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Judith Gertler and Amanda DiFiore

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13. ABSTRACT (Maximum 200 words)

This report presents the results of a study designed to characterize the work/rest schedules and sleep patterns of U.S. railroad train and engine service (T&E) personnel and to examine the relationship between these schedules and alertness. The methodology was a survey of a random sample of U.S. railroad T&E personnel who completed a background survey and kept a daily log for 2 weeks. The majority of T&E workers are either locomotive engineers or conductors. One-third of T&E workers have fixed work start times with the remainder having variable start times with significant start time variability. The median length of a work period was similar for the two types of schedules; however, limbo time increases total work time for variable workers. Although T&E workers report longer daily sleep than U.S. adults, they report poor sleep quality and high stress levels, particularly those with variable start times. Variable workers engage in supplementary sleep on workdays because of scheduling issues preventing them from planning adequate rest. Variable workers report being less alert than fixed start workers. The Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model predicted variable start workers work at a slightly lower effectiveness level than fixed start workers. Although total work time at low effectiveness is minimal, the total number of labor-h at low effectiveness exceeds 10M annually for the industry.

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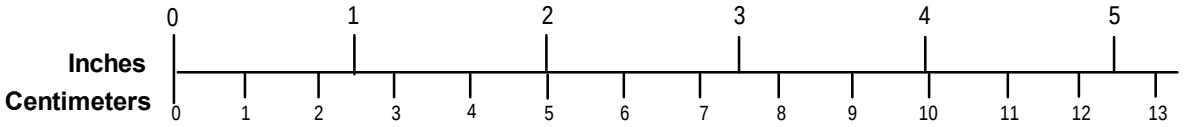

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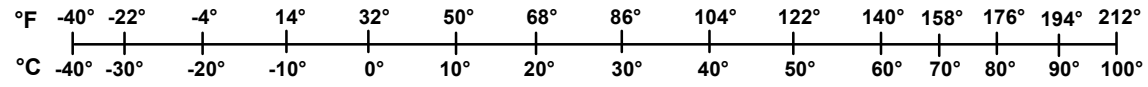

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Contents

Illustrations

Tables

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Finally, the authors express their thanks to the many T&E employees who participated in the study and provided the data, which is the basis for this report.

Executive Summary

The Federal Railroad Administration's (FRA) efforts to improve railroad safety and to reduce the number of injuries and fatalities to railroad workers led the agency to explore the issue of train crew fatigue. A seminal study in 1991 provided insights into the locomotive engineer's sleep and work patterns. Because this study used a sample of convenience rather than a statistical sample, the results were not necessarily representative of all U.S. locomotive engineers. Since this initial fatigue research, FRA has sponsored surveys of three other railroad groups. The purpose of these more recent studies was to characterize, using a consistent statistical survey methodology, the work schedules and sleep patterns of each unique group of railroad workers. Because these three studies used a random sample of each worker population, they provide defensible and definitive data on work/rest cycle parameters and fatigue for the respective group. The present study of train and engine service workers used this same methodology.

This study had two primary objectives:

- To design and conduct a survey to collect work schedule and sleep data from train and engine service (T&E) employees.
- To analyze data to characterize the work/sleep patterns and to identify work schedule-related fatigue issues.

The goal was to characterize U.S. T&E personnel as a group, not to characterize T&E personnel on a specific railroad.

T&E employees operate trains both between terminals and in railroad yard environments. The types of T&E work include road freight, local freight, passenger and commuter operations, and railroad yard operations. There are eight types of positions are in T&E service. The locomotive engineer is in direct control of the train while the conductor is responsible for the train and its crew. A brakeman/trainman may assist the conductor. A yard foreman has responsibilities in the yard similar to those of the conductor in road freight operations. A switchman assists the yard foreman on a yard crew. Yard operations may also include a remote control locomotive operator and car hostler. All of these positions are subject to the limitations of the Hours of Service (HOS) Law that apply to train service employees if the position's duties relate to the movement of a train.

The work schedules of T&E employees may have either a regular starting time or one that varies unpredictably from day to day. Most yard operations, local freight service, and passenger and commuter operations have jobs with regular starting times. Jobs in passenger service may involve a split assignment where individuals work both morning and afternoon peak periods and have time off in the middle of the day. In contrast, T&E workers in road freight service do not have a regular work schedule in terms of either the days that they work or the time that they must report for work.

The research described in this report had three phases: preparation, field data collection, and data analysis. Since no existing source would provide answers to the study's research questions, a survey of T&E employees was the only means to obtain the necessary data. The preparation phase included securing approval from the Office of Management and Budget for the proposed data collection. Representatives from the Brotherhood of Locomotive Engineers and Trainmen

(BLET) and the United Transportation Union (UTU) worked closely with the researchers throughout the study.

Survey Design

The study used two survey instruments—a background survey and a daily log. Survey participants used the background survey to provide demographic information; descriptive data for their type of work, type of position, and work schedule; and a self-assessment of overall health. The daily log provided the means for survey participants to record their daily activities in terms of sleep, personal time, commute to/from work, work time, limbo time, and interim release. Study participants also provided self-assessments of the quality of their sleep and their level of alertness at the start and end of each work period. This study used a 14-day data collection period to accommodate the many T&E workers who do not work a regular schedule.

Researchers drew a random sample of 809 T&E workers. The size of the sample from each of the two unions was proportional to that organization's representation in the total number of eligible participants. Retirees, fulltime union officials, and anyone currently holding a railroad management position were not eligible for the study. Determination of the sample size assumed a 95 percent confidence interval on the estimates for mean sleep time, an error tolerance of 15 percent and a 42 percent response rate.

Mailing of the survey materials occurred on May 9, 2008. Ten days (d) later, every potential survey participant received a postcard, signed by their union president, to encourage them to participate in the survey. Two weeks after distribution of the materials, a second postcard thanked those who had decided to participate and encouraged those who had not yet done so to participate.

Survey Response Rate

The overall response rate for the survey was 33 percent. Table 1 provides a breakdown of the survey responses.

Table 1. Breakdown of survey responses

	Number	Percent
Returned both background survey and daily log	265	32.8
Returned only one survey instrument	19	2.3
No response	525	64.9
Total surveys mailed	809	

Of the 265 complete responses, 15 could not be part of the analysis because either there were problems with their log books or they were not in crafts covered by the survey. (It was not possible to identify these individuals *a priori* from the union membership databases.)

The nonresponse bias study based on age found no difference between survey respondents and nonrespondents.

T&E Worker Demographics

Nearly all of the survey respondents indicated that they worked as a locomotive engineer (49 percent) or conductor (40 percent). Many are qualified to work in more than one position. Similarly, T&E workers may work in more than one type of work, for example, road freight and yard operations. Nearly two-thirds reported working road freight and a third work in yard operations. A third of the T&E employees reported working a job that had a fixed starting time while the starting time for the remainder varied from day to day. Work in yard operations, local freight and passenger/commuter operations typically have a fixed start time while road freight does not.

The average age of a T&E worker is 45 years (yr) and over 40 percent are 50 yr or older. They have, on average, 17 yr of T&E experience, 15 with their current employer. The more experienced T&E workers held positions that had fixed starting times and the less experienced people held jobs with variable start times and irregular schedules. Only 2 percent of the survey respondents were women.

The majority (80 percent) of T&E workers is married, but few have children under the age of 2 yr. In contrast, 69 percent of U.S. males aged 40 to 44 are married. The lack of young children is consistent with the average age of this population.

As a group, T&E employees take more sick days than U.S. adults, yet over 80 percent of T&E workers rated their overall health as good or excellent. There was no difference in ratings between those working a job with a fixed start time and those with a variable start time. However, a difference existed between these two groups in terms of number of sick days taken, 3.2 d for fixed start time and 6.3 d for variable start time. The higher rate of sick time for the variable start group is likely due to marking off sick to catch up on sleep.

Approximately 8 percent of T&E workers reported having a sleep disorder. All of these reported having sleep apnea and two-thirds reported receiving treatment. The rate of sleep apnea is twice the norm for U.S. working adults. Two possible explanations exist: an awareness of the signs and symptoms of sleep apnea and the sedentary nature of a locomotive engineer's job that requires sitting for extended periods of time. (Sedentary jobs may lead to obesity; a known risk factor for sleep apnea.)

Job Characteristics

Two-thirds of T&E workers hold positions with a variable start time. The most common call times for these people are 2 hours (h) at the home terminal and 1.5 h when at an away terminal, although a few reported other arrangements.

Provision for rest days differs between the two types of work schedules. Two-thirds of those with variable start times have no guaranteed rest days while nearly all of those with fixed start times have at least one guaranteed rest day per week.

The median length of a work period (hours:minutes) was similar for the two types of schedules, 8:42 for fixed start and 8:39 for variable start. When limbo time is considered, the total time increases to 8:55 for fixed start and 9:09 for variable start. The median number of work periods is 10 for both groups. Although the total work time is similar for both groups, the median work start time variability is .5 h for fixed start people and 7.1 h for those working jobs with a variable start time. In comparison with data from 1993, today's T&E jobs require more work starts in a 2-week period and have greater start time variability.

Management policies were the greatest source of stress for both schedule groups. The two groups had statistically different ratings for 6 of the 14 sources of job-related stress. Five of these dealt with work schedule and rest.

Sleep Characteristics

As a group, T&E employees obtain longer average daily sleep than U.S. adults. However, sleep length alone does not necessarily predict fatigue. Primary sleep is statistically the same for fixed and variable workers. Daily sleep and the average number of sleep periods on workdays are greater for variable workers. The results suggest that variable workers engage in supplementary sleep on workdays, primarily between noon and 2 a.m., to manage fatigue.

While fixed workers make up their sleep on rest days, variable workers do not have the same opportunity because of the unpredictable nature of their schedules. The variability of their work start time makes it difficult for these workers to plan for rest. Furthermore, variable workers without a call window report interrupted sleep from call centers.

For all of the sleep quality ratings on the survey (e.g., ease of falling asleep, ease of arising, etc.), variable workers consistently rate their sleep quality lower than fixed workers. Compared with fixed workers, variable workers report higher stress ratings related to work schedule and rest. Participants also rate away-from-home sleep of poorer quality than sleep at home. Away-from-home primary sleep is significantly shorter than sleep at home. Because variable workers engage in away-from-home sleep to a greater extent than fixed workers, they are at an increased risk for fatigue at away terminals.

Alertness

Responses to a question on the background survey indicated that more than 60 percent of the fixed start people reported that they were frequently or always alert at work while only 43 percent of the variable start people reported this level of alertness. Self-ratings of alertness from the daily logs confirmed this difference. Differences in alertness ratings between the start and end of the work period also existed based on the length of the work period. This was particularly pronounced for work periods of 9 h or more.

Effectiveness

This study used the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model to predict effectiveness, or lack of fatigue, during time at work. T&E workers with a variable start time were more likely to be working at a lower effectiveness level than those with a fixed start; however, the percent of time working at an unacceptable effectiveness level was less than 8 percent for both groups. Although the portion of total work time at low effectiveness is small, the total number of labor-h at low effectiveness exceeds 10 million annually for the industry.

Textual Analysis of Log Book Comments

A qualitative analysis of the textual comments in the daily logs provides insight into the concerns of T&E workers. Also, the analysis helps explain some of the quantitative data trends. The most frequently mentioned topics are sleep, work schedule, alertness/fatigue, and personal issues. Issues with schedule lineups were initially categorized as work schedule comments. However, numerous comments about problems with the lineup prompted its own category. Lineup is the sixth most frequently mentioned word in the comments.

Findings and Recommendations

The following lists the key findings with respect to T&E workers' health, work schedules, sleep patterns, and alertness:

- T&E workers with variable start time jobs mark off sick at twice the rate of their counterparts in fixed start time jobs (6.3 vs. 3.2 d annually), yet both groups give similar ratings to their overall health. Their rate of sick days is also considerably higher than that for U.S. adult males, 3.9 d. Several possible explanations exist for this more frequent use of sick days. A possible explanation is that this group of T&E workers marks off sick to recover from fatigue because they lack guaranteed rest days.
- The reported rate of diagnosis of sleep apnea among T&E workers is higher than that of U.S. working adult males, perhaps as a result of industry education and wellness programs. Yet, 25 percent of the study participants reported receiving no fatigue education. The opportunity exists for the industry to expand its education efforts on this important subject.
- The number of hours worked did not differ significantly between the two groups of T&E workers. Regardless, for T&E workers with jobs that do not have a fixed starting time, five of the top eight sources of stress related to work schedules and sleep loss. The lack of guaranteed rest days for two-thirds of this group and the high level of variability in their work start times undoubtedly account for work schedules being a major source of work-related stress. The provisions of the Rail Safety Improvement Act of 2008 (RSIA) requiring longer undisturbed rest and guaranteed rest days under certain circumstances may improve this situation.
- Overall, T&E workers get more total sleep on workdays than U.S. adults. Frequently, T&E workers with variable start time jobs have multiple sleep periods in a day due to their erratic work schedule and sleep at an away-from-home location. This compromises the quality of their sleep and its restorative value, as reflected in their sleep quality ratings.
- While the effectiveness analysis with the Fatigue Avoidance Scheduling Tool (FAST) indicates that T&E workers spend a small portion of their work time at a compromised level of effectiveness, the total industry exposure, based on number of T&E labor-hours annually, justifies attention to the issue of fatigue among T&E workers.

Based on the experience of this study, several methodological changes should be a part of future studies of this nature. The following lists the recommended changes:

- *Provide definitions for interim release and limbo time.* T&E workers in road freight service are familiar with limbo time just as people in passenger service understand the meaning of interim release. Lack of familiarity with these terms lead to some innovative uses of those columns in the daily log book. Clear definitions of these terms should be part of the instructions for any future studies of this type.
- *Provide for ratings of multiple work periods in one day.* The daily log included space to rate alertness at the beginning and end of a work period. In a few cases, an individual had two work periods in a day. The log book and instructions did not cover this situation. This issue is of particular concern for individuals working split assignment schedules and

those who complete their regular work period and are called back to work later in the day.

- *Provide a way to capture sleep interruptions.* The present study asked participants to log sleep interruptions exceeding 15 minutes (min). Given the results of the textual analysis with regard to sleep interruptions by call centers, noise, and other sources, future studies of T&E employees should capture the frequency of all sleep interruptions regardless of length.

RSIA requires changes to provisions of the HOS Law. In particular, once RSIA provisions are in effect, there will be a limit on the number of hours that a T&E employee may work in a calendar month and a guarantee for 10 h of undisturbed rest between duty tours. Because most T&E people in road freight service have a 2-h call window at home, this new provision will guarantee T&E workers who are on call 12 h off duty before reporting for a work start. The intent of the new law is to ease the fatigue problem for T&E workers. The new law also requires changes in HOS provisions for passenger service employees; however, the implementation date for those changes will occur later.

The delay in implementation of HOS changes for passenger service T&E workers provides an opportunity for closer study of this subpopulation. The small number of passenger service workers with split assignment schedules (interim release) in the present study did now allow for meaningful conclusions with regard to this subpopulation of T&E workers. However, an opportunity exists now to conduct an additional study that will provide baseline fatigue data from passenger service T&E workers before changes in their HOS requirements occur.

The results of the present study provide a baseline for comparison after the changes prescribed by the new law take effect. Comparison of the results of the subsequent study with those presented here will give an indication of the success of the measures in reducing fatigue in the railroad industry.

1. Introduction

FRA's efforts to improve railroad safety and to reduce the number of injuries and fatalities to railroad workers led FRA to explore the issue of crew fatigue. Beginning in the late 1980s, FRA sponsored two studies, an initial one to examine crew-calling systems and to identify problems that contribute to fatigue and loss of alertness (Pollard, 1991), and a followup study to collect quantitative data on locomotive engineer fatigue and stress (Pollard 1996). This seminal study provided insights into the locomotive engineer's sleep and work patterns, but because it used a sample of convenience rather than a statistical sample, the results were not necessarily representative of all U.S. locomotive engineers.

Since this initial research, FRA has sponsored surveys of other railroad worker groups. The purpose of the more recent studies was to characterize, using a consistent statistical survey methodology, the work schedules and sleep patterns of each unique group of railroad workers. In 2001, FRA decided to begin exploring fatigue of the nonoperating craft workers by initially focusing on signalmen, then maintenance of way (MOW) workers, and most recently, railroad dispatchers (Gertler & Viale, 2006(a); Gertler & Viale, 2006(b); Gertler & Viale, 2007). Because these three studies used a random sample of each worker population, they provide defensible and definitive data on work/rest cycle parameters and fatigue for the respective group. The present study of train and engine service workers used this same methodology.

1.1 Nature of Train and Engine Service Work

T&E employees are the largest group of employees on a railroad. They operate the trains both between terminals and in railroad yard environments. There are several types of T&E work. *Road freight* work involves moving trains over long distances between major terminals or interchange points and frequently requires overnight stays at an out-of-town location. In contrast, *local freight* involves moving trains between a railroad yard and a nearby location, and the employee returns to the starting location at the end of the work period. T&E employees who work in *passenger or commuter operations* usually return to their starting location, but some who work in intercity service may be required to stay at an out-of-town location. Work in a *railroad yard* involves breaking up inbound trains, identifying freight for local delivery, and making up trains of outbound freight.

There are eight types of positions in T&E service. A *locomotive engineer* is in immediate and direct control of the motion of a train and is responsible for obeying all directions and signals as well as controlling train movements and speed between stops. A *conductor* is responsible for the train and its crew. The conductor position usually applies to road freight or passenger service. A train crew may have a *brakeman/trainman*, in addition to a locomotive engineer and conductor. The brakeman is the conductor's assistant. A *yard foreman* has responsibilities in the yard similar to those of the conductor in road freight operations. The person in this position works as a team with the locomotive engineer to break up and assemble trains in a yard. While the brakeman is an assistant to the conductor in road freight operations, a *switchman* is an assistant to the yard foreman on a yard crew. Yard operations may include two additional positions. With the introduction of remote controlled locomotives in yard operations, the position of *remote control locomotive (RCL) operator* has evolved. The RCL operator controls the movement of a specially-equipped yard locomotive from the ground rather than the cab of the locomotive. If the

yard includes a mechanical shop for repair of locomotives, *hostlers* may move engines between the yard track and repair facility.

The HOS Law limits the length of the T&E worker's on-duty period to a maximum of 12 consecutive h in a 24-hour period. After working 12 h, the T&E worker must have at least 10 h off duty before returning to work. If he or she works less than 12 h in a 24-hour period, then the required off-duty period is 8 h. If the employee has 12 non-consecutive h on duty in a 24-hour period, then the Law requires that the employee have only 8 h off before returning to work. The T&E worker may work a total of 16 h (non-consecutive) in a 24-hour period if the individual has at least 8 h off duty between two 8-hour work periods. The HOS Law limits the length of the T&E worker's on-duty period and provides for guaranteed time off, but it does not address either the number of consecutive days that the individual may work or guaranteed rest days.[1]

Although the HOS Law is intended to reduce fatigue and assure that workers are well-rested, situations arise where this is not the case. For example, a locomotive engineer goes to bed at 10 p.m. The railroad notifies the engineer at 4 a.m. that he or she must report for a 6 a.m. work start. The employee goes back to sleep until 4:30 a.m. and then gets up to report to work. The employee works from 6 a.m. to 2 p.m. At 10 p.m., according to the Hours of Service Law, the employee is fully rested and available to work for up to 12 h. If the employee is called at 8 p.m. for a 10 p.m. start of work, the reality is that at most he or she has had only a few hours of sleep before returning to work. In this situation, the employee is sleep-deprived and will be performing safety-critical duties with an increased risk of making an error.

The work schedules of T&E employees may have either a regular starting time or one that varies unpredictably from day to day. Most yard operations, local freight service, and passenger and commuter operations have jobs with regular starting times. Employees on the extra board, in both yard and road freight operations, fill in for regularly assigned T&E workers and as such their work schedule may vary from day to day. Because most yards operate 24 h a day, railroads staff their yards with either three 8-hour shifts or two 12-hour shifts. Jobs in passenger service may involve a split assignment where the individual works the morning rush, has time off in the middle of the day, and returns to work the evening rush. The period of time between the two work periods may be referred to as "interim release." During this period, the employee is off duty but must be available to work if called. If the interim release occurs at a location other than the employee's reporting point, the railroad must provide a quiet room or other facility where the employee may rest. If the interim release period is less than 4 h, it will count as on-duty time in terms of the HOS Law, so there is a disincentive for the railroad to limit the time between the two work periods. The end result is that the time that the employee has before and after work for personal activities and sleep becomes limited.

T&E workers in road freight service do not have a regular work schedule in terms of either the days that they work or the time that they must report for work. A limited number of collective bargaining agreements have provisions for guaranteed rest days. This situation makes it difficult for the T&E worker to plan his/her sleep and personal activities. In an attempt to assure some

[1] Following the completion of the data collection for this study, Congress passed and the President signed the Rail Safety Improvement Act of 2008 which provides that T&E workers must have 10 h of undisturbed rest in a 24-hour period, regardless of the number of hours worked, and may work no more than 276 h in a calendar month. In addition, RSIA requires that if a T&E employee has a work start on 6 consecutive d, then the employee must have 48 h off duty. RSIA also requires 72 h off duty following seven consecutive work starts.

advance notice to the worker, most collective bargaining agreements stipulate the minimum notice, which is rarely more than 2 h, that the railroad must give the T&E worker before the start of the duty period. This call time may be different for the home and away terminals. In addition, a few agreements also specify a period of time, referred to as the call window, during which the railroad may call the employee to work. In most cases, the employee must be available 24 h a day unless he or she notifies the railroad that he or she is not available to work.

Other situations compromise the start of the rest period. When the T&E worker in road freight service reaches the 12-hour limit of the on-duty period, the employee's rest period may not begin immediately. Frequently a crew reaches this limit, but they have not yet arrived at their destination. When this occurs, they must wait for a relief crew or transportation to the final destination. Sometimes this situation creates the opportunity for a nap depending on railroad policy. This period of time is referred to as limbo time, meaning that it is neither on-duty time nor rest period. Another circumstance that can postpone the start of the rest period involves deadheading (e.g., ride as passengers, not crew, on another road freight train or in other transportation) back to the home terminal. When the crew arrives at the destination terminal, regardless of whether or not they have reached the statutory 12-hour limit, they may be asked to deadhead back to their home terminal. In this situation, the deadhead time is considered limbo time, thus postponing the start of the rest period. Once again, the crew may be able to nap on the return to the home terminal.

1.2 Objectives

This study had two primary objectives:

- To design and conduct a survey to collect work schedule and sleep data from T&E employees.
- To analyze data to characterize the work/sleep patterns and to identify work-schedule-related fatigue issues.

The goal was to characterize U.S. T&E workers as a group, not to characterize T&E workers on a specific railroad.

Specific research issues that the study sought to answer included the following:

- What is the distribution of T&E employees among T&E positions and types of work?
- On average, how many hours does a T&E employee work in 2 weeks? How does the average number of hours worked vary by type of work, position, or work schedule? What is the average length of a work period?
- For employees working jobs with fixed starting times, how does the nominal schedule compare with the actual time worked?
- What are the differences in start time variability by type of work and schedule?
- What is the average daily sleep of T&E employees? How does this compare with other adult populations?
- What is the average length of work period by type of work?

- How does daily sleep vary for T&E workers with fixed start times compared with non-fixed start times? How does daily sleep vary by type of work?
- How does the length of sleep at home compare with sleep away from home? Does the sleep quality differ by location?
- For jobs without fixed starting times, what is the average length of call time? How many T&E workers have a call window? Does the type of call window (24-h or time interval) affect feelings of alertness/sleepiness?
- Does the number of sick days taken vary by type of work or schedule? How does this compare with U.S. adult norms?
- Are work schedule issues major sources of workplace stress?
- To what extent have railroads provided sleep/fatigue education?
- How prevalent is sleep apnea among T&E workers?

1.3 Overall Approach

Since no existing data sources could provide answers to the above issues, a survey of T&E workers was the only means to obtain the necessary work schedule and sleep data. The research project consisted of three phases: preparation, field data collection, and data analysis (see Figure 1). The preparation phase involved designing the survey methodology and procedures, conducting a pilot survey to refine the survey instruments and data collection procedure, securing approval from the Office of Management and Budget (OMB), and preparing the final survey instruments. (Because this survey involved more than nine participants, Federal regulations required that OMB approve the overall study design.) Activities during this phase included discussions with BLET and UTU representatives to assure that the survey instruments had suitable wording and would collect the data necessary to address the research issues. A pilot survey, conducted in parallel with the OMB review process, assured that the survey would capture the data needed to meet the survey objectives.

The second phase of the research consisted of distributing the survey materials and collecting the survey data. Analysis of the survey data was the final phase. A nonresponse bias study validated that no difference existed between the survey participants and the non-respondents. The data analysis methods for the survey data included descriptive statistics, analysis of variance (ANOVA), and textual analysis of the log book comments.

1.4 Scope

This research involved T&E employees working in the United States and covered by the HOS Law. Yardmasters and trainmasters are T&E workers who oversee the activities of the work described in section 1.1. In general, they are not subject to the limits of the HOS Law except in circumstances in which they themselves perform functions comparable to those described in section 1.1. For this reason, yardmasters and trainmasters were not included in the study. The study characterized T&E workers as a group. It did not attempt to characterize T&E employees working for specific railroads. Making recommendations regarding fatigue countermeasures was beyond the scope of the study.

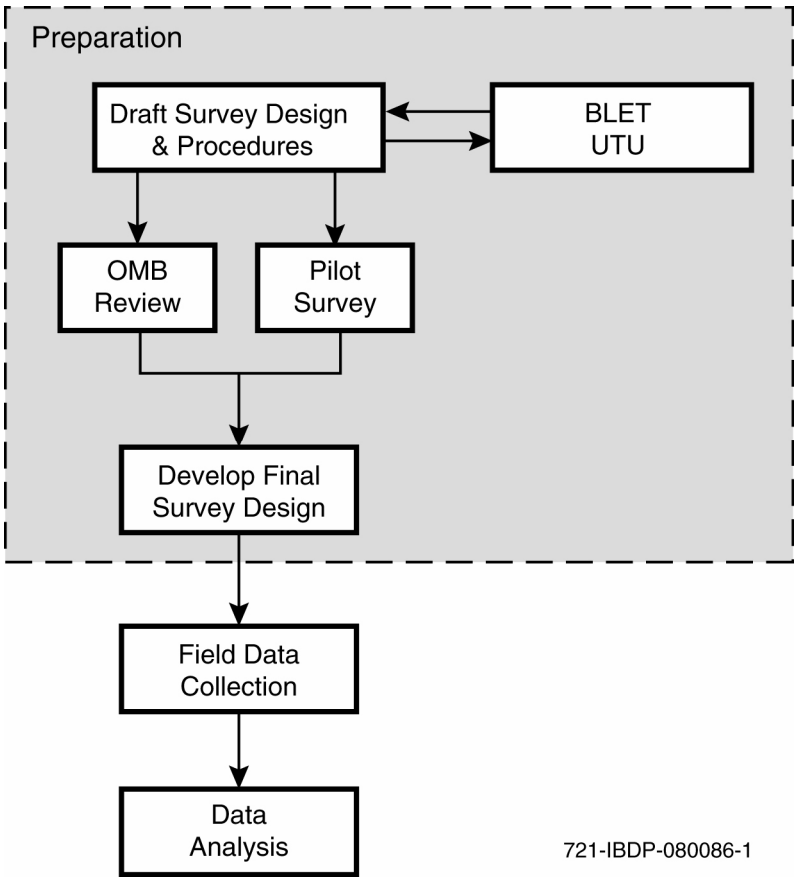

Figure 1. Overall approach

1.5 Organization of the report

Section 2 describes the overall survey design and procedures. Section 3 provides analysis of the survey results, and Section 4 contains the findings and recommendations. A list of the references appears in Section 5. A glossary containing definitions for statistical and railroad terminology used in this report, follows Section 4. The Appendix contains copies of the survey materials. A list of abbreviations and acronyms used in the report follows the appendix.

2. Survey Design

One of the objectives of this study was to characterize the work schedules and sleep patterns of U.S. T&E workers. Achieving this objective required a nationwide survey. The only practical means of reaching these individuals was through their labor organizations, the BLET and the UTU. This section describes the potential respondent universe, the survey instruments, sampling plan, and procedures that the researchers developed to survey this population. This methodology is similar to that used in the earlier studies of railroad signalmen, MOW workers, and dispatchers.

2.1 Potential Respondent Universe

The potential respondent universe was the 86,000 actively working railroad T&E employees in the United States. The majority of U.S. T&E employees, approximately 55,000, are members of the UTU. The remainder belongs to the BLET. There is a very small number of T&E employees who work for short line railroads and are not represented by a labor organization. No way existed to easily identify and contact these individuals so they could not be part of this study.

2.2 Survey Instruments

This study used two survey instruments, a background survey and a daily log. (Copies of both instruments appear in the Appendix.) The background survey gathered demographic information, descriptive data for the T&E worker's current position, type of work, and work schedule. The purpose for collecting this data was twofold. First, it provided data for characterizing the U.S. T&E worker population. Second, it provided identifying data that researchers used in conjunction with the daily log to characterize the work/sleep patterns by the two primary types of work schedule: regular starting time and variable starting time. This instrument also asked participants to rate, using a Likert scale of 1 to 4, potential sources of stress at work. In addition, the background survey included a list of life stress events. In the event that a participant's daily log indicated frequent nighttime awakenings or excessive fatigue, the researchers could use the individual's response to this section of the background survey to assure that no nonwork circumstances were confounding the survey data. Completion of the background survey required less than 15 min.

The daily log provided the means for survey participants to record their daily activities in terms of sleep, personal time, commute to and from work, work, limbo time, and interim release. T&E workers recorded the start and end time of each activity in a graphical format. They also provided self-assessments of the quality of their sleep and their level of alertness at the start and end of each work period. These subjective assessments used a five-point Likert scale. The daily log included space to record "Comments on Today's Activities." The instructions for the log encouraged participants to use this space to explain anything unusual about the day's activities. These comments proved useful in understanding an irregular work or sleep pattern and, in general, complemented the study's quantitative findings. Completion of the daily log required less than a total of 10 min daily.

2.3 Data Collection Period

Examination of the relationship between work schedules and fatigue requires data from each person that encompasses at least a full work cycle. Fatigue is cumulative, and its effects on the individual are not readily identified from 1 or 2 d of data. In addition, adequate data must be available from both workdays and rest days so that the individual's ability to compensate for lost sleep on workdays can be assessed. T&E workers with a regular work schedule have a work cycle of 1 week. This study used a 14-day data collection period to accommodate the many T&E workers who do not work a regular schedule.

2.4 Sampling Plan

Both the BLET and the UTU maintain databases with the names, mailing addresses, and date of birth for all of their members. These databases do not include the type of work, current position(s), or whether or not the member's job has a regular work schedule. Only actively working union members living in the United States could be in the sampling frame. Retirees, fulltime union officials, and anyone currently holding a railroad management position were not eligible for the study. The effective sampling frame was 85,594 after these exclusions. A total of 54,610 were UTU members (63.8 percent), and the remainder (30,984) were BLET members (36.2 percent). The researchers drew a random sample from each group. The size of the sample from each of the two union databases was proportional to that organization's representation in the sampling frame.

One of the most important issues in conducting this study was determining how large a sample was necessary for the estimates obtained from the survey data to be reliable enough to meet the objectives of the study. In general, the larger the sample, the greater the reliability of the resulting estimates, but this must be traded off against the expense of a larger sample. The first step in this process was to specify the level of reliability needed for the resulting estimates.

The appropriate sample size, n, for estimating the mean daily sleep time can be computed from the following (Levy & Lemeshow, 1999):

$$n \geq \frac{(z^2 N V_x^2)}{z^2 V_x^2 + (N-1)e^2}$$

where z = reliability coefficient (1.96 for 95 percent confidence level)

N = population size

V_x = unknown population variance

ε = error tolerance

This estimation for sample size applies as well to other mean values, such as work and commute time, that the study seeks to estimate.

Webb (1992) estimates the standard deviation for daily sleep for the general population is 1 h (Webb, p. 72). Applying this estimate of standard deviation (and hence V_x, variance) to the T&E employee population (N = 85,594) and using an ε = .15 (±.075), there must be 340 (n) in the sample. Because it was not possible to know *a priori* the type of position or type of work that each BLET and UTU member works, a stratified sample was not possible.

Because not every BLET and UTU member who is selected to participate in the survey would choose to do so, oversampling was necessary. The extent of oversampling was a function of the anticipated response rate. The researchers assumed a 42 percent response rate. This is the average of the response rate from the three prior surveys of this type. (The already completed signalmen, MOW, and dispatcher surveys achieved response rates of 50 percent, 30 percent, and 46 percent, respectively.) If 42 percent of the selected individuals in the random sample decide to participate in the survey, then the random sample must be 809 (340/.42) to yield 340 participants.

2.5 Procedure

In accordance with government regulation, FRA sought approval for the proposed survey from OMB. OMB approved this collection of information under OMB control number 2130-0577 on April 30, 2008.

Concurrent with submittal of the OMB application, the researchers conducted a 1-week pilot survey with eight participants. The purpose of the pilot survey was to refine the data collection procedures and survey instruments. Both BLET and UTU assisted the researchers in identifying suitable participants for this pilot survey. People working yard jobs, road freight, local freight and commuter operations participated in the pilot survey. The study participants also represented both regular and nonregular starting times. Pilot study participants completed the Train and Engine Service Employee Background Survey and Train and Engine Service Daily Log as well as a brief Post-Survey Feedback Form to provide feedback on the survey instruments and procedures. Similar to the full survey, pilot survey participants received a $75 gift certificate to a national retail establishment. Based on the experience with the pilot survey, the researchers made the following changes in the background survey:

- A question was added to ask about the number of times the employee checks the lineup.[2]
- A question was added regarding guaranteed rest days.
- A "none" option was added to the question regarding fatigue education.
- "Irregular work schedule" was added to the list under Stress at Work.

Changes to the daily log were the following:

- The time scale was changed to military time.
- A fifth activity category, interim release, was added.
- Two minor errors in the sample entry were corrected.

In addition, problems that pilot participants had in recording data in the daily log necessitated refinements to the instruction sheet.

Following the pilot survey and prior to mailing the survey materials, an article describing the upcoming survey was posted on the Web sites of both BLET and UTU.

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[2] The lineup is the list, by time, of trains expected to leave the terminal. By knowing the expected departure time of trains and the employee's position on the crew call list, the employee can estimate when he or she will be called to work.

The researchers drew a random sample of 299 BLET members and 510 UTU members, without replacement from the sampling frame derived from the two membership lists. The package mailed to each participant on May 9, 2008, consisted of the following items:

- *Train and Engine Service Employee Background Survey* in booklet form. Each page was 5.5 x 8.5 in, printed on white paper with no questions on the cover page.
- *Train and Engine Service Employee Daily Log* in spiral notebook form. Each page was 5.2 x 6.5 in. The Daily Log included 14 sections, one for each day of the data collection period. Brief instructions and a sample entry appeared at the beginning of the log book.
- *Cover letter* signed by the President of the T&E employee's labor organization. This letter explained the purpose of the study and encouraged participation.
- *Instructions* explaining the survey procedures and how to complete the daily log.
- *Return envelope*, postage paid.
- *$5 bill.*

Copies of the cover letters and instructions appear in Appendix A along with the survey instruments.

All materials were printed on high quality paper, and each letter was individually addressed to the recipient. The instruction sheet was printed on yellow paper to increase the likelihood that recipients would read it. The mailing envelope for the survey packet used the union return address rather than Foster-Miller, because it would be familiar to recipients. The purpose of the $5 was to encourage participation. Those who returned both the background survey and daily log also received a $75 gift certificate to a national retail establishment.

The instructions emphasized that 14 consecutive d of data should be provided and that data should not be reported during vacation periods. Both the instructions and the log included contact information for two Foster-Miller staff members who were available to answer questions regarding the survey instruments and procedures and to provide additional copies of the survey materials.

Ten d after distribution of the survey materials, every survey recipient received a postcard, signed by their union president, to encourage them to participate in the survey. Two weeks after distribution of the materials, every survey recipient who had not yet returned the survey materials or indicated that they were not interested in participating, received a second postcard to thank those who had decided to participate and to encourage those who had not yet done so to participate in the study. The second postcard also established July 15 as the deadline for returning survey materials and provided a Foster-Miller contact for duplicate survey materials.

3. Analysis of Survey Data

This chapter presents the survey findings based on data provided in respondent background surveys and daily logs. The results are organized into the following subtopic headings:

- Survey response rate
- Nonresponse bias study
- T&E worker demographic characteristics
- Job characteristics
- Sleep characteristics
- Alertness
- Effectiveness on the job
- Textual data

This study used a confidence interval of 95 percent. The researchers used SPSS 15.0 to analyze the survey data and ATLAS.ti® V 5.5.9 for textual analysis.

3.1 Survey Response Rate

The survey materials were mailed to 809 Train and Engine Service Employees. A total of 265 respondents returned both the background survey and the activity/sleep log. Fifteen respondents replied with both survey instruments but their data were not a part of the analysis because either there were problems with their log books or they were not in crafts covered by the survey. (In some locations, UTU represents all employees. Excluding non-T&E people from the sampling frame was not possible because the UTU database does not identify members by craft.) One individual was a member of both UTU and BLET and was in the random sample from each group. This individual returned two sets of survey materials so only one was used. Nineteen individuals returned only one of the survey instruments and thus were not a part of the analysis. Nineteen individuals responded that they did not want to participate in the survey. The overall response rate was 33 percent. The final analysis used data from 250 respondents who returned both survey instruments. Because the number of usable responses was less than the target level of 340, the effective error tolerance (ε) is 0.175 or $\pm$.0875.

3.2 Nonresponse Bias Study

The OMB requires a statistical analysis assessing response bias if the response rate of a survey is less than 75 percent. The purpose of this analysis is to determine whether or not respondents differ from non-respondents with respect to personal characteristics.

Personal information for non-respondents was limited to information from the union membership databases. In addition to each member's address, these databases contain members' birth dates. Birth date (or age) is an appropriate variable to use for assessing nonresponse bias as sleep patterns are known to change as an individual ages (Van Cauter, Leproult, & Plat, 2000). In addition, age is positively correlated with years of experience. Therefore, experienced personnel

with more seniority may get to choose convenient work schedules and as a result be more rested than individuals with less seniority.

The 265 individuals who returned both survey instruments were respondents. The remaining members of the sample were nonrespondents. One member did not have available birth date information and was not included in the nonresponse bias study reducing the number of non-respondents to 543. An analysis comparing the mean age of respondents and non-respondents found no significant difference, $t(806) = 1.83$, $p = 0.067$. The t value was adjusted for unequal variances.

3.3 T&E Worker Demographic Characteristics

This section provides demographics, as well as basic job-, family-, and health-related information based on responses in the background survey. Where appropriate, the study includes comparisons of the study results with national norms.

Characterization of the T&E workers considered many factors. These factors are sex and age, type of position and type of work, experience, overall health, sick days taken, incidence of sleep disorders, and caffeine consumption.

3.3.1 Sex and Age

The T&E workforce is predominantly male. Only 2 percent of the usable survey responses were from females so reporting of results by sex was not meaningful.

Survey respondents have an average age of 45.4 yr, and their median age is 46 yr. As is common with other railroad craft groups, this is an aging workforce with over 40 percent being 50 or older. Figure 2 contains the age distribution of survey respondents. The response rate among the 20–29 and 60-plus age groups was lower than that for the other age groups thus showing them as a smaller proportion of the work force.

Research has found that a higher perceived age, relative to chronological age, can be an indicator of chronic stress and poor psychological well-being (Barnes-Farrell & Piotrowski, 1989, 1991). Overall, T&E workers reported a lower perceived age (41.2 yr) in comparison with their average chronological age (45.4 yr). As shown in Table 2, the T&E population tends to feel younger as they age. This is the same pattern that Barnes-Farrell and Piotrowski found with permanent day shift workers in a manufacturing plant. They point out that younger people tend to report feeling older to reflect perceived maturity. The T&E workers' perceived age follows the pattern reported by these researchers and, as such, is not indicative of poor psychological well-being. Statistical analysis confirmed the differences in perceived versus chronological age, χ^2 (8, N = 243) = 29.15, $p < .001$.

3.3.2 Type of Position

Many T&E workers are qualified to work in more than one position. For example, a remote control operator may also be qualified as a conductor. For this reason, some survey respondents reported working more than one type of position. Nearly all of the survey respondents indicated that they worked as a locomotive engineer (49 percent) or conductor (40 percent). A total of 11

percent reported working as a switchman, brakeman or trainman, 8 percent worked the position of yard foreman, and 7 percent were RCL operators.

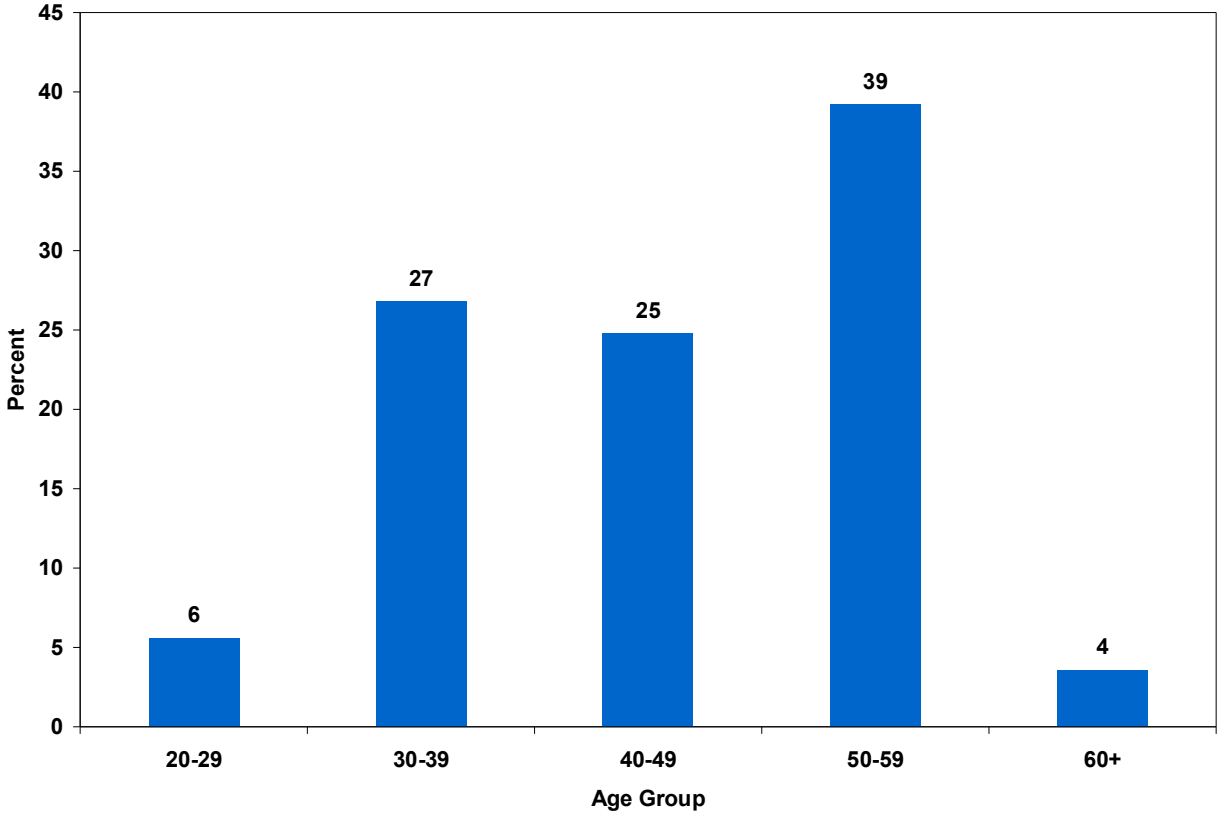

Figure 2. Distribution of respondents by age group

Table 2. Discrepancies between chronological and perceived age by age group (percent)

	Worker Age (yr)				
Age Perception	**20-29**	**30-39**	**40-49**	**50-59**	**60+**
Younger	28.6	42.4	64.4	66.3	88.9
Same Age	21.4	25.8	22.0	24.2	11.0
Older	50.0	31.8	13.6	9.5	0

3.3.3 Type of Work and Work Schedule

Railroads use T&E employees in several different types of work. They may work in road freight, yard operations, local freight, or passenger operations. Approximately 2 percent of respondents reported work other than that previously listed. Most of these individuals were trainers. As in the case of type of position, some may work in more than one type of work, for

example, road freight and yard operations. Nearly two-thirds reported working road freight and a third work in yard operations (see Figure 3). Nearly a quarter worked in local freight operations and a small number, 7 percent, worked in passenger operations. Overall, 21 percent of respondents reported exposure to more than one type of work

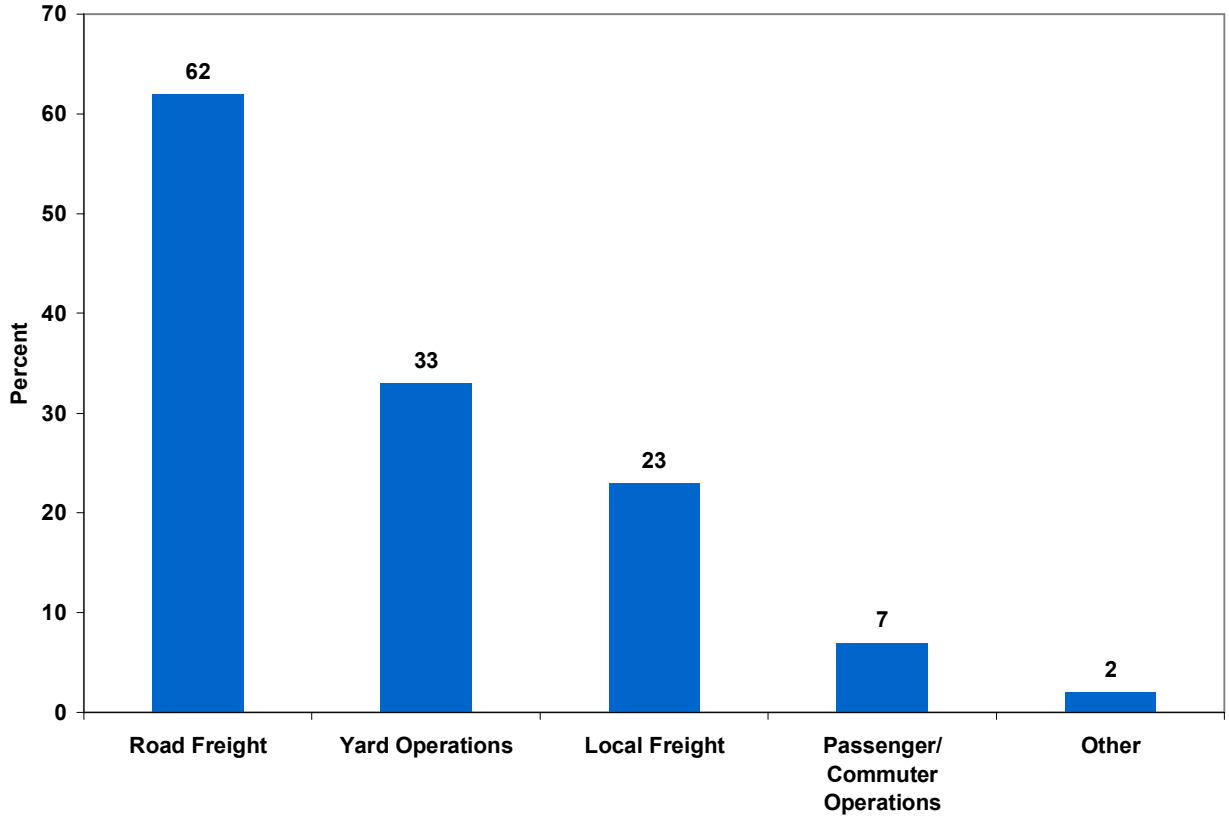

Figure 3. Type of T&E work

A third of the T&E employees reported working a job that had a fixed starting time while the starting time for the remainder varied from day to day. Eighty-five percent of those working a job with a variable start time held road freight jobs. Yard operations accounted for more than half of those with a fixed start time; local freight and passenger/commuter operations each accounted for 15 percent.

The researchers felt that work schedule, as characterized by the start time, was a key determinant of work-related fatigue. For this reason, the analyses that follow compared two T&E groups on the basis of the regularity, or lack of regularity, of their work starts.

3.3.4 Experience

Overall, T&E workers who participated in the study have an average of 17.2 yr of T&E experience and 15 yr with their current employer. Since their average age is 45.4 yr, this group worked in either another industry or another railroad craft prior to working in train and engine service. T&E workers with more experience tend to work the jobs with a fixed start time, as

Table 3 illustrates. Because jobs are chosen by seniority, those with more experience select the more desirable jobs, which have regular schedules.

Table 3. Years of T&E experience by type of schedule

	Schedule*	Mean (Std. Dev.)	Median
Total experience	Fixed start	23.5 (13.6)	29.5
	Variable start	14.0 (11.7)	9.9
Experience with current employer	Fixed start	19.1 (12.9)	17.2
	Variable start	12.9 (11.1)	9.7

*Total experience comparison between fixed and variable start, $t(248) = 5.74$, $p < .001$
Current experience comparison between fixed and variable start, $t(248) = 3.97$, $p < .001$

3.3.5 Marital and Family Status

Most recent population data from the U.S. Census indicates that 68.6 percent of U.S. males age 40 to 44 are married (U.S. Census Bureau, 2007). For the U.S. male population 18 and older, 59.9 percent are married. At the time of the study, 80 percent of the respondents were married, 10.8 percent single, 7.2 divorced, 0.8 widowed and 1.2 categorized themselves as other. (These people were likely separated or living with a partner.) Because many railroaders report that their work schedule strains marital relationships, finding such a high proportion of T&E people who are married was surprising. This data, however, does not indicate whether or not the married individuals were in an initial marriage or one subsequent to a divorce.

The survey asked participants whether or not their family included young children, a factor that can lead to disrupted sleep. Although a large percentage of the group is married, only 10.3 percent had children under 2 yr. This finding is not surprising given the average age of a T&E worker.

3.3.6 Health

A recent study of the health of the American workforce (Aumann & Galinsky, 2009) found that 79 percent of the respondents rated their overall health as good (51 percent) or excellent (28 percent). The T&E background survey asked an identical question. Participants rated their health as excellent, good, fair or poor. A total of 86 percent of T&E workers rated themselves in good (62.4 percent) or excellent (23.6 percent) health. The difference in perceptions of overall health between T&E workers and the U.S. workforce may be due to the availability of health insurance to all T&E workers.

Analysis of these responses by work schedule found no difference in perceived health between those working a job with a fixed start time and those with a variable start time, χ^2 (3, $N = 248$) = 1.18, $p = 0.76$. The self-assessment of health did not differ between the two groups based on type of schedule, but a difference existed in terms of the number of sick days taken. Those with a fixed start time averaged 3.2 sick days while those with a variable start averaged 6.3 d (see Table 4). These means were statistically different by work schedule, $t(247) = -3.87$, $p < 0.001$.

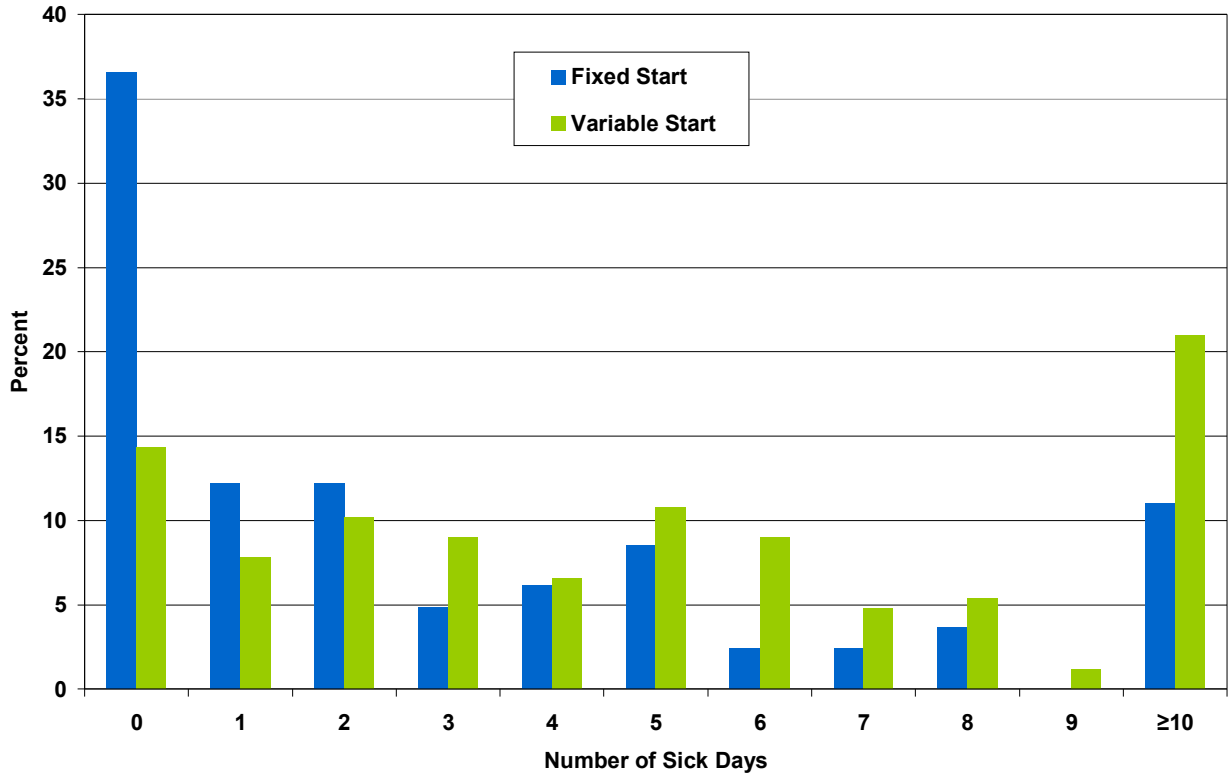

Figure 4. Sick days by type of schedule

As a group, T&E employees take more sick days than U.S. adults (see Table 4). Those with a variable start, who comprise two-thirds of the total, average 6.3 sick days per year. In fact, the T&E workers with a variable start exceed the mean sick days for U.S. adults, U.S. adult males, age-based subsets of U.S. adults, and U.S. adults with private health insurance. Because no difference exists in how the two groups of T&E workers rate their health, it is likely that the T&E employees working jobs with a variable start are marking off sick to catch up on sleep or to handle personal business. Comments in the daily logs support this explanation.

3.3.7 Incidence of Sleep Disorders

The Wisconsin Sleep Cohort Study, a longitudinal study of cardiopulmonary sleep disorders among middle-aged working adults, estimated that 2 percent of women and 4 percent of men have sleep apnea (Young, et al., 1993). (The definition of sleep apnea for this study was an apnea-hypopnea score of 5 or higher and daytime hypersomnolence.) The National Sleep Foundation (NSF) and the National Institutes of Health report the numbers from the Wisconsin study as an estimate of the prevalence of sleep apnea among U.S. adults. Some sleep researchers hypothesize that the prevalence of sleep apnea may in fact be higher because many remain to be diagnosed. According to the Wisconsin study, 9 percent of women and 24 percent of men have undiagnosed sleep-disordered breathing, a condition that in some people results in excessive daytime sleepiness.

Table 4. Comparison of T&E annual sick days with U.S. working adults

Group	Mean Work-Loss Days
All T&E	5.3
T&E Fixed Start	3.2
T&E Variable Start	6.3
U.S. Adults*	4.1
U.S. Adult Males*	3.9
U.S. Adults Age 18-44 *	3.7
U.S. Adults Age 45-64 *	5.0
Private Health Insurance (<age 65 yr)*	4.0

*U.S. Department of Health and Human Services, 2007

Of the 250 participants in this study, 21 or 8.4 percent reported having a sleep disorder. All reported having sleep apnea. Two-thirds of those reported receiving treatment. The remaining third may have mild to moderate sleep apnea which does not always require treatment or these individuals may have chosen not to seek treatment. Two possible reasons exist as to why this group's incidence of sleep apnea is twice that of the reported norm for U.S. middle-aged working males. Railroad and labor educational and wellness programs, as well as media publicity, in recent years may have made this group of railroad employees more cognizant of the symptoms of sleep apnea and its consequences and caused them to seek medical evaluation. In addition, the job of a locomotive engineer is a sedentary job that requires sitting in one place for extended periods of time. Sedentary jobs may lead to weight gain, which exacerbates sleep apnea.

3.3.8 Fatigue Education

The background survey asked about participants' exposure to educational materials or training on fatigue, sleep hygiene, napping, or sleep disorders. Three quarters reported having some type of fatigue education, but a quarter reported that they never had this type of training. The most common types of training were a videotape or brochure (see Figure 5). Some reported more than one type of fatigue education.

3.3.9 Use of Caffeine

NSF reports that 250 mg of caffeine a day, the equivalent of a soda and a couple of coffees, generally poses no harm. Almost all participants (92.4 percent) reported consuming caffeinated beverages on a daily basis, and those who did, average four beverages per day. This level of caffeine consumption is within normal healthy limits, and T&E workers' sleep, in general, is not likely disrupted because of caffeine, unless caffeine consumption occurs close to a sleep period (NSF, 2002).

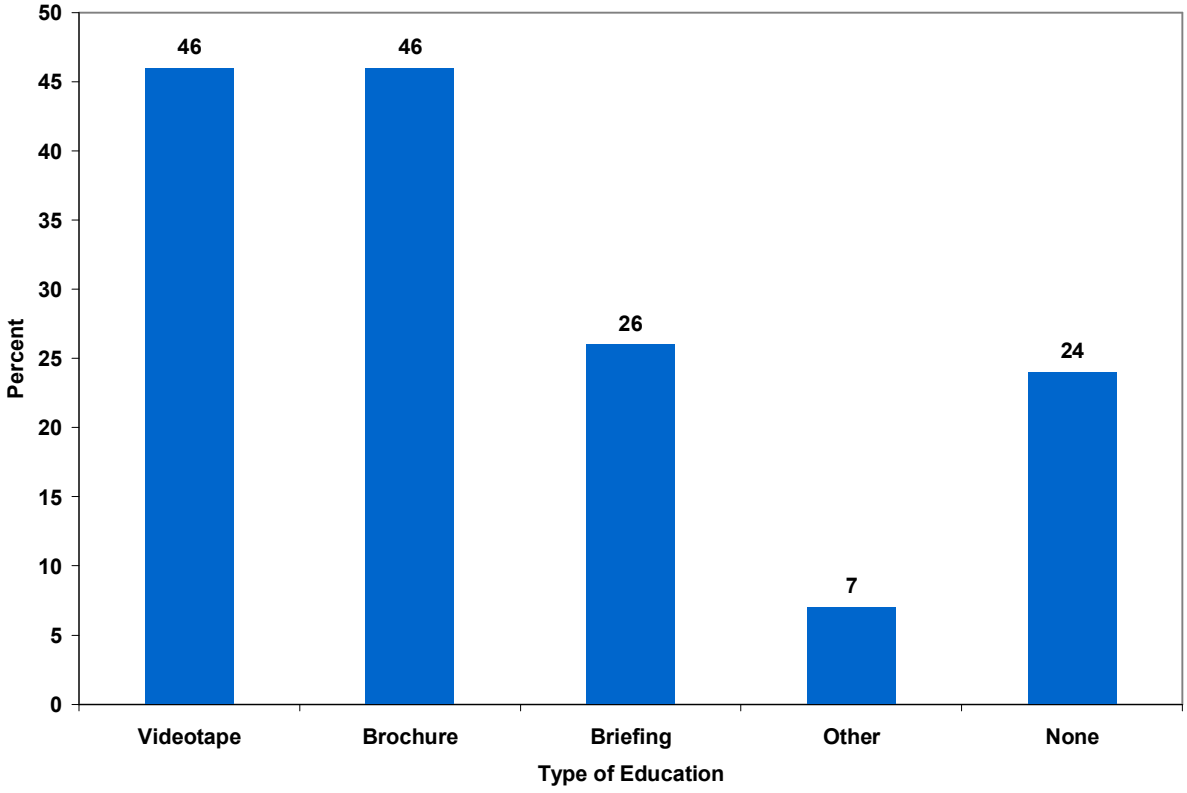

Figure 5. Exposure to fatigue education

3.3.10 Summary of T&E Worker Demographic Characteristics

Participants in the study reported an average age of 45.4 yr. Only 2 percent are female. Nearly two-thirds work in road freight and a third work in yard operations, and over a third perform more than one type of work. A third holds a job with a fixed start time and the remainder hold jobs where their start time varies. Overall T&E workers have over 17 yr of T&E experience, nearly all of it (15 yr) with their current employer. Those with more experience hold the jobs with a fixed start time. Eighty percent are married but only 10.3 percent have children under the age of 2 yr. A total of 86 percent rated themselves in good or excellent health, but T&E workers whose jobs have a variable start time take more sick days than U.S. working adults. Over 8 percent of T&E workers report having sleep apnea but a third is not receiving treatment.

3.4 Job Characteristics

This section explores several aspects of the T&E worker's job, including work/rest schedule, hours worked, start time variability, call time, and sources of workplace stress.

3.4.1 Call Time

T&E workers who work a job with a variable start time have a call time associated with their job. These would be people either working road freight jobs or holding extra board jobs. Call time is the amount of advance notice that the employer must give the employee of the start of the work

period. More than half of these people have a 2-h call time at home and 1.5 h at an away terminal, but there is some variation, as shown in Figure 6. Most T&E people are subject to call 24 h a day, but 5 percent reported that they have a limited call window when the railroad may call them for work, such as 6 a.m. to 3 p.m.

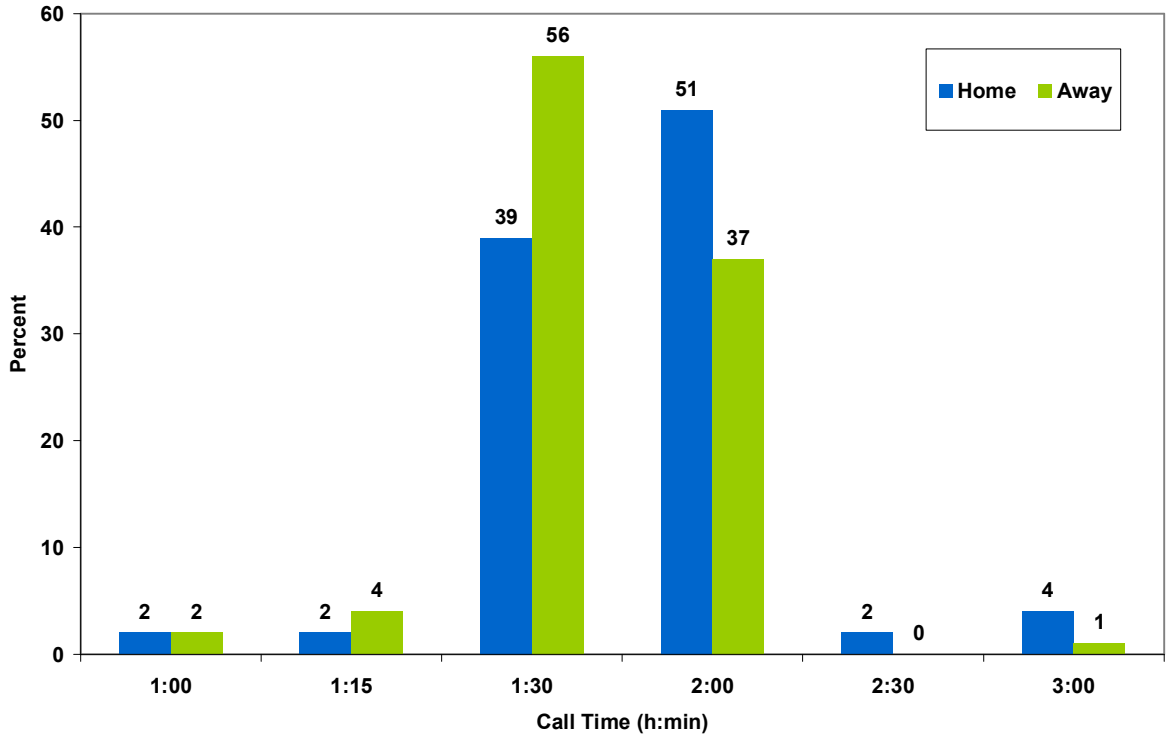

Figure 6. Call time by location

3.4.2 Rest Days

Provision for rest days differs between the two types of work schedules. Two-thirds of the people with variable start times have no guaranteed rest days, while 81 percent of those with fixed start times have 2 consecutive rest d per week (see Table 5). The provision for guaranteed rest days was statistically different by type of schedule, $\chi^2(4, N = 250) = 181.5$, $p < 0.001$.

Table 5. Guaranteed rest days by type of schedule

Guaranteed Days	Fixed Start	Variable Start
None	1.2%	65.9%
2 d per week	1.2%	0%
2 consecutive d per week	80.7%	2.4%
1 d per week	12.0%	13.2%
Other	4.8%	18.6%

3.4.3 Hours Worked

Through the background survey, the study collected data on a nominal workweek and a typical workweek. For people working jobs with a fixed start time, their nominal workweek was 40 h. Jobs with a variable start time by their nature do not have a nominal workweek. Using the daily log book, T&E workers recorded their actual work hours. The actual hours worked included work as well as limbo time and interim release. In addition, they recorded their commute times.

Table 6 summarizes the work periods for the two groups of T&E workers based on the type of start time. Those with a fixed start time reported that they typically work 43 h per week (or 86 h in 2 weeks) while those with a variable start reported typically working 54 h per week. The actual work reported in the log books of those with fixed start times was close to their typical work but this was not the case for those working jobs with variable start times. Either the survey period was atypical for this group or they tend to recall the longest workweeks that they experience. The average length of the individual work periods was similar for both groups, as Table 6 indicates, but those in the variable start group were more likely to have work periods of 10 h or more (see Figure 7).

A General Accounting Office (GAO) analysis of 1990 engineer schedule data from four railroads found 63.4 percent of the work periods to be less than 8 h (GAO, 1992). This finding differs from the results of the present study where the median work period exceeded 8 h. In addition, the GAO study found 3.1 percent of the work periods exceeded 12 h whereas the data reported in the present study had 8.1 percent of fixed start time work periods and 9.2 percent of variable start time work periods exceeding 12 h. Using the GAO results as a point of comparison, it appears that T&E people are working longer shifts now than they did in 1990. Because engineers and conductors work the same schedules, the fact that the GAO analysis considered only engineer schedules does not affect this comparison.

A subsequent GAO analysis examined shift lengths of engineers working yard and mainline (road) jobs at CSX and Conrail (GAO, 1993). For both CSX and Conrail, as in the present study, the average yard shift was slightly longer than the shift for a mainline engineer. The 1993 GAO study found the median number of work starts in a 2-week period to be 8 while the individuals in the present survey had a median of 10 work starts for 2 weeks (see Table 7). This second GAO study also examined start time variability. Start time variability is the difference in start time, in hours, between consecutive work starts. It is of concern because a variable schedule may make it difficult for the individual to plan and get adequate rest between work periods.

Table 6. Work in 2 weeks (h:min)

	Fixed Start					Variable Start				
	Mean	**Median**	**Std. dev.**	**1st quartile**	**3rd quartile**	**Mean**	**Median**	**Std. dev.**	**1st quartile**	**3rd quartile**
Typical work*	98:00	96:00	10:11	40:00	55:00	110:00	108:00	13:09	48:00	62:00
Actual work	90:53	86:17	17:13	79:30	102:36	85:17	84:12	23:49	69:14	101:20
Length of work period	8:52	8:42	1:50	7:51	10:07	8:54	8:39	1:30	7:55	10:02
Actual work + limbo	91:29	86:47	17:38	79:47	103:43	87:31	86:35	24:47	70:53	105:02
Length of work period + limbo	8:55	8:51	1:53	7:51	10:06	9:09	8:56	1:38	8:05	10:25
Actual work + limbo+ commute	101:20	96:07	25:13	86:36	121:53	99:30	97:19	25:34	83:16	114:07
Length of work period + limbo + commute	10:12	10:10	2:07	8:48	11:31	10:15	10:03	1:44	9:06	11:40
Number of work starts	10.6	10	2.5	9.3	11.0	9.7	10	2.5	8	11.0

*Reported in background survey. Remaining data in table from daily logs.

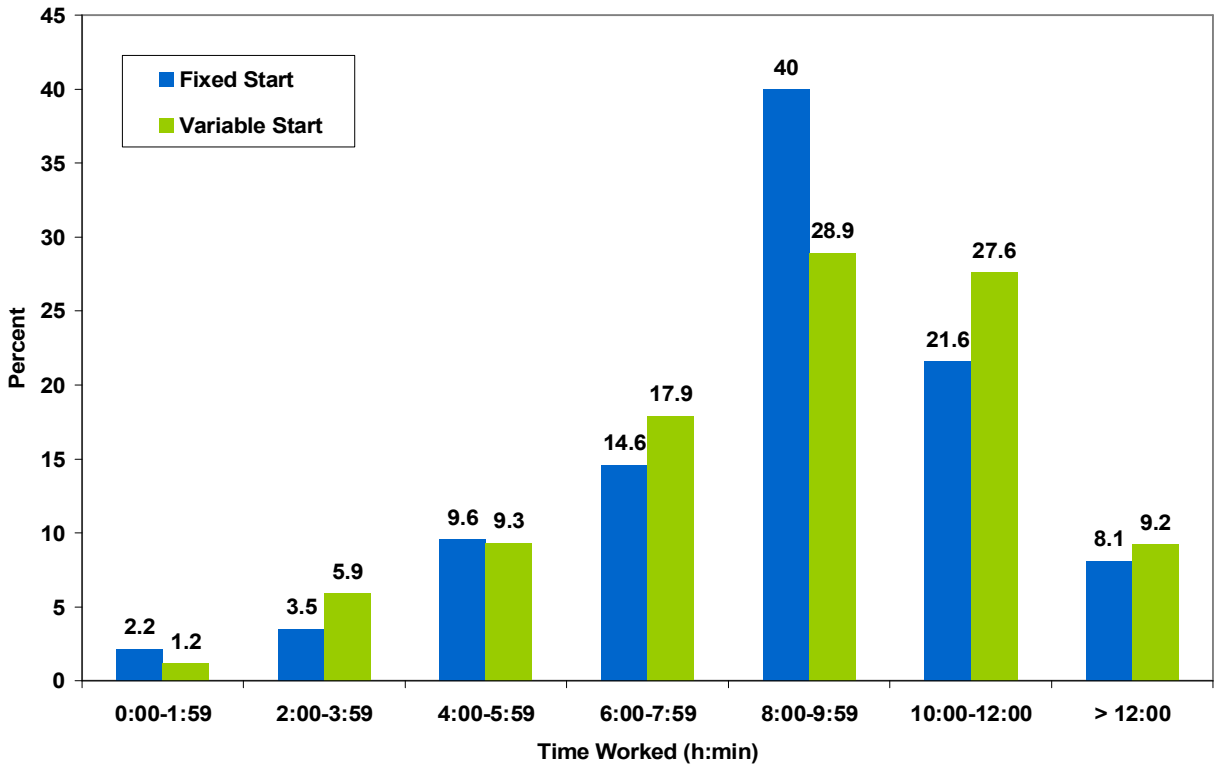

Figure 7. Frequency of work period length by schedule type

Table 7. Number of work starts in 2 weeks

	Mean	Std. dev.	Median	1st quartile	3rd quartile
Fixed Start	10.6	2.5	10	9.3	11.0
Variable Start	9.7	2.5	10	8.0	11.0
CSX*	7.8	n/a	8	6	10
Conrail*	7.6	n/a	8	6	10

*Source: GAO, 1993.

Table 8 presents several statistical measures of start time variability for the present study along with the results from the 1993 GAO study. These data, from both the present study and the GAO study, suggest several differences between the schedules of fixed start or yard jobs and those of the variable start or mainline jobs. First, the average start time variability for fixed start jobs is less than half that of the variable start time jobs, and half of the fixed start work periods have little or no start time variability; the median variability for CSX and Conrail is 0 h, for the survey it is .5 h. The survey data indicate that a quarter of the variable start jobs have a start time variability of nearly 9 h or more. In comparison with the earlier CSX and Conrail data, it appears that T&E work schedules today have more start time variability than was true at the time of the GAO analysis

Table 8. Work start time variability (h)

	Mean	Std. Dev.	Median	1st quartile	3rd quartile
Fixed Start	3.3	5.0	.5	0	6.6
CSX Yard*	2.2	n/a	0	0	4.3
Conrail Yard*	1.6	n/a	0	0	1.4
Variable Start	7.1	2.7	7.1	5.1	8.9
CSX Mainline*	5.2	n/a	4.9	2.3	8
Conrail Mainline*	4.7	n/a	4.3	1.8	7.4

Source: GAO, 1993.

The variable nature of the T&E worker's job is further complicated by the fact that the worker may be asked to work off his or her regular assignment. This may mean working a different shift, if the worker has a yard job, or working from a different home terminal, if the worker is in freight service. On average, those with fixed start jobs were used off their regular assignment 6.3 times in the past year and those on variable start jobs averaged 4.8 times; however, the median number of nonregular assignments for fixed start jobs was 0 and for variable start jobs it was 2.

T&E employees working variable start jobs check the lineup to estimate when they might be called to work. This is a key strategy that they employ in trying to plan their rest and personal activities. On average, they reported checking the lineup five times a day. Those working jobs with regular start times have no need to employ this strategy.

T&E employees working road jobs frequently reach the statutory limit of 12 h on duty and find themselves on limbo time before finally reaching their release point when their rest period begins. If the limbo time is added to the work period time, the average work period for people with fixed start jobs increases only 3 min and for those with variable start jobs, the average work period increases by 15 min (see Table 6). As Figure 7 illustrates, 9.2 percent of the work periods for jobs with variable starts exceeded 12 h. When limbo time is added to the work period, 16.2 percent of the variable start and 10.2 percent of the fixed start work periods exceeded 12 h. This means that a T&E worker on a fixed start job is likely to have to work more than 12 h in one out of every 10 work starts whereas a T&E worker on a variable start job is likely to work this length of time in one out of every six work starts.

RSIA limits total time on duty, including limbo time, to 276 h in a calendar month. Another provision of RSIA provides that after an employee has work starts on 6 consecutive d, the individual must have at least 48 hr off duty, and after 7 consecutive d, the individual must have at least 72 hr off duty. While these restrictions were not in place at the time of the survey, the survey data provides an indication of the extent of the impact that these new limits will have on T&E work schedules.

By extrapolating the 14 d of survey data to 30 d, it is possible to estimate the number of T&E workers who likely exceeded this limit during the study period. There were 232 survey respondents whose diaries had complete work histories for 14 d. Of these, 12 (5.2 percent),

exceeded the new statutory limit. Of the 12, two worked a job with a fixed start time and the remainder worked jobs with variable start times.

In terms of work starts, there were 49 instances of six or more consecutive work starts. Of this total, 16 occurred at the end of the 14-day survey period so it was not possible to determine whether or not there was a subsequent rest period. Of the remaining 33 occurrences, there were 17 six-day work starts followed by a break; 13 had less than 48 hr before the next work start. For the occurrences of seven consecutive starts, none had 72 hr before the next work start. In fact, 12 of these worked on the following day (see Table 9). These data indicate that 11.6 percent of the survey participants had work patterns that would be disallowed once the rest provisions of RSIA are in effect. The incidence of this work pattern is probably even greater since with the survey data it was not possible to include occurrences where the last day worked was on the 14th day of the survey.

Table 9. Compliance with RSIA rest period requirements (number of occurrences)

Number of consecutive work starts	Length of rest period		
	Meets RSIA requirement	Does not meet new requirement	Total
6	4	13	17
7	0	16	16
Total	4	29	33

When commute time is considered along with work time and limbo time, the total time devoted to work in 2 weeks increases by 10 h for those with fixed start jobs and 12 h for those on variable start jobs. The average time devoted to work increases from 8:55 to 10:12 for people on fixed start jobs but from 9:09 to 10:15 for variable start jobs. These results indicate that those on variable start time jobs live close to their reporting point while those on variable fixed time jobs either live further from their home terminal or are frequently required to travel to an alternate reporting point further from home. When people working road freight jobs are at an out-of-town terminal, if their travel time between lodging and reporting or release point is more than 30 min, this commute time would be reported as limbo or on duty time. For this reason, the 1-hour increase observed for variable start people when commute time is included most likely reflects travel time between the employee's home and the home terminal.

3.4.4 Sources of Stress

In the background survey, T&E workers rated job-related sources of stress. They rate stress using a Likert scale with values from 1 to 4 with 1–no stress, 2–a little stress, 3–stressful, and 4–very stressful. As Figure 8 illustrates, the top stressor for both groups of T&E workers was management policies. Of the 14 sources of stress, statistically different ratings existed for six of them (see Table 10). Five of the six stressors dealt with work schedule and rest. For all six stressors with a difference between the two groups, the variable start group gave the stressor a higher rating. Overall, the variable start group has a higher level of work-related stressprimarily because of their work schedule and sleep issues.

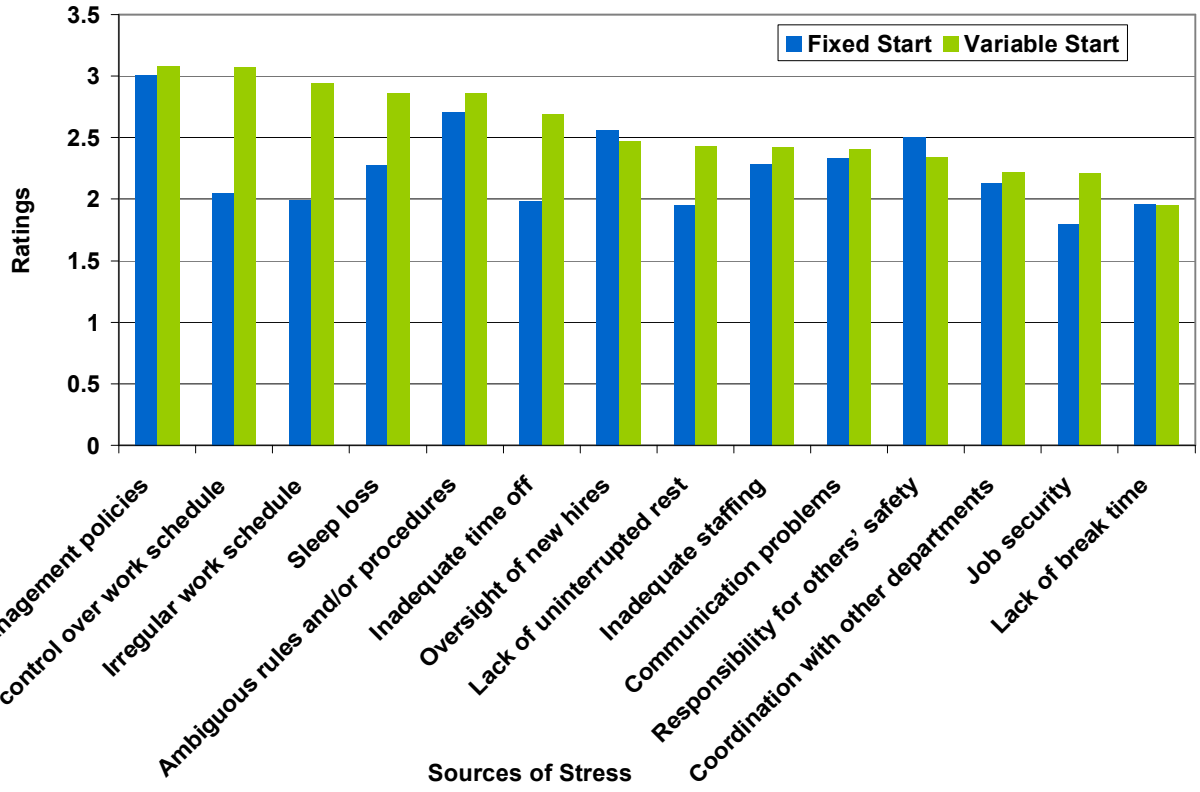

Figure 8. Sources and levels of stress by type of schedule

Table 10. Stress ratings by schedule type

Source of Stress	Fixed Start	Variable Start	Significance Test
Management policies	3.01	3.08	$t(245) = -0.55$, $p = .58$
Lack of control over work schedule	2.05	3.07	$t(243) = -8.23$, $p < .001$
Irregular work schedule	1.99	2.94	$t(130) = -7.56$, $p < .001$*
Sleep loss	2.27	2.86	$t(125) = -4.60$, $p < .001$*
Ambiguous rules and/or procedures	2.71	2.86	$t(246) = -1.21$, $p = .23$
Inadequate time off	1.98	2.69	$t(245) = -5.43$, $p < .001$
Oversight of new hires	2.56	2.47	$t(245) = -0.61$, $p = .55$
Lack of uninterrupted rest	1.95	2.43	$t(244) = -3.55$, $p < .001$
Inadequate staffing	2.29	2.42	$t(246) = -0.90$, $p = .37$
Communication problems	2.33	2.40	$t(246) = -0.53$, $p = .60$
Responsibility for others' safety	2.50	2.34	$t(246) = -1.27$, $p = .21$
Coordination with other departments	2.13	2.22	$t(244) = -0.65$, $p = .52$
Job security	1.80	2.21	$t(246) = -3.09$, $p < .01$
Lack of break time	1.96	1.95	$t(245) = -0.14$, $p = .89$

*Degrees of freedom were adjusted for unequal variances.
Note: 1 = no stress, 2 = a little stress, 3 = stressful, 4 = very stressful

3.4.5 Job Characteristics Summary

Two-thirds of T&E workers hold jobs with a variable start time. The most common call times for these people are 2 h at the home terminal and 1.5 h when at an away terminal, although some people reported other arrangements. Over 80 percent of T&E people with fixed start jobs were guaranteed 2 consecutive rest days per week but two-thirds of those with variable start jobs had no guaranteed rest days. The average work period did not differ between the two groups but when limbo time, and then both limbo time and commute time were considered, the variable start group had a longer total time devoted to work. Variable start jobs also had higher work start time variability (7.1 h versus 3.3 h) than fixed start jobs. In comparison with data from 1993, today's T&E jobs require more work starts in a 2-week period and have greater start time variability. Management policies are the greatest source of stress for all T&E workers. For T&E workers with variable start time jobs, work schedule issues and lack of opportunity for adequate sleep cause the most job-related stress.

3.5 Sleep Characteristics

This section reports the results from analyzing the sleep data of T&E employees. The sleep analyses focus on primary and daily sleep, the number of sleep periods per day, and the quality of sleep. The study examines sleep characteristics with respect to type of schedule (fixed or variable start), the location of sleep (home or away), and the prevalence of sleep disorders.

For the purpose of the study, primary sleep for a given calendar day is the longest sleep period ending on that day. Likewise, daily sleep is the sum of all sleep periods that end on a calendar day. Each sleep period ending on a calendar day is counted to determine the number of sleep periods per day. Finally, the study examines workday and rest day sleep characteristics. Workdays have at least one work start time reported on the activity log for a calendar day. By contrast, rest days have no work starts occurring on a calendar day. If a sleep period ends on a workday, it is classified as workday sleep. Otherwise, if a sleep period ends on a rest day, it is considered rest day sleep. Understanding the method for categorizing sleep as workday or rest day sleep is important when reviewing the sleep results.

3.5.1 Primary and Daily Sleep

Table 11 presents descriptive statistics for primary sleep, daily sleep, and the average number of sleep periods per day by type of schedule (fixed or variable start) and type of day (work or rest).

Table 11. Sleep by type of day and work schedule

	Fixed Start					Variable Start				
	Mean	Median	Std. dev.	1st quartile	3rd quartile	Mean	Median	Std. dev.	1st quartile	3rd quartile
	Primary sleep									
Workday	6:48	6:59	0:57	6:17	7:35	6:58	6:51	1:01	6:16	7:36
Rest day	7:32	7:38	1:30	6:31	8:29	7:16	7:15	1:24	6:19	8:04
	Daily sleep									
Workday	7:12	7:15	0:58	6:45	7:48	7:34	7:30	1:03	6:47	8:12
Rest day	8:06	8:08	1:39	7:04	8:55	7:50	7:51	1:26	6:52	8:47
	Number of sleep periods									
Workday	1.17	1.10	0.26	1.00	1.20	1.28	1.20	0.25	1.10	1.43
Rest day	1.21	1.20	0.30	1.00	1.25	1.25	1.20	0.29	1.00	1.40

A 2 (schedule) x 2 (type of day) mixed-model ANOVA examines the average length of primary sleep for each respondent. The results indicate that no overall difference exists in the length of primary sleep between individuals working a fixed start schedule and those with a variable start time, $F(1,492) = .28$, $p = .60$. However, the length of primary sleep is significantly longer on rest days when compared to the length on workdays, $F(1,492) = 91.03$, $p < .001$, suggesting that T&E workers make up lost sleep on their days off. Also a significant interaction exists between type of schedule and day, $F(1, 492) = 19.18$, $p < .001$. Additional analysis reveals that the source of this interaction is a nonsignificant trend for fixed workers reporting longer primary

sleep on rest days when compared with variable workers, $F(1,492) = 2.98$, $p = .08$. No difference exists between the type of schedule worked and the length of primary sleep on workdays, $F(1,492) = 1.26$, $p = .26$. Although not significant, these latter findings suggest a trend whereby fixed start workers have longer, uninterrupted sleep periods on rest days when compared with variable workers. With respect to workdays, fixed and variable workers obtain approximately the same amount of primary sleep. A potential explanation for these findings may be the schedule inconsistency of variable workers. Start time variability prevents this group from identifying specific time periods dedicated for long, uninterrupted sleep periods. Therefore, they may not be able to distinguish between work and rest days for the purpose of planning sleep.

Primary sleep provides limited information about an individual's sleep on a calendar day. Daily sleep, that is primary plus any supplementary sleep periods, provides a more complete measure of sleep. Since workday and rest day sleep may differ, it is important to characterize average daily sleep for fixed and variable scheduled employees on both workdays and rest days to determine the overall pattern of supplementary sleep. A 2 (schedule) x 2 (type of day) mixed-model ANOVA examining average daily sleep yields a main effect for type of day, $F(1,492) = 86.66$, $p < .001$, and a significant interaction between schedule and type of day, $F(1,492) = 32.46$, $p < .001$. The main effect for schedule is not significant, $F(1,492) = .27$, $p = .60$, suggesting that no *overall* difference in daily sleep exists between fixed and variable workers.

Similar to the results of the primary sleep period analysis, examination of average daily sleep indicates that T&E workers sleep longer on rest days than on workdays. This finding confirms that T&E workers as a group make up their sleep debt on their days off. Comparing fixed and variable workers daily sleep on workdays and rest days yields different sleep trends for those days. Figure 9 presents the average daily sleep by schedule and type of day. Variable workers log significantly more daily sleep on workdays than fixed workers $F(1,492) = 5.52$, $p < .05$. Similar to primary sleep, fixed workers have longer daily sleep on rest days than variable workers, however, this latter trend was not statistically significant, $F(1,492) = 2.84$, $p = .09$. As mentioned previously, no statistically significant difference exists between primary sleep for the two groups on workdays; however, variable workers get more daily sleep than fixed workers on these days. These results indicate that variable workers are napping on workdays. Figure 10 shows that variable workers engage in supplementary sleep most often between noon and 2 a.m.

An analysis comparing fixed and variable workers' daily sleep periods supports the hypothesis that variable workers log more daily sleep (but not primary sleep) on workdays, because they are engaging in supplementary sleep. A 2 (schedule) x 2 (type of day) mixed-model ANOVA examining the average number of sleep periods per day yields a main effect for schedule, $F(1,492) = 10.55$, $p < .01$, but not for type of day, $F(1,492) = .51$, $p = .48$. That is, the average number of sleep periods per day is significantly higher for variable workers than for fixed workers. While T&E personnel obtain approximately the same amount of sleep regardless of schedule, these results show that variable workers must obtain supplementary sleep to achieve the same restorative effect. There was a significant interaction between schedule and type of day for average daily sleep period, $F(1,492) = 8.63$, $p < .01$. Two additional analyses explain this interaction. As a group, variable workers logged more sleep periods on workdays than on rest days, $F(1,492) = 5.29$, $p < .05$. An examination of workdays showed that variable workers logged more sleep periods on these days than did fixed workers, $F(1,492) = 11.16$, $p < .01$. This provides additional evidence that variable workers obtain supplementary workday sleep.

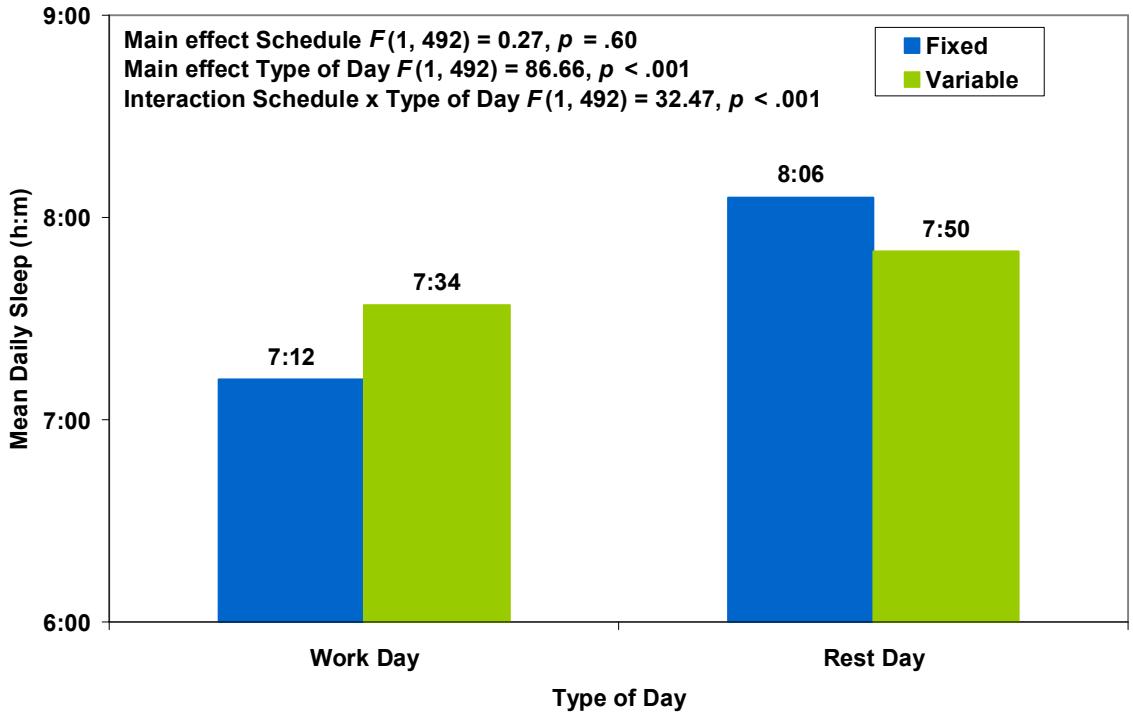

Figure 9. Daily sleep by type of day and schedule

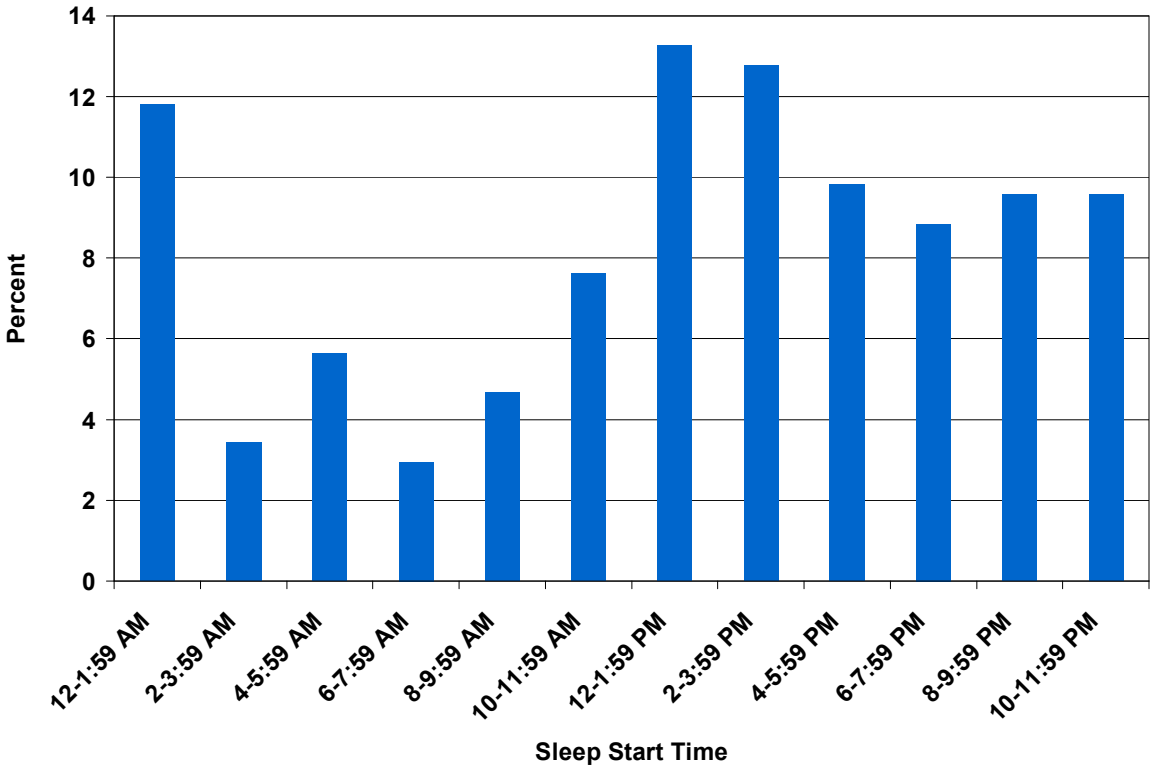

Figure 10. Supplementary workday sleep start times for variable start workers

3.5.2 Comparison with Other Adult Populations

Sleep data from other adult populations are not readily comparable to the T&E population. The National Sleep Foundation's (NSF) 2008 *Sleep in America Poll* reports nighttime sleep on workdays as total sleep time. Because people with daytime jobs usually get their daily sleep at night, comparison with the NSF data is reasonable. Data from the NSF survey show that as a group, T&E workers get more daily sleep on workdays than the national average for U.S. adults (see Figure 11). Mean total sleep, as reported in the NSF survey, was 6:40; mean workday sleep for the combined T&E group was 7:26 and the 1996 Pollard study reported 7:08. Since the T&E data are for a population where the majority do not have a regular work schedule, comparison with normative data for U.S. adults may be misleading. As discussed above, multiple daily sleep periods for T&E workers and the quality of many T&E workers' sleep makes their sleep less than fully restorative. In contrast, most U.S. adults have a single nighttime sleep period on workdays. While these data indicate T&E workers sleep more, increased total sleep time does not always indicate a lack of fatigue.

3.5.3 Sleep Quality

Study participants rated the quality of their longest sleep period on a Likert scale from 1 to 5. Lower ratings indicate poorer sleep quality. Table 12 lists the average sleep quality ratings for participants working fixed and variable start work schedules. Statistical analyses reveal that variable workers consistently rate the quality of their sleep lower than fixed workers. These differences are statistically significant for all sleep ratings.

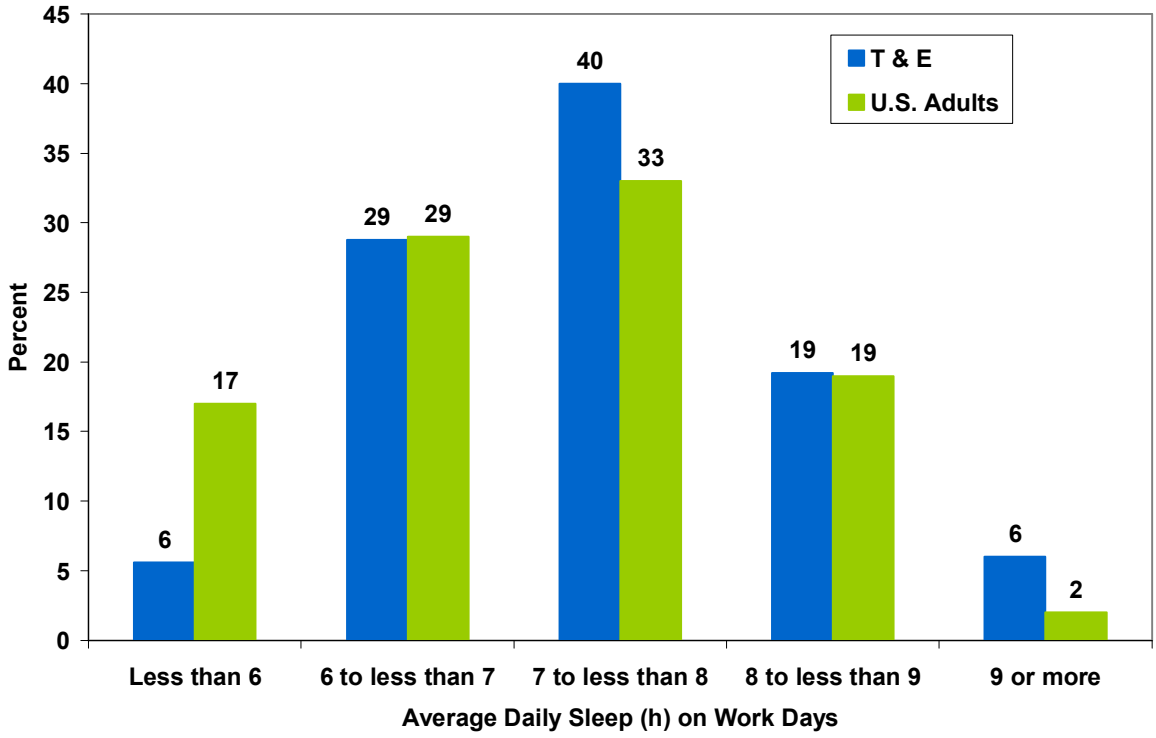

Figure 11. Daily sleep on workdays for T&E and U.S. adults

Table 12. Average sleep quality ratings by type of schedule

Sleep Rating	Fixed Schedule	Variable Schedule	Significance Test*
Ease of falling asleep	4.06	3.83	$t(2452) = 6.16$, $p < .001$
Ease of getting up	3.57	3.34	$t(2221) = 5.84$, $p < .001$
Length of sleep	3.58	3.36	$t(2304) = 5.86$, $p < .001$
Quality of sleep	3.69	3.48	$t(2261) = 5.56$, $p < .001$
Alertness upon awakening	3.72	3.57	$t(2172) = 4.11$, $p < .001$

*Equal variances for t-tests were not assumed; the degrees of freedom were adjusted accordingly. In addition to the t-tests, Mann Whitney nonparametric analyses also yielded significant differences between fixed and variable workers for each sleep rating. These additional nonparametric analyses were conducted because of the categorical nature of the dependent variable.

Participants also recorded the location of their sleep as either home or away. Table 13 lists the average length of home and away primary sleep periods as well as the qualitative sleep ratings for the different sleep locations. Statistical analyses reveal that primary sleep periods occurring away from home are significantly shorter than they are at home. Average sleep ratings indicate poorer sleep quality for away sleep when compared to home sleep; this difference is statistically significant for all rating categories. As compared with fixed workers, a larger proportion of primary sleep periods for variable workers occurs away from home, $\chi^2(4, N = 3370) = 209.1$, $p < 0.001$. This may explain why these workers consistently report poorer sleep quality than fixed workers.

Table 13. Primary sleep length and quality ratings by sleep location

Primary Sleep and Qualitative Ratings	Home Sleep	Away Sleep	Significance Test*
Primary sleep (h:min)	7:08	6:41	$t(827) = 4.36$, $p < .001$
Ease of falling asleep	3.94	3.76	$t(793) = 3.28$, $p < .01$
Ease of getting up	3.45	3.24	$t(888) = 4.35$, $p < .001$
Length of sleep	3.48	3.18	$t(871) = 6.45$, $p < .001$
Quality of sleep	3.61	3.29	$t(852) = 6.79$, $p < .001$
Alertness upon awakening	3.64	3.52	$t(892) = 2.81$, $p < .01$

*Equal variances for t-tests were not assumed; the degrees of freedom were adjusted accordingly. Mann Whitney nonparametric analyses were conducted on qualitative ratings between home and away sleep ratings; the results were statistically different for all sleep ratings.

3.5.4 Sleep Quality and Sleep Disorders

One-way between subjects ANOVAs with three levels (untreated sleep disorder, treated sleep disorder, and normal workers) calculated for each sleep quality rating resulted in no significant differences. The small number of participants with a sleep disorder is inadequate for meaningful statistical conclusions. Table 14 presents the average sleep quality ratings for respondents with and without sleep disorders.

Table 14. Sleep quality ratings for respondents with and without sleep disorders

Sleep Rating	Untreated Sleep Disorder (n=7)	Treated Sleep Disorder (n=14)	Normal (n=228)
Ease of falling asleep	3.8	3.7	3.9
Ease of getting up	3.4	3.2	3.4
Length of sleep	3.3	3.2	3.4
Quality of sleep	3.4	3.4	3.6
Alertness upon awakening	3.5	3.3	3.6

3.5.5 Sleep Characteristics Summary

As a group, T&E employees report longer average daily sleep than U.S. adults. However, the analyses reveal that sleep length alone does not necessarily predict a lack of fatigue. Although primary sleep is not statistically distinguishable between fixed and variable workers, daily sleep and the average number of sleep periods per day are different for these two groups in very telling ways. Compared with fixed workers, variable workers report longer daily sleep and more sleep periods on workdays. This suggests that on workdays, variable workers engage in supplementary sleep to manage fatigue. These groups also report differences in their sleep quality. For all of the sleep quality ratings on the survey, variable workers consistently rate their sleep quality lower than fixed workers; these differences are statistically significant. Participants also rate away-from-home sleep of poorer quality than sleep at home. A χ^2 analysis demonstrates that variable workers sleep away from home more frequently than fixed workers. Away-from-home primary sleep is also significantly shorter than sleep at home. These findings show that variable workers, more so than fixed workers, are at risk for fatigue because the nature of their work schedules forces them to sleep away from home on a frequent basis.

3.6 Alertness

Through a question on the background survey, T&E workers rated their overall alertness at work. As Table 15 indicates, those with fixed start time jobs reported being alert more often than those with variable start time jobs. More than 60 percent of the fixed start people reported that they were frequently or always alert at work while only 43 percent of the variable start people reported this level of alertness. These are statistically significant differences, $\chi^2(3, N = 247) = 23.1, p < 0.001$.

Table 15. Alertness at work by type of schedule (percent)

Alert at Work?	Fixed Start	Variable Start
Never	3.8	1.2
Occasionally	33.8	55.7
Frequently	47.5	41.3
Always	15.0	1.8

Study participants rated their alertness at the start and end of each work period and recorded this rating in their daily log. A 2 x 2 mixed model ANOVA found significant differences between ratings for start/end of work, $F(1, 494) = 207.97$, $p < .001$, with ratings of alertness at the end of work significantly lower than pre-work ratings. Variable schedule workers rated their overall level of alertness significantly lower than fixed schedule workers, $F(1, 494) = 13.67$, $p < .01$. The interaction between time of alertness rating and schedule was not significant, $F(1,494) = .85$, $p = .36$. Differences in alertness ratings between start and end of the work period also existed based on the length of the work period, as Figure 12 illustrates. For work periods of 9 h or more, the difference between starting and ending alertness rating increases markedly. This indicates that alertness dramatically decreases for these longer work periods.

Wesensten, Balkin, and Belenky (1999) conducted a review and reanalysis of studies investigating sleep fragmentation. These studies showed that sleep interruptions significantly impair daytime alertness and performance similar to sleep deprivation. Sleep interruptions are thought to prevent the transition to deeper, more restorative stages of sleep. Variable workers rate their levels of alertness significantly lower than fixed schedule workers. They also rate their sleep of poorer quality. Textual comments from section 3.8 provide anecdotal reports of variable workers reporting interrupted sleep, which may help to explain why this group has lower alertness and poorer sleep quality ratings than the fixed start workers.

The study also compared alertness ratings for individuals with sleep disorders, treated and untreated, with alertness ratings for individuals reporting no sleep disorders. A 2 (alertness ratings before and after work) x 3 (normal, treated sleep disorder, and untreated sleep disorder) mixed model ANOVA revealed a main effect for time of alertness rating, $F(1, 492) = 49.43$, $p < .001$. That is, after-work alertness ratings were significantly lower compared to the before-work ratings. There was a marginally significant main effect for sleep disorder, $F(2, 492) = 3.22$, $p = .041$; however, subsequent post hoc analyses yielded no significant differences among subgroups. No significant interaction existed between time of alertness rating and presence/absence of a sleep disorder. Table 16 presents the mean pre- and postwork alertness ratings for workers with and without sleep disorders. The small numbers in the two sleep disorder categories make meaningful results difficult to obtain.

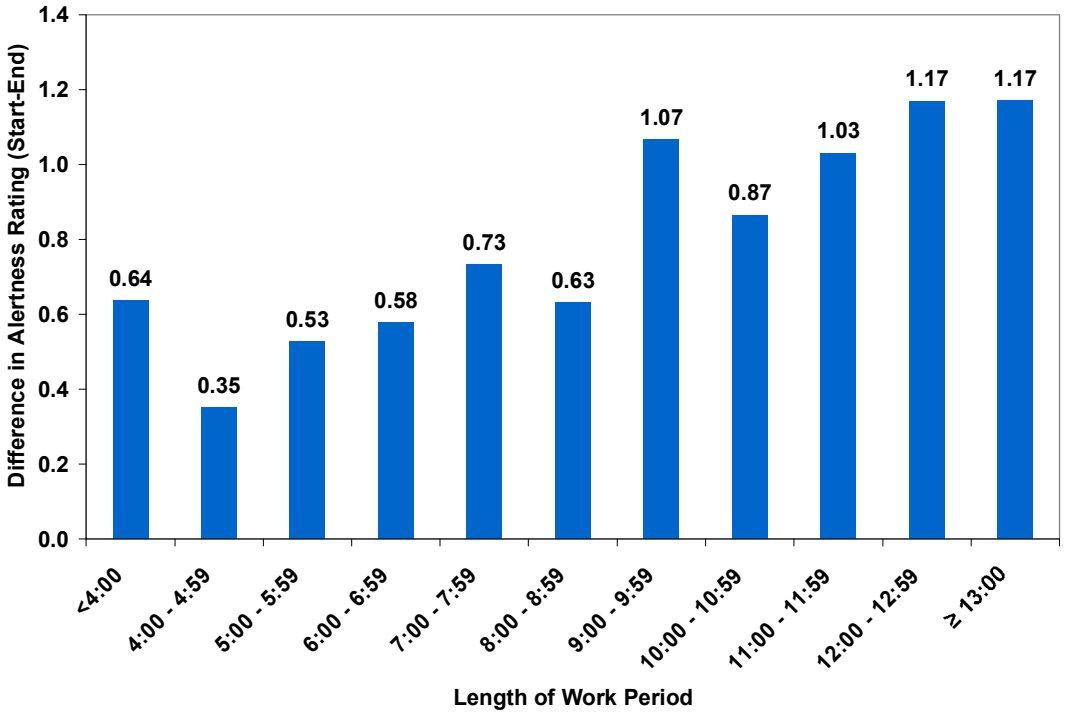

Figure 12. Differences in alertness ratings between start and end of work as function of work period length

Table 16. Alertness ratings before and after work by sleep disorder status

Sleep Rating	Untreated Sleep Disorder (n=7)	Treated Sleep Disorder (n=14)	Normal (n=228)
Start of work alertness	3.7	3.4	3.8
End of work alertness	2.2	2.7	2.8

3.7 Effectiveness

The SAFTE model is a biomathematical model for predicting fatigue based on sleep schedule. The SAFTE algorithm is incorporated in FAST, a software tool for analyzing work schedules and predicting the individual's effectiveness, or lack of fatigue during the work period (Hursh, Balkin, Miller & Eddy, 2004). The FASTBatch software provides the capability to analyze multiple schedules in one batch analysis.

This analysis used the FASTBatch software tool to compute effectiveness. FASTBatch predicts effectiveness at work based on the sleep pattern and the number of hours since awakening. The FAST effectiveness metric is a score based on predicted speed on a psychomotor vigilance test (PVT). FAST computes effectiveness as percent of the performance of the average well-rested daytime worker. The FASTBatch results, provided in an Access database, include an effectiveness score for each half hour of work time. By combining these results for all work periods and all individuals in a specified group, it is possible to create a cumulative distribution

of the percent of work time spent at or below specified efficiency levels. Of particular interest is the time spent working at or below 70 percent efficiency. This efficiency level corresponds to a reaction time that is 1.4 times that of a well-rested person, cognitive throughput that is 81 percent of a well-rested individual, and five times the likelihood of a lapse in attention relative to a well-rested person.

As Figure 13 indicates, T&E workers with a variable start time were more likely to be working at a lower effectiveness level than those working with a fixed start time. The percent of work periods at or below an effectiveness of 70 was 7.5 percent and 7.7 percent for fixed and variable start, respectively. The mean effectiveness scores for the two groups were 88.9 for fixed start jobs and 86.5 for variable start jobs. These two scores were statistically different, $t(30774) = 22.59$, $p<.001$ (equal variances not assumed). Of the 21 T&E workers whose first quartile mean effectiveness was ≤70, nine worked a third shift job with a regular start time.

More than 40 percent of Class I railroad employees are T&E workers. This group accounts for over 150 M labor-h annually. While the portion of total work time at low effectiveness is less than 10 percent, the total number of labor-hours at low effectiveness exceeds 10 million annually.

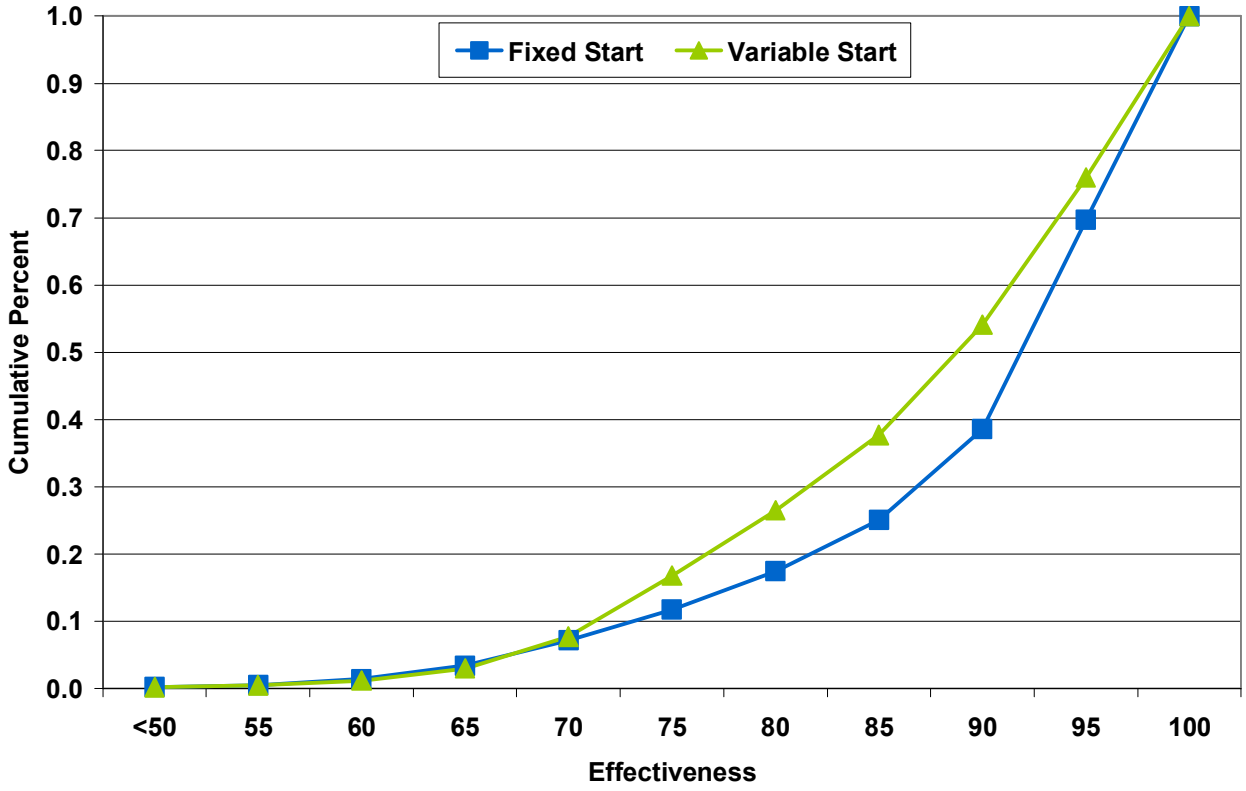

Figure 13. On-the-job effectiveness by work schedule

3.8 Textual Data

The daily log included space for participants to record any comments regarding their sleep and work periods each day. This section presents an overview of participants' comments on their sleep and work experiences throughout the 2 weeks of the study.

While not a requirement for participation, commenting on sleep and work experiences presented participants with the opportunity to qualify part of their day. Not all participants chose to record daily comments. As such, these data are not statistically meaningful. However, the content of the participants' comments do provide valuable qualitative information regarding common themes in the work and personal lives of train and engine service employees. The following themes emerged from a review of the log book comments:

1. Sleep
2. Work Schedule
3. Alertness/Fatigue
4. Personal Issues (family, leisure activities)
5. Travel
6. Lineups
7. Naps
8. Responsibility
9. Management
10. Stress
11. Communication
12. Safety

Researchers used ATLAS.ti® software V 5.5.9 to autocode comments based on keyword searches and to tally the number of comments made under each topic area. Table 17 lists the keywords that were the basis for each topic area search.

These categories were not mutually exclusive because a single comment may have contained keywords of multiple topic areas. As a result, comments fell into more than one category. For example, a comment may have been counted in both the stress and work schedule categories because the comment contained the keywords "stress" and "schedule." The most frequently mentioned topics were sleep, work schedule, alertness/fatigue, and personal issues. The high frequency of the keywords "nap" and "lineup" (associated with the sleep and work schedule topics, respectively) warranted including separate topic categories for these items. Table 18 presents more detailed results of keyword searches.

The comments complement the quantitative survey results by exemplifying the personal effects of work or sleep patterns present in the survey data. For example, variable start employees reported taking more annual sick days than fixed start employees even though these groups rated their health comparably. An examination of the textual data demonstrated that many variable schedule employees "laid off sick" because the call to work came sooner than anticipated and they were not adequately rested to accept the assignment. In this way, the comments provide a

more complete picture of train and engine service employees' concerns regarding the effects of job-related fatigue.

Table 17. Keywords used for each topic area search

Topic	Keywords
Alertness (mental)/Fatigue (physical)	Alert*, atten*, awake, aware*, energy, exhaust*, fatigue*, prepared, sleepy, tired, vigilant, watchful, weak*, weary
Communication	Communicat*, communication equipment, dispatch*, radio
Lineups	Lineup*
Management	Administration, boss, chief, company, control, inadequate, manage*, organization, policy, rule*, staff, supervis*
Naps	Nap
Personal Issues (family, etc.)	Baby, child*, daughter, domestic, family, father, girlfriend, grand*, husband, in-law, kid*, mother, personal, private, relative*, son, wife
Responsibility (trainees)	Accountab*, blame, duty, incident, responsib*
Safety	Accident, casualty, error, injury, protect*, safe*
Sleep (including location)	Accommodation*, away from home, bed, hotel, lodging, motel, nois*, quarters rest, room*, sleep*
Stress	Anx*, pressure, strain, stress*, tense, worr*
Travel	Car, commute, driv*, drove, travel, truck, van
Work Schedule	Call time, deadhead, extra*, hours, limbo, overtime, relief, respond, rest day, schedul*, time off

Note: ATLAS.ti® search logic uses the symbol "*" as a wildcard. For example, searching for "stress*" would result in all words starting with s-t-r-e-s-s including any ending (such as stressful, stressor, etc.).

The selected comments that appear following Table 18 illustrate the consequences of the work and sleep patterns in the survey data. For example:

- *Sleep*-related comments occurred at a high frequency because many of the participants reported sleep onset times. The more detailed comments highlighted participants' difficulty with interrupted sleep and sleeping away from home. Commonly cited reasons for sleep problems included noise, sleeping during the day, call center interrupting sleep, and inadequate opportunity to rest because of work scheduling.
- Comments on *Work Schedule* concerned primarily the uncertainty of work start time for variable start employees. According to the comments, the start time variability for these workers was a substantial source of stress for this group. Fixed start workers who once

worked a variable start schedule commented on the problems associated with these schedules and how their quality of life improved after beginning a fixed start schedule.

- Several participants commented on the difficulty of staying *Alert* towards the end of long shifts (>10 h). Some participants commented that they went to work *Fatigued* because they got called to work sooner than anticipated.
- Many survey participants reported that their work schedule interfered with their *Personal* lives including the inability to plan for family responsibilities and activities.
- Comments regarding *Travel* centered on issues with commuting to and from work including the issue of driving while fatigued. Some participants commented on long wait times for vans to transport them from the away terminal to their point of rest.
- There were a large number of comments regarding poor *Lineups*, which resulted in workers not being able to plan rest or personal activities. As such, poor lineups led to fatigued and stressed workers.
- Comments regarding *Naps* included the way many T&E workers strategically used short sleep periods to counteract the effects of fatigue.
- A majority of the comments related to worker *Responsibility* centered on the stress of being in charge of trainees.

Table 18. Frequency of comments by topic area

Topic	Frequency
Sleep	1267
Work Schedule	740
Alertness/Fatigue	286
Personal Issues	272
Travel	199
Lineups	136
Naps	132
Responsibility	130
Management	52
Stress	44
Communication	19
Safety	17
Total	**3164**

The keywords associated with the *Communication* topic area yielded comments that focused on issues associated with poor lineups and are reported in that category.

The comments that follow are representative of the topic areas:

Sleep

- "A key to rest at [the] hotel is getting a room in a timely manner and people respecting day sleepers."
- "The railroad calls our rooms directly with our assignments 2 hours prior to work. In the past, the railroad would give that information to the hotel front desk clerk, and the hotel would call us. We were able to request any amount of time we wanted to be called up to the two hours. On nights like tonight, I would request a 30–45-minute call to get the most sleep possible. But the railroad now says we must accept the full two hours because that's what the contract says!"
- "Hotel at away terminal. Sleep interrupted three times by banging noises. Hotel repair work."
- "Should be mandatory [eight hours rest] at hotels. Called after 5 hours. How do you eat and sleep and expect to be rested to work 12 more hours?"
- "…I was deadheaded to the away from home terminal for rest. I couldn't find any logical reason why additional crews were needed. Looks like we will be here for a while. My afternoon nap has spoiled my night's sleep as it is after midnight and I still am not ready to go to bed for the evening. I wish that I had resisted the urge to nap this afternoon, but there was a slight possibility that we might be rested prior to the crews ahead of us in turn order. As it turns out, those other crews became rested before us, so we will be here all night and into tomorrow...It is virtually impossible in pool or extra board service to foresee what might occur and thus how to plan when to take rest."
- "Was on lineup for 21:10. Was not called until 14:50, 17 hours later. Was at away from home for 27 hours 10 minutes. This is the way it is. Away more than home. How can you get rested either end with this kind of margin."
- "Deadheaded home after being off at away from home terminal for 26 hours. Deadheaded home, tied up 6 times out at home. Rest cycle day at midnight. I was to be on a rest cycle day, but at 06:59 I was notified that my rest cycle was changing. I laid off sick."
- "1 hour and 30 minute call time doesn't give me time to shower, dress, pack, shave, brush teeth, eat and get to work on time at away from home and not be rushed and a little late and totally uncomfortable and maybe edgy."
- "Short rest…Makes for a long day. Hard to gauge your sleep when you don't know if you are going to be away from home 10 hours or 16 hours."
- "Don't sleep well away from home when tie up in afternoon and then go to work in the middle of the night."
- "If you go to bed early you are up 4–6 hours before you go to work. If you go to bed late and get called on your rest, you are short rested."

Work Schedule

- "I have changed jobs from a pool job to an assigned job so that I might have a more predictable schedule for a week or so. The railroad does not have enough manpower to grant adequate time off requests, so I try to jump to a different position so that I can gain a little time off between assignments."
- "Wonderful RR schedule. On lineups for 22:40 train. Still waiting for call at 02:15. Train is tied down at depot. Train station activity was stimulus for 02:15 wake-up event."
- "Thanks for the chance to participate in this study, which is a good idea, but I don't think it can really start to describe how fatigued and wore out you feel after doing this kind of work schedule for months on end and limited days off for the rest and doing just every day chores."
- "Guaranteed time off or at least a lineup that is close to call times would make a world of difference."
- "I spent 16 hours and 15 minutes in hotel waiting for return train. This in itself can be exhausting. Very poor utilization of crews."
- "This is a consensus of a 14 day work/rest period. My pool job that I have worked for several years in a row has an 8-hour call time or activation. This system is the best for providing me with the most structured work schedule. I know 8 hours in advance when my call time is, which makes all the difference when scheduling my rest and sleep time. I can be first out and not 'locked' or 'activated' and be able to spend time with my family or do the things I want and not have to worry about the phone ringing unexpectedly. With the way the lineups are these days, this system is a godsend. Every pool in the system should have a program like this."
- "Most of the time I have worked an extra board, it is much harder to get rested and be ready for work off the extra board."
- "It is virtually impossible in pool or extra board service to foresee what might occur and thus how to plan when to take rest."
- "Terrible dispatching! Sat on train over 12 hours."

Alertness/Fatigue

- "I am frequently up 24–30 hours straight when working nights. Needless to say, I am not alert when doing that."
- "I was lucky enough to sleep at home in my own bed at night so I got a fairly good rest, but now here I'm called for 19:25 after being up all day. I'll be up all night and have to try to stay alert and focused, and probably by the time I get to bed I will have been up close to 24 hours."
- "I absolutely despise working in this manner, where I sleep at night then work in the morning, take the required 8 hours off in the afternoon, then must work again in the evening. I intentionally short myself sleep/induce fatigue on these days so I can get some sleep during these afternoon layovers."

- "Started to get very sleepy towards end of trip. I found myself micro-napping occasionally. When one gets like this, it is difficult to remember the last signal or whether you have sounded the horn properly at the last crossing. Your mind is very foggy (almost like being intoxicated) and concentration is difficult. You try to snap out of it, but before you know what has happened, you have fallen back into a fatigue-induced fog."
- "I was told I would not work any earlier than late afternoon…, so I stayed up late, going to bed killed I might add at 02:00 a.m. ready for a good 8 hours or more of sleep, only to be called 2.5 hours later at 04:35 for a 06:55 on duty time. I had slept only five hours and 50 minutes in the last 42 hours when I went to work extremely fatigued."
- "Maybe having a 12 hour period to cover and then 12 hours off, that might help on the fatigue on the extra board."
- "[Laid off sick] at 14:45…because I showed to go back to work on rest at 18:30. Was too fatigued and did not feel safe going back to work that soon. Marked up at 23:59."
- "I work a regular yard job, so sleeping is not a problem. For 30 years I worked crazy hours, had trouble sleeping during the daylight hours, and was always tired. Hopefully those days are behind me."
- "You will always have a tired work force when we have no idea when we are going to work."
- "Laid off sick due to exhaustion and lack of sleep."

Personal Issues

- "Son had a baseball tournament…, so after work I lay down in our van in the…parking lot for a few hours of sleep. Got up at 08:00 and picked up my son at the…station and we drove to the baseball tournament. I knew I wouldn't be able to get much sleep so I marked off from work Saturday night, taking a personal day."
- "It is frustrating that I spend a lot of my personal time in the morning calling and wondering when I will be called for work. We get a two hour call on this job and the commute takes one hour and forty minutes. The more advance warning I can get about when I will go to work, the better."
- "Called right on rest, not getting a lot of personal time with family. Keep losing my seven starts in seven days rest due to call times. Trying to remember last day off?"
- "Came in on off day. Didn't go to bed until 22:30. A lot of off days I stay up because I only have one off day, and if I get to bed and sleep most of the day, I have no time for family or even mowing my grass, and the rest of my yard work."
- "Sleep was patchy. So many family things during daylight hours. Railroaders at best have 1/2 a family life. Trying to work family life when you go to work is tough."
- "My son had a field trip that I had to attend. It lasted longer than expected so when I checked the stand line at 13:30, I realized that I was first out. As a single parent (male), I had to find out who was going to watch him since his mother was unable to do it this weekend."

- "Sleep the night before very poor. I was interrupted by my 1.5 year old daughter, stuffy nose and a bad road phone call to work. Beginning of shift. I am quite tired."

Travel

- "We get a two hour call on this job and the commute takes one hour and forty minutes. The more advance warning I can get about when I will go to work, the better."
- "Called to work for 9:00 a.m. Work was routine. Van was late picking us up. Was on limbo time driving back to tie up."
- "Had great night's sleep. Felt very rested with good outlook for coming day. Good day at work. Got all work accomplished and almost made it back to terminal. I wish company had a van at siding outside of terminal. Knew we were not going to be able to get in terminal 30 minutes later. We got to siding and had to wait 35 minutes at siding for van."
- "Worked 12 hours. Went on the law. Waited for 5 hours 50 minutes for a van ride. Had a couple of naps in that period. Got a van ride home."

Lineups

- "It's basically a crap-shoot when you'll go to work. Generally the line-ups will jump 12–14 hours up. You just check the…line-ups to get an idea when you'll go to work. I don't think crew management (mis-management) has a clue."
- "Lineups are bad. They show a time when I should get called so I go to bed and get rested. Then I wake up and don't get called for several hours. By the time that I finally get called, I am tired and should be going to bed instead of to work."
- "Train lineups are terrible. The company needs to communicate with the crew callers and dispatchers more and maybe the lineups could be better."
- "Standing to get out on rest. Did not happen. No conductor available. Went to work poorly rested because of poor line up. Made 10.5 hour trip…No breaks."
- "Very poor line ups today. They fell down 12 hours. Very difficult to get rested for work."
- "Problems with sleep or lack of sleep mostly consist of poor train lineups."
- "Lineups of trains are rarely accurate and are not updated enough to get a proper estimate of when trains will be called. Too many variables to plan rest."
- "Went to bed at 19:30…for a train that was on the lineup for 23:00. Did not get called for work until 04:30…From midnight until I was called, my sleep pattern was very disjointed while I waited for the phone to ring. During the day…I checked the lineup on the internet seven different times."
- "The train lineup was so bad. The day before I was on the lineup for 05:30 hours. I had to cancel my…test at the hospital which was scheduled for 08:45 hours…I didn't get called until 21:40 hours."
- "Got up at 06:30. Was three times out. There were two loaded trains at…[location X] and…[location Y]. Track turn at…[location X] protect all day. No idea from the poor lineup. It shows me to get out at 06:30…These lineups…only show the empty trains, but

not the loads we have to go get at the [location X]. So, per lineup, I was tied to the phone all day, never knowing if I should try and start something around the place or not. Finally went to bed around 20:30, and got called at 21:30 for 23:00 on a train that was called at 19:40 for a different crew. Some rest. They don't even try to give us an idea when we are going to work."

- "Today I woke up at 09:30 rested. Scheduled and expecting to go to work in the afternoon. At 16:00, I was first in line to go to work. I watched the lineup and expected to go to work any time. The phone call came finally at 20:45. At 20:55 they called and busted our call. I checked the lineup and it looked like I could get called any time so I did not nap. Finally at midnight, I lay down to sleep but the phone rang at 00:25 to be on duty at 02:25. This is going to be a long night."
- "Did not sleep well. Just kept waking up to check train lineup. Did not get called until 5 a.m."

Naps

- "Took two naps, one for 30 minutes at 11:00 a.m. and one for 30 minutes at 1:15 p.m. First nap was on train waiting to get to terminal. Second nap was in van from terminal (yard where take train) to tie up, which takes about 50 minutes."
- "The naps helped me a lot on getting through the day."
- "My afternoon nap has spoiled my night's sleep as it is after midnight and I still am not ready to go to bed for the evening. I wish that I had resisted the urge to nap this afternoon, but there was a slight possibility that we might be rested prior to the crews ahead of us in turn order. As it turns out, those other crews became rested before us, so we will be here all night and into tomorrow…It is virtually impossible in pool or extra board service to foresee what might occur and thus how to plan when to take rest."
- "Even if I go to bed late or get off work late, I always try to get up early and take a nap later if needed. It makes me feel a little normal. I'll usually do this for a week or so and then finally my body says enough and I'll sleep for 12–14 hours and then start all over again."

Responsibility

- "Had a[n]…engineer [trainee]. Wanted to help him learn to run an engine. High stress. I get no pay and full responsibility for a new [trainee] learning to run engines. What holds me to 100 rule compliance for a guy who does not know what he is doing—that makes for a lot of stress!!"
- "Being one hundred percent responsible to train new hires is stress we don't need."
- "Worked with new employee. One year seniority. Some stress."

Management

- "One thing to remember: just because the amount of time between work cycles is larger does not mean a person is more rested. I hate when a [supervisor] points out about an incident that the employee had been off for a long period of time."

- "Long night! Have to love the 'availability' policy. Don't layoff unless near death or face a reprimand."

Stress

- "Totally burnt out. Ill, standing for train on my rest. Already stressed. Mentally confused. Will probably lay off fatigued."
- "Good day of work. Very little stress related to work. More stress put on men from management than work. We get very little communication from [supervisor] other than threats and belittlement."
- "Called to work off my turn on a different sub-division that I was forced to qualify on over eight months ago, on a job that's called late at night, which adds stress, besides being tired and not as alert because of the time and not expecting to go to work."
- "Was called at 17:55 for a 18:15. Called to work off turn. At the time I took the call I thought I was being stepped up in my pool I am assigned to. It turns out that I am going to [location X]. I haven't been to [location X] in [many] years on the railroad tracks. I tried to talk a [supervisor] into changing me to something else but he wouldn't. So I take the train to [location X] and the call office hangs my turn and doesn't fill my assignment. This will be the last time I work off my turn. I felt quite unsafe in going to [location X]. Thank god my engineer knew the road. He is an extra board engineer."

Safety

- "I have seen accident assessments come out from the railroad after a bad train wreck and in recent years, in the first paragraph of the cause, the railroad will state, 'Engineer off 27 hours, conductor off 34 hours, fatigue was not an issue in this accident.' My hope is that after this study, the FRA will understand that time off does not necessarily mean the crew was properly rested. Good line ups will get rested crews. 10 hour calls would get you rested crews. Active and inactive boards would probably help too!"
- "Worked through the night. Felt bad all night, couldn't go to hotel after work because I was forced away from my home terminal 108 miles. Company doesn't allow us to stay in hotel on off days. It was too far to drive home and not safe so I went to a friend's house and goofed around all day. Exhausted, finally went to sleep but couldn't get quality sleep."
- "Worked a double day with very little sleep today and yesterday. Working any and all 3 shifts at any given time makes it difficult to sleep. Days like this make me wonder how important the safety at work issue is."

4. Findings and Recommendations

Analysis of the data from this study provides some insights into the demographics of the U.S. railroad T&E worker population as well as their work schedules and sleep patterns. The data came from a random sample of T&E workers who are members of either the UTU or the BLET. Nevertheless, the results are representative of the U.S. railroad industry's T&E population at the time of the survey because the vast majority of the Nation's T&E workers are represented by these two labor organizations. It is reasonable to assume that the work schedules and sleep patterns of T&E workers in nonunion positions are similar to the study population because of the limitations of the Hours of Service Law.

4.1 Key Study Findings

The following subsections highlight the key study findings with regard to worker health, work schedules, alertness, and sleep.

4.1.1 T&E Worker Health

T&E workers with variable start jobs mark off sick at twice the rate of their counterparts in fixed start jobs (6.3 vs. 3.2 d annually). Their rate of sick days is also considerably higher than that for U.S. adult males, 3.9 d. Several possible explanations exist for this more frequent use of sick days. The most likely explanation is that this group of T&E workers marks off sick to recover from fatigue since a majority of this group lacks guaranteed rest days. Comments in the daily log books support this explanation.

In recent years, the railroad industry and the various labor organizations have conducted programs to educate T&E workers about the symptoms of sleep apnea and the risks that an untreated sleep disorder poses to safety-critical work. The reported rate of sleep apnea diagnoses among T&E workers is higher than U.S. working adult males, probably as a result of industry education and wellness programs. Yet 25 percent of the study participants reported receiving no fatigue education. The opportunity exists for the industry to expand its education efforts on this important subject.

4.1.2 Work Schedules

During the study period, the number of hours worked did not differ significantly between the two groups of T&E workers. The average work period for both groups was 8:40 and a quarter of each group worked more than 10 h. When limbo time was considered, the total of work plus limbo for variable start T&E people was only slightly longer than for those with fixed start time jobs. Both groups averaged 10 work starts in 2 weeks and a quarter averaged 11 or more work starts. Regardless, for T&E workers with jobs that do not have a fixed starting time, five of the top eight sources of stress related to work schedules and sleep loss. The lack of guaranteed rest days for two-thirds of this group and the high level of variability in their work start times undoubtedly account for work schedules being a major source of work-related stress. The comments in the log books provided anecdotal evidence of the fatiguing and stressful nature of variable start time jobs.

RSIA guarantees 10 h of undisturbed rest and limits the maximum number of consecutive days that may be worked without extended time off. These provisions should reduce the level of fatigue from irregular work, but most T&E employees will probably continue to look forward to having enough seniority to bid for a job that has a fixed starting time and does not require away-from-home overnight stays.

4.1.3 Effectiveness and Alertness

Subjective assessments of alertness at work revealed a difference between those working a job with a fixed starting time and those whose start time varied. Analysis of the log book data with the FAST tool predicted that T&E workers are working below an acceptable effectiveness level less than 10 percent of the time, with little difference between the two groups of T&E workers. Regardless, since the number of labor hours for T&E workers in the industry as a whole is substantial, the exposure to less than acceptable effectiveness levels poses a risk that justifies attention to the fatigue issues for this group. RSIA acknowledges this situation in that it requires each railroad to implement a fatigue risk management plan. Individual railroads could use the FAST tool in the same way to assess the fatigue risk associated with their work schedules.

4.1.4 Sleep

As a group, T&E employees sleep more on workdays than U.S. adults. However, sleep length alone does not necessarily predict lack of fatigue. Although primary sleep is the same for fixed and variable workers, daily sleep and the average number of sleep periods per day are different for these two groups. Compared with fixed workers, variable workers report longer daily sleep and more sleep periods on workdays, suggesting they engage in supplementary sleep on workdays to manage fatigue.

While fixed workers make up their sleep on rest days, variable workers do not have the same opportunity due to the unpredictable nature of their schedules. This makes it difficult for these workers to plan for adequate rest. Variable workers without a call window also report interrupted sleep from call centers. Analyses of sleep length, work start time variability and textual comments regarding poor line ups support these conclusions.

Fixed and variable workers also report differences in sleep quality. For all of the sleep quality ratings on the survey (e.g., ease of falling asleep, ease of arising, etc.), variable workers consistently rate their sleep quality lower than fixed workers. Compared with fixed workers, variable workers report higher stress ratings related to work schedule and rest. Stress has the potential to impair the quality of sleep. This may explain why variable workers have low sleep quality ratings. Participants also rate away-from-home sleep of poorer quality than sleep at home. Away-from-home primary sleep is also significantly shorter than sleep at home. Because variable workers engage in away-from-home sleep to a greater extent than fixed workers, they are more likely to be affected by fatigue because of the poorer quality and shorter length of away sleep.

4.2 Recommendations for Improvements in Study Procedures

This was the fourth FRA-sponsored study of work schedules and sleep patterns of a group of railroad workers. Each successive study has led to improvements in the subsequent one in terms

of study design as well as procedures for coding and analysis of the data. The experiences of the T&E survey suggest areas to improvement future studies of this population:

- *Provide definitions for interim release and limbo time.* T&E workers in road freight service are familiar with limbo time but those who have never worked in road freight are not. Similarly, only people in passenger service understand the meaning of interim release. The lack of familiarity with these terms led to some innovative uses of those columns in the daily log book. (In nearly all cases, the researchers were able to re-categorize the time that was inappropriately recorded.) Clear definitions of these terms should be part of the instructions for any future studies of this type.
- *Provide for ratings of multiple work periods in one day.* The daily log included space to rate alertness at the beginning and end of a work period. In a few cases, an individual had two work periods in one day. The instructions did not cover this situation. As a result, analysis of these ratings assumed that the ratings were for the first work period ending on the calendar day. This issue is of particular concern for individuals working split assignment schedules.
- *Provide a way to capture sleep interruptions.* The instructions did not require participants to log all sleep interruptions, only those exceeding 15 min. Given the results of the textual analysis with regard to sleep interruptions by call centers, noise, and other pertinent reasons, future studies of T&E employees should consider capturing the frequency of all sleep interruptions. These data would be useful to provide quantitative support for the anecdotal reports of troublesome interrupted sleep.

4.3 Recommendations for Additional Research

RSIA requires changes to provisions of the Hours of Service Act. In particular, there will be a limit on the number of hours that a T&E employee may work in a calendar month and a T&E employee will be guaranteed 10 h of undisturbed rest. Because most T&E people in road freight service have a 2-hour call window at home, this new provision will guarantee the T&E worker an opportunity for quality undisturbed sleep and often12 h off duty before reporting for a work start. The intent of the new law is that this requirement will ease the fatigue problem for T&E workers. The new law also requires changes in HOS for passenger service employees; however, the implementation date for those changes will occur later.

The delay in implementation of HOS changes for passenger service T&E workers provides an opportunity for closer study of this subpopulation of T&E workers. The accident in Chatsworth CA that led to passage of the Rail Safety Improvement Act last year also called into question the impact of split assignment schedules on employees who work them. There were an inadequate number of passenger service workers in the present study to make meaningful conclusions with regard to this subpopulation of T&E workers. An opportunity exists now to conduct an additional study that will provide baseline fatigue data from passenger service T&E workers before changes in their HOS limitations occur.

The results of the present study, as well as the three earlier studies, provide a baseline for comparison after the changes prescribed by the new law take effect. A study, using similar methodology, could be conducted several years after the changes are implemented. Comparison

of the results of the subsequent study with those presented here will give an indication of the success of the measures in reducing fatigue in the railroad industry.

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Appendix
Survey Materials

This appendix contains copies of the following survey materials:

- Cover letters from the BLET and UTU Presidents
- Instructions to participants
- Train and Engine Service Employee Daily Log (1 day)
- Train and Engine Service Employee Background Survey

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Brotherhood of Locomotive Engineers and Trainmen

A Division of the Rail Conference — International Brotherhood of Teamsters

NATIONAL DIVISION OFFICE
1370 Ontario Street, Mezzanine • Cleveland, OH 44113-1702
Phone: (216) 241-2630 • Fax: (216) 241-6516 • rodzwicz@ble-t.org

EDWARD W. RODZWICZ
National President

<<Enter date here>>

«Whole_Name»
«Address_1»
«Address_2»
«Location»

Dear Sister or Brother:

Fatigue is a major concern in our industry. Poor line-ups, excessive limbo time, operating at near capacity, and crew shortages all combine to compromise your quality of life. It is more important to optimize rest time between work shifts. However, it seems that many factors that the carriers fail to control adequately conspire against us.

As you may have read in the *Locomotive Engineers and Trainmen News*, the Federal Railroad Administration (FRA), along with the cooperation of the BLET, is conducting a fatigue study that focuses on operating crews. You have been randomly selected to participate in this very important scientific study. The results of the study will provide the FRA and the BLET with a clearer picture of work schedules and sleep patterns of operating crews. The study will also provide the statistical basis necessary to identify areas for improvements.

You are among a small group of randomly selected BLET members nationwide that are being asked to fill out work/sleep diaries for a two-week period. Your participation in this study involves: (1) completing a brief background survey; and (2) keeping a daily log for 14 consecutive days of your sleep and work times along with self-assessments of your level of alertness three times per day.

To insure that your personal information is completely confidential, the FRA has engaged the services of Foster-Miller for executing the study. The names and personal information of the participants from the sample group will be completely confidential, and the data gathered will only be used to compile the information as a group. After the study's conclusion, all the personal data gathered will be destroyed and only the compiled information will be distributed.

Completing the background survey should take less than 15 minutes; making entries in the daily log should require no more than a total of 10 minutes per day. As a reward for your participation in this study, you will receive a $75 gift certificate to either Home Depot or Sears. *You must provide 14 consecutive days of data and a completed background survey to receive the gift certificate.*

The purpose of the study is to develop a better understanding of the work/rest schedules and sleep patterns of operating crews and to evaluate the relationship between these schedules and fatigue. Your participation is critical to the success of this study. The data will allow us to identify any fatigue-related problems specific to our crafts. Once we have the data, we will be able to work toward reducing the risk of fatigue-related accidents and incidents and improving the quality of life for our members. A report concerning this study will be published next year in the *Locomotive Engineers and Trainmen News.*

Please read the enclosed instructions carefully before beginning your data collection. Thank you for your participation in this important research study.

Fraternally yours,

Edward W. Rodzwicz
National President

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M. B. FUTHEY JR.
International President

ARTHUR MARTIN III
Assistant President

KIM N. THOMPSON
General Secretary and Treasurer

united transportation union

14600 DETROIT AVENUE
CLEVELAND, OHIO 44107-4250
PHONE; 216-228-9400
FAX: 216-228-5755

www.utu.org

<<enter date here>>

<<whole_name>>
<<Address_1>>
<<Address_2>>
<<City>>, <<state> <<zip>>

Dear Sister or Brother:

Our UTU members greatly assisted with the passage of H.R. 2095, the Federal Railroad Safety Improvement Act, through the United States House of Representatives, which, among, other positive provisions, would increase the number of Federal Railroad Administration (FRA) safety inspectors.

Efforts by our National Legislative Office in Congress are putting increasing scrutiny on the probability of underreporting by railroads of employees' injuries, as well as harassment and intimidation of workers who request time off when they are tired or sick.

In this regard, the FRA has begun an initiative, fully supported by the UTU, to gain direct input from train and engine service employees regarding the relationship between fatigue, quality of life, hours of service violations, limbo time and crew shortages. Such a study will provide a better understanding of the situations our members are placed in when railroads do not hire enough crews, forcing T&E service employees to be moved up in turns.

You are among a random sample of UTU members nationwide who are being asked to fill out work/sleep diaries for a two-week period. You are being requested to complete a brief background survey, keep a daily log for 14 consecutive days of your sleep and work times, and self-assessments of your level of alertness three times each day.

The information provided will be strictly confidential, and the FRA has engaged the consulting firm of Foster-Miller to conduct the study, tabulate the results, and insure the privacy of survey participants. The names of participants and their responses will not be divulged in any fashion, and the data gathered will be used solely to complete the study. After the study is complete, all personal data will be destroyed.

We estimate that it should require fewer than 15 minutes to complete the background survey, and making the entries in the log should require fewer than 10 minutes daily. You will receive a $75 gift certificate to either Home Depot or Sears in exchange for your completing the survey according to instructions.

Your participation is crucial to developing a database on work/rest schedules and sleep patterns of operating crews – a database that will better help to identify fatigue-related problems affecting train and engine service crews. The final report will be made available to all members.

Please read carefully the enclosed instructions before beginning the background survey and daily log.

Fraternally yours,

M. B. Futhey, Jr.
International President

Cc: Arthur Martin, Assistant President
James Brunkenhoefer, National Legislative Director

Survey of Work Schedules and Sleep Patterns of Train and Engine Service Employees

Important: Please Read Before Making Entries in Daily Log

Using the Daily Log

The log is divided into 14 sections. Start a new section for each new day. On the section divider page, write the date. Please start with Day 1. Begin your log on a day that you will be working. It is important that you provide data for **14 consecutive days**. If you have scheduled a vacation during this 14-day period, do not begin the log until after the vacation.

Complete the log for every day of the study, not just the days that you work. **We need a record of your sleep for all 14 days.**

Try to make entries in the log upon arising and at the start and end of each work period. If for any reason you do not record data at the appointed time, fill out your log as soon as possible to the best of your ability. The study results will not be meaningful without complete log book entries from you.

Draw a vertical line in the appropriate column for the time period of each activity or sleep period and write the start and end times next to the line. Please use military time.

The log contains a sample entry for 2 days. Please review this example to make sure that you understand how to make entries in the log.

Sleep Periods (complete daily)

Record your main sleep periods as well as any supplementary sleep periods or naps. Enter sleep quality ratings for your longest sleep period ending on each day. If your sleep is interrupted due to family or other circumstance for more than 15 minutes, please record this on the log by showing two separate sleep periods. Treat interruptions of less than 15 minutes as continuous sleep.

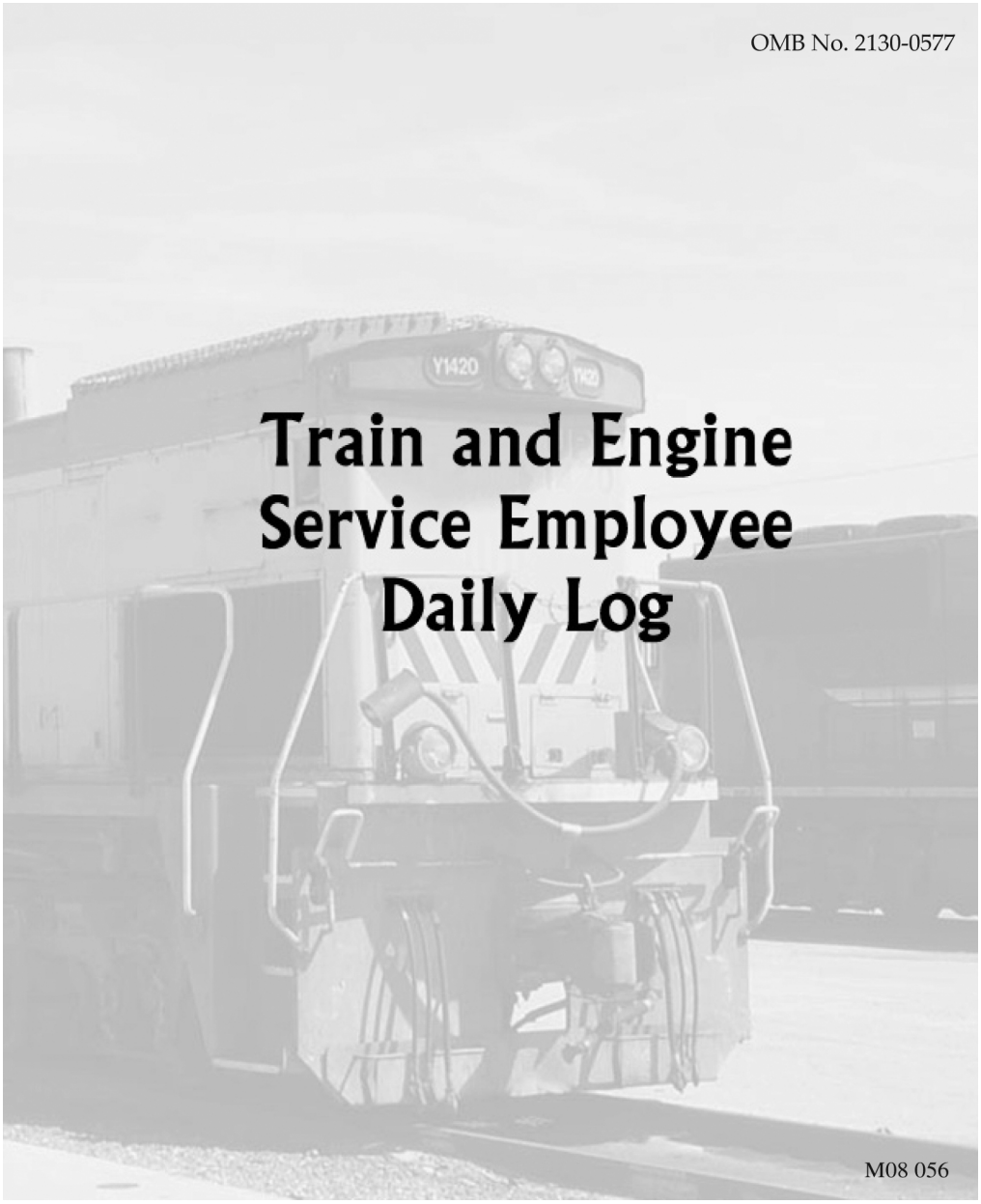
Next to the vertical line in the sleep column of the activity page, write an "A" to indicate that you slept away from home or "H" to indicate that you slept at home.

You may report a nap concurrently with work, limbo time, or interim release if this occurs.

Explain anything unusual about your sleep in the Comments section.

Work Periods	Make entries on the activity page to record your travel to/from your reporting point (Commute), your work period (Work), and limbo time or period of interim release, if any. Record as commute, the period from leaving home or lodging until you arrived at your reporting location. **If you arrive at your reporting point in advance of your sign on time, record this time as work. Similarly, if you do not leave company property immediately following the end of your service, record this time as work.** **If you start a work period today that will end tomorrow, rate your alertness today when you report for work and tomorrow when you complete the work period.** Explain anything unusual about your work period in the Comments section.
Study Compensation	**You must return a completed background survey and 14 days of sleep and work schedule information to receive the compensation.** You will receive a $75 gift certificate to a retail establishment as compensation for your participation in this study. Complete the last page of the log book to indicate your preference for the study compensation. You should receive your gift certificate within 4 weeks of returning your materials.
Returning Study Materials	Return your Background Survey and Daily Log in the postage paid envelope. If you cannot locate the return envelope, please contact Haila Darcy, hdarcy@foster-miller.com or 781-684-3966, for a replacement.
Questions or Problems?	If you have questions on any aspect of these instructions, are not sure how to report specific work or sleep information, or need additional survey materials, please contact Judy Gertler, jgertler@foster-miller.com or 781-684-4270.

OMB No. 2130-0577



Train and Engine Service Employee Daily Log

M08 056

ID Number_____

If you have questions, you can contact:

Judy Gertler
781.684.4270
jgertler@foster-miller.com

FRA F6180.128 (08/07)

Instructions for T&E Service Employee Log

This log is divided into 14 sections, one for each day that you will be recording data. Each section has a page for recording your self-assessments of your sleep and your alertness. A table for recording sleep, personal time, commute to/from work, work periods, limbo time, and interim release follows the self-ratings.

Please assign the time in each day to one of the six categories. Draw a vertical line in the appropriate column to indicate the time that you spent in that activity. Put a horizontal bar at the top and bottom of the vertical line to indicate the beginning and end of the activity. Please enter the actual start and stop time of each activity period. Next to the vertical line in the "Sleep" column, write an "A" if you slept away from home or "H" if you slept at home. Be sure to record all sleep periods, including naps. You may report work, limbo, or interim release concurrently with a nap if this occurs.

You may use the blank page following each daily entry for any comments about the day's activities. This is optional.

The following pages contain a sample entry for two consecutive days. This example illustrates how to record information in this log book.

Study Compensation

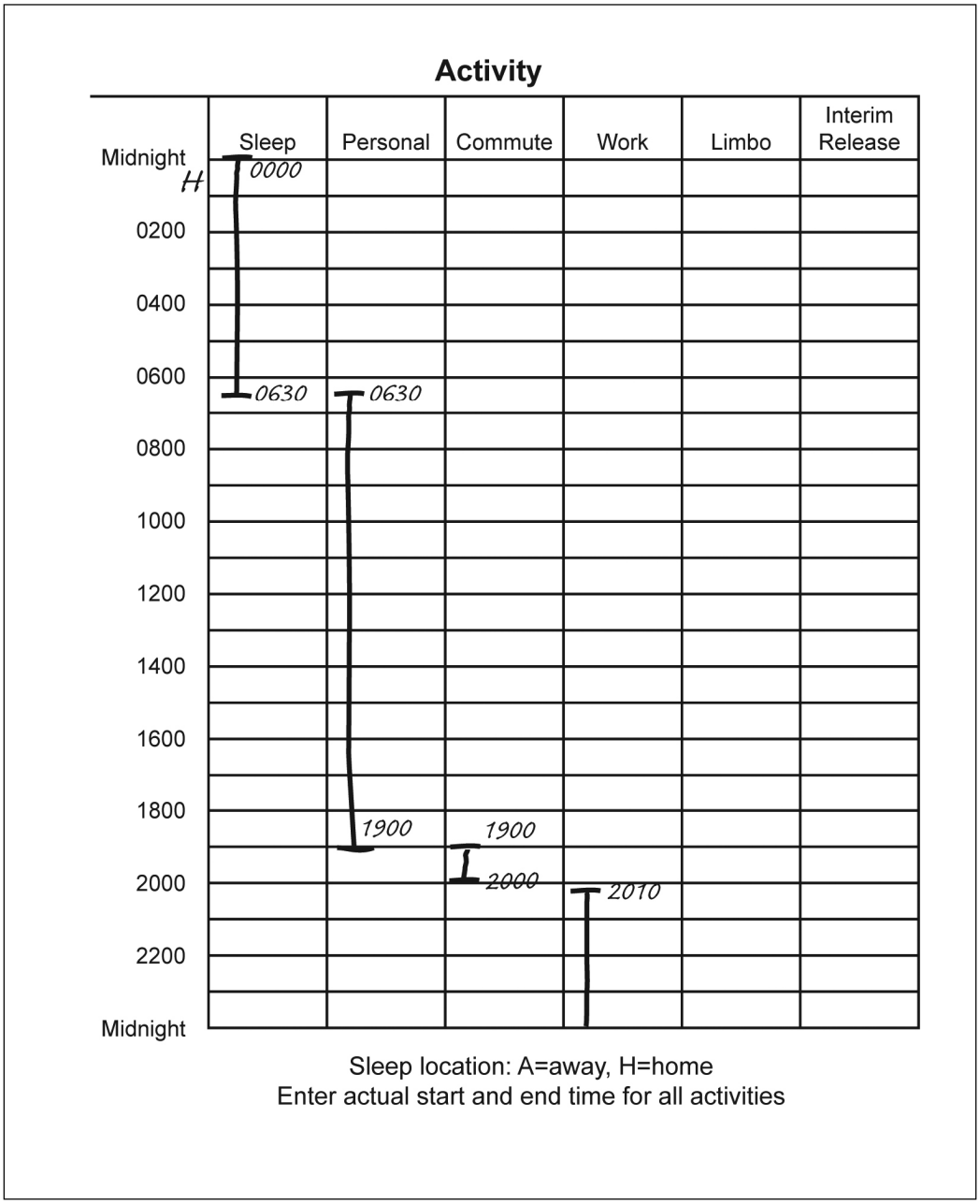
Complete the last page of this log book to indicate your preference for the study compensation.

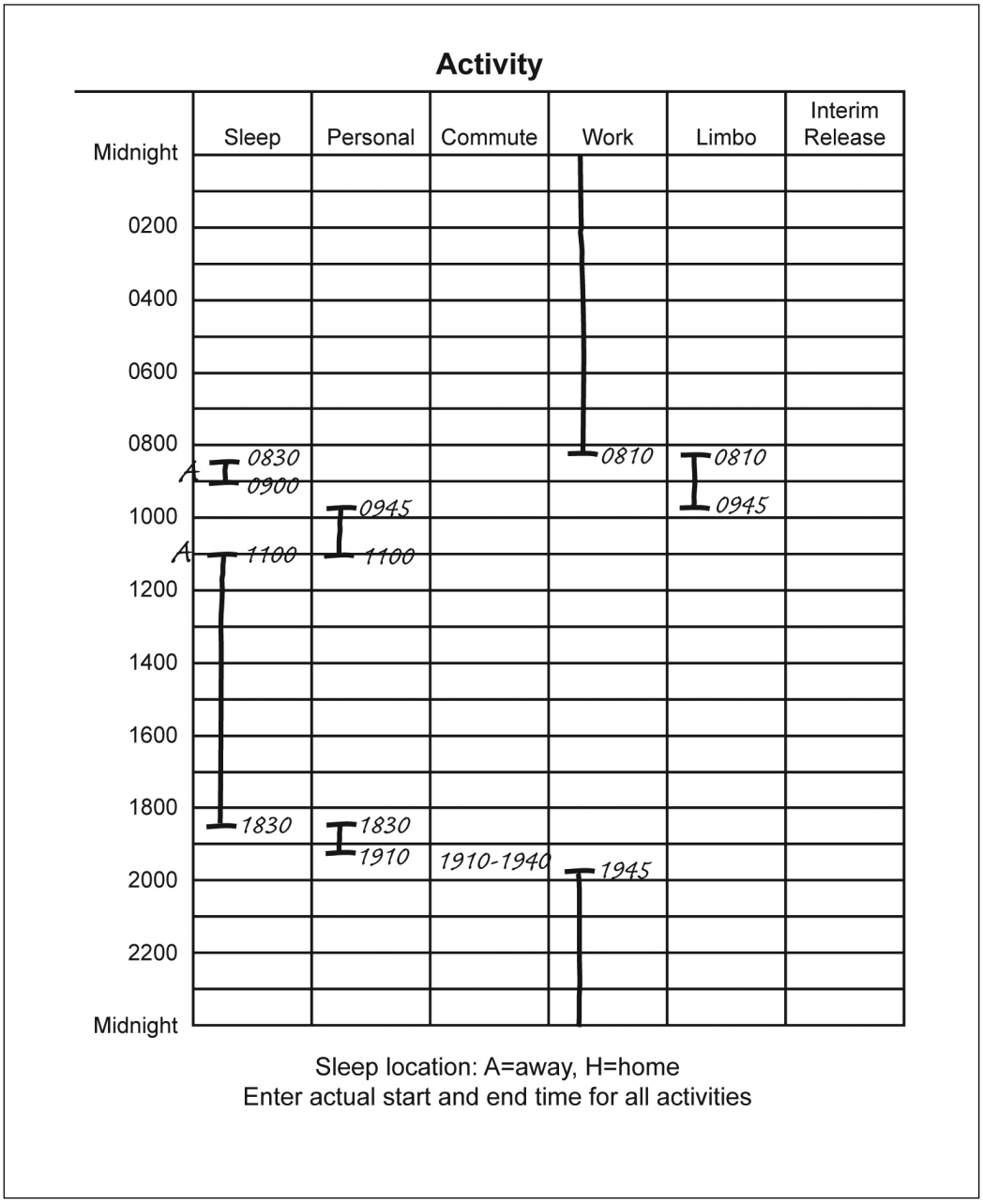
Sample Entry

You sleep at home Sunday night, going to sleep sometime before midnight, and you wake up at 6:30 a.m. Monday morning. You are not eligible to work today until 8 p.m. so during the day, you decide to fiddle around the house, run errands, and interact with your kids, until you are called. You receive the call to work at 6 p.m. You then prepare for work, get in your car at 7 p.m., and arrive at work at 8 p.m. You report for work at 8:10 p.m. Your work today takes you on the road, away from home.

You proceed to drive through the night, and into Tuesday morning. You realize that you are not going to reach your destination before your HOS expire, and you are forced to stop the train at 8:10 a.m. You call for a van and sit waiting in limbo. Because your agreement allows for napping, you doze for 30 min. A van arrives at 9 a.m. to take you to your lodging, and you arrive at 9:45 a.m.

You check into your room, and decide to have some breakfast and take a shower before lying down to sleep at 11 a.m. You are awoken at 6:15 p.m. when you receive a call informing you to be to work at 7:45 p.m. You are still tired and decide to get 15 min more sleep, so you lay back down. At 6:30 p.m. you wake up to prepare for work. Before the van arrives you make your way across the street to the convenience store to grab a sandwich and some snacks for the ride home. The van picks you up at 7:10 and drops you off at 7:40 p.m. You report for work exactly at 7:45 p.m. and you work up through midnight.


Activity
Sleep
Personal
Commute
Work
Limbo
Interim Release
Midnight
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
Midnight
H
0000
0630
0630
1900
1900
2000
2010
Sleep location: A=away, H=home
Enter actual start and end time for all activities


Activity
Midnight
Sleep
Personal
Commute
Work
Limbo
Interim Release
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
Midnight
A 0830 0900
0945 1100
A 1100 1830
1830 1910
1910-1940
0810
1945
0810 0945
Sleep location: A=away, H=home
Enter actual start and end time for all activities

Day 1

Date _____ / _____ / 2008

Self-Assessments

Rate your sleep upon arising from longest sleep period

Ease of falling asleep					
	1	2	3	4	5
	Very difficult				Very easy
Ease of getting up					
	1	2	3	4	5
	Very difficult				Very easy
Length of sleep					
	1	2	3	4	5
	Wholly insufficient				More than sufficient
Quality of sleep					
	1	2	3	4	5
	Very poor				Very good
Indicate how you feel now					
	1	2	3	4	5
	Very sleepy				Very alert

Start of Work

Indicate how you feel now					
	1	2	3	4	5
	Very sleepy				Very alert

End of Work

Indicate how you feel now					
	1	2	3	4	5
	Very sleepy				Very alert

Activity

	Sleep	Personal	Commute	Work	Limbo	Interim Release
Midnight						
0200						
0400						
0600						
0800						
1000						
1200						
1400						
1600						
1800						
2000						
2200						
Midnight						

Sleep location: A=away, H=home
Enter actual start and end time for all activities

Comments on Today's Activities

OMB No. 2130-0577

ID Number:_____

Train and Engine Service Employee Background Survey

The Federal Railroad Administration (FRA) is conducting a study of the work schedules and sleep patterns of railroad operating crews. The purpose of the study is to develop an understanding of the issue of work schedule-related fatigue of train and engine service employees. The study results will inform possible future FRA policy and regulatory actions, will assist the railroad industry in addressing any work-schedule related fatigue issues of train and engine service employees, and, in general, will contribute to overall railroad operational safety.

The data collected from this study will be used primarily for statistical purposes, and is authorized by law (49 U.S.C. 20901). Your participation in this study is completely voluntary. Your personal information will be kept private to the extent permitted by law, and will not be disclosed to anyone other than employees and contractors who work on this study.

Public reporting burden for this information collection is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Please note that an agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a valid OMB control number. The OMB control number for this information collection is OMB No. 2130-0577 and the expiration date is April 30, 2011.

About Yourself

1. Age: ____ years
2. Sex: ____ male ____ female
3. How long have you worked in train or engine service?
   _____ years and ____ months
4. How long have you worked in train or engine service at your current railroad?
   _____ years and ____ months
5. What type of work do you currently do?
   ____ yard operations, including hostling
   ____ local freight ____ road freight
   ____ passenger or commuter operations
   ____ other (please explain) _____
6. My current position is
   ____ conductor ____ locomotive engineer
   ____ RCL operator ____ hostler
   ____ brakeman ____ yard foreman
   ____ trainman ____ switchman
   ____ trainee
   ____ other (please explain) _____
7. What is your marital status?
   ____ single ____ divorced ____ other
   ____ married ____ widowed
8. How many children or other dependents do you have (not including your spouse)? _____
9. How many of your dependents are under the age of 2 years?_____
10. a) Do you drink caffeinated beverages?
    _____ yes _____ no
    b) On average, how many cups and/or cans of these beverages do you drink per day?_____

Your Health

1. How many times have you marked off sick in the last year? ___ days
2. In general, how would you rate your health? Circle one:

   Poor Fair Good Excellent
3. Some people feel younger or older than their biological age. How old do you feel? ____ years
4. What type of educational materials or training has your railroad provided you on fatigue, sleep hygiene, napping, or sleep disorders?

   ____ videotape ____ safety briefing

   ____ brochure ____ none

   ____ other (please explain) _____
5. Have you been diagnosed as having a sleep disorder?

   ____ yes ____ no (skip questions 6 and 7)
6. Do you have sleep apnea?

   ____ yes ____ no
7. Are you receiving medical treatment for your condition?

   ____ yes ____ no

Sleep/Rest Arrangements

Please complete this section *only* if your job requires you to spend time at an away terminal or interim release point.

1. When held at the away-from-home terminal or point of interim release, most times:

   ____ I share a hotel room or camp car with one or more other workers.

   ____ I sleep in an individual room, not shared with anyone.

   ____ I use the company-provided quiet room.

2. When at an away terminal or point of interim release, the company:

____ Provides me with sleeping accommodations.

____ Provides a daily per diem and I must find my own overnight accommodations.

____ Provides me with a quiet room.

____ Does not provide either sleep/rest accommodations or daily per diem.

Your Work Schedule

1. a) If you work a job that has a fixed starting time, please describe your work schedule using this table. Leave rest days blank and use military time.

	S	M	T	W	Th	F	S
Start time							
End time							

b) If you work a job that does not have a regular schedule, please answer the following:

at home call time _____(hr:min)

away call time _____(hr:min)

call window ___ 24 hr *or* from _____ to _____

On average, how many times a day do you check the line up?____

2. On average, how many hours do you work per week?

____

3. How does your job provide for rest days?

____ no guaranteed rest days ____ 2 consecutive days per week

____ 2 days per week ____ 1 day per week

____ other (Please explain. For example, 7 on/2 off, 8 on/2 off)

_____

3

4. How many times in the past year have you been used off your regular assignment or used to cover work that your pool does not usually cover? ____

5. How often do you feel well rested and alert over the course of your work period? Circle one:

   Never Occasionally Frequently Always

Stress at Work

Use the following scale to rate how much each factor below contributes to your stress at work:

No Stress	A Little Stress	Stressful	Very Stressful
1	2	3	4

Please assign a rating to *each* of the following items:

___ Irregular work schedule
___ Lack of control over work schedule
___ Loss of sleep
___ Lack of guaranteed uninterrupted rest
___ Coordination with other departments
___ Ambiguous operating rules or procedures
___ Management policies and decisions
___ Job security
___ Communication problems
___ Inadequate staffing
___ Responsibility for safety of others
___ Lack of break time
___ Inadequate time off
___ Oversight of new hires
___ Other (please specify) _____

_____

Life Events

Please indicate with a ✓ whether any of the events listed below has occurred to you in the last 6 months:

___ Personal illness or injury
___ Marital difficulties
___ Birth of a child
___ Death of a spouse
___ Change in sleeping habits
___ Difficulty with the law
___ Illness/injury of family member or friend
___ Financial difficulties
___ Change in living conditions
___ Change in social activities
___ Death of a close family member

Glossary

convenience sample – a sample from a population that is selected because it is readily available and convenient. Generalizations about the population cannot be made using data from a convenience sample.

extra board – a list of employees who fill in when regularly scheduled employees are not available to work

hostler – a person who moves locomotives only in engine house territory.

interim release – a period of 4 h or more between two on duty periods at a designated terminal.

limbo time – time that is neither on duty nor off duty. It is the time after which Hours of Service expire and an employee stops operating the train until he or she is released from duty.

statistical sample – a sample from a population that was selected in a way to assure that it is representative of the entire population and that conclusions about the entire population can be drawn from the sample data.

Abbreviations and Acronyms

ANOVA	analysis of variance
BLET	Brotherhood of Locomotive Engineers and Trainmen
d	day
FAST	Fatigue Avoidance Scheduling Tool
FRA	Federal Railroad Administration
GAO	General Accountability Office
h	hour
HOS	Hours of Service
min	minutes
MOW	maintenance of way
NSF	National Sleep Foundation
OMB	Office of Management and Budget
PVT	Psychomotor Vigilance Test
RCL	remote controlled locomotive
SAFTE	Sleep, Activity, Fatigue and Task Effectiveness
T&E	train and engine service
UTU	United Transportation Union
yr	year