleep accommodations/Berths
Time zone transitions
Personal living conditions, stress, security issues
Work environment: stress, security issues
Overall living conditions: city vs rural effects
Geography/weather: hours of and in light per day
Close calls reporting system established to confidentially identify precursor safety risks so they can be addressed before becoming serious incidents
Performance traits & practices; individual differences
Perceived locus of control
Coping flexibility/profile (approach coping and active acceptance versus avoidance coping)

Variable and Sub-variable Attributes
Openness for and adjustment to change
Stress resilience/hardiness
Dispositional optimism
Gardner's Multiple Intelligences
Absenteeism
Presenteeism
Activities outside work, physical/mental exertion
Awareness/Insight of fatigue-related concerns
Desire to manage fatigue/reduce risk
Health and Wellness Profiles
Markers (e.g., BP, HR, BMI, weight, neck size)
Diagnosed and undiagnosed medical conditions and predispositions (e.g., obstructive sleep apnea)
Sickness/Illness: Severity, frequency, duration, onset, functional impact
Sleep hygiene; sleep quantity, quality
Preemptive napping
Exercise (frequency, duration, intensity, type)
Wellness/quality of life training/metrics
Physical agility, capabilities, limitations
Nutrition/timing and content of meals
Disability/Injury: onset, severity, duration, triggers
Sick days
Workers' Comp metrics
Personalized Fatigue Risk Management (PFRM)
Medications: prescribed and OTC
Alcohol and other drugs not prescribed
Caffeine
Perceived health and wellness
Demographics
Years working shift work
Years at current job
Age
Location
Gender
Ethnicity
Cultural norms
Partner status
Children living at home/away