HUMAN FACTORS ISSUES IN RAIL SAFETY

(109–92)

HEARING

BEFORE THE

SUBCOMMITTEE ON

RAILROADS

OF THE

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TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

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CONTENTS

TESTIMONY

PREPARED STATEMENTS SUBMITTED BY MEMBERS OF CONGRESS

PREPARED STATEMENTS SUBMITTED BY WITNESSES

SUBMISSIONS FOR THE RECORD

ADDITION TO THE RECORD

HUMAN FACTORS ISSUES IN RAIL SAFETY

Tuesday, July 25, 2006

HOUSE OF REPRESENTATIVES, COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE, SUBCOMMITTEE ON RAILROADS, WASHINGTON, D.C.

The subcommittee met, pursuant to call, at 10:00 a.m., in room 2167, Rayburn House Office Building, the Honorable Steven C. LaTourette [Chairman of the subcommittee] presiding.

Mr. LATOURETTE. We are going to call the Subcommittee to order this morning. Good morning. The Subcommittee will come to order. I want to welcome all of the members and witnesses to today's hearing on the subject of Human Factors Issues in Rail Safety. Working the rails can be a difficult and dangerous job. The men and women of our Nation's railroads work outdoors in the blistering heat of summer and the frigid cold of winter. Whether through mountain blizzards or coastal storms, the trains have to go through. Our Nation's railroads run 24 hours a day, 365 days a year. Railroad employees often work through the night or on weekends or on holidays. Overtime work is the norm on many of our major railroads.

This grueling schedule can have an impact on safety. Many railroad accidents have been attributed to employee fatigue, including accidents involving major loss of life. The work schedules of railroad employees is governed by the Hours of Service Act, a law dating back to 1907 when the railroad still ran steam engines. The purpose of today's hearing is to revisit the Hours of Service Act in light of new medical discoveries with due regard to the demands and responsibilities placed on employees in today's railroad operating environment.

Before yielding to Mr. Barrow, our guest Ranking Member today, I will just do a couple of brief housekeeping items.

I ask unanimous consent to allow 30 days for members to revise and extend their remarks and to permit the submission of additional statements and materials by members and witnesses. Without objection, so ordered.

Also, I ask unanimous consent to permit Ms. Schwartz of Pennsylvania to sit with the Subcommittee and to ask questions throughout the course of the hearing. Without objection, so ordered.

Now it is my pleasure to yield to Mr. Barrow for any opening remarks he would want to make.

Mr. BARROW. Thank you, Mr. Chairman.

Along the housekeeping lines, I would also like to ask unanimous consent that Representative Schwartz be allowed to sit as guest Ranking Member of this Committee when I have to leave.

Mr. LATOURETTE. Without objection.

Mr. BARROW. Thank you, Mr. Chairman, for holding this hearing.

Since the 1980's, the National Transportation Safety Board has been urging the Federal Railroad Administration, the railroad industry, and labor to create common sense solutions to reduce accidents caused by human factors. A leading cause of these accidents is fatigue. In 1999, the NTSB published an evaluation of the Department of Transportation's efforts to address operator fatigue.

Rail employees often work long and unpredictable hours and are constantly under the threat of exhaustion. In fact, rail workers put more time on the clock than any other worker in the transportation industry.

The NTSB recommended the rail industry develop schedules and working conditions to encourage employees to rest and implement better testing to determine fitness for duty. They also recommend the industry work more closely with its employees to reduce the amount of tasks that induce fatigue. The FRA agreed with the NTSB's findings, and in 2003, they established the North American Rail Alertness Partnership, a joint labor-management forum to address these issues. However, the NTSB made these original recommendations over seven years ago, and we haven't heard of any specific actions the industry has taken to address fatigue with one exception, new technology and positive train control.

Combating fatigue is a win-win proposition for the rail industry. The railroads should provide across the board training on fatigue management. Rail workers and their supervisors should get regular training on the importance of sleep, how to recognize sleep disorders, sleep strategies, and how to counter the effects of fatigue which can be effective in dealing with fatigue and ensuring the safe operation of our trains.

The railroads should also allow workers who are fatigued to go home when they are tired without fear of being disciplined or dismissed from their jobs. In addition, the railroad should actively work to limit limbo time where an employee is neither on the clock or off but is usually traveling from one job to the next.

The FRA should be rigorously enforcing the hours of service law, developing crew scheduling practices for the railroads, and requiring the railroads to adopt fatigue mitigation plans which should be submitted to the FRA and approved by the FRA. Congress needs to revise the Railroad Hours of Service Act which was enacted in 1907, which everyone agrees is in desperate need of updating.

Thank you, Mr. Chairman. I look forward to hearing from witnesses today, and I yield back the balance of my time.

Mr. LATOURETTE. I thank you, Mr. Barrow.

Mr. Cummings?

Mr. CUMMINGS. Thank you very much, Mr. Chairman. I will be very brief. I too thank you, Mr. Chairman, for holding this hearing with regard to the human factors that affect safety on our national railroad network.

During a hearing held by this Subcommittee earlier this year to examine overall trends in rail safety, several of the witnesses who appeared before us emphasized the fact that in 2005, human factors were the primary causes of accidents among all four major

Class I railroads. Today's hearing will give us the opportunity to explore the human factors that affect rail safety in more detail.

Statistics published by the Association of American Railroads show that during 2004, there were 556 railroads operating more than 201,000 miles of track and employing nearly 216,000 workers. The total number of accidents and incidents of all kinds per year on the rail network have fallen dramatically over the past decade from nearly 17,719 in 1996 to just under 13,800 in 2005.

However, while these overall trends are very encouraging, there are other safety indicators that have not shown this kind of improvement. For example, during the 1996 to 2005 period, the total number of train accidents has been steadily increasing. In addition, after falling between 2000 and 2002, the number of train collisions has been rising in recent years, increasing from 192 collisions in 2002 to 261 collisions in 2005. Unfortunately, the rate of human factors in train accidents has shown a particularly steep rise, increasing from 783 accidents attributed to human factors in 1996 to more 1,200 attributed to human factors in 2005.

Among those human factors that are contributing to accidents is worker fatigue which was cited as a contributing cause to the 2004 train collision in Texas that led to the release of a chlorine gas cloud that killed two local residents. Trains now carry more than 1.8 million carloads of hazardous materials per year, and the safe operation of trains is particularly essential to ensuring the safe transportation of such cargos. The prevalence of fatigue as a contributing factor in rail accidents calls into question whether current regulations regarding hours of service and current railroad crew scheduling procedures are truly designed to protect the safety of workers and of the communities through which trains pass.

Mr. Chairman, a month with 31 days has only 744 hours in it. The National Transportation Safety Board has indicated that the maximum allowable number of hours that a locomotive engineer could work under current rules governing hours of service is 432. By comparison, a truck driver is allowed to work only 260 per month while an airline pilot may work only 100 hours per month.

In addition to the sheer number of hours worked, train crews are on call every hour of the day and may be summoned for work at any time. Such an irregular schedule surely interferes with train crews' ability to plan their lives including their sleep schedules. These are certainly less than optimal working conditions for anyone but particularly for someone who is driving a freight train weighing hundreds of tons and potentially carrying a highly toxic or even deadly substance.

I look forward to hearing from today's witnesses regarding what can be done to reduce the human factors that are contributing to train accidents. With that, Mr. Chairman, I thank you and I yield back.

Mr. LATOURETTE. I thank you, Mr. Cummings.

Our hearing today is comprised of two panels. The first panel has the Honorable Joseph Boardman who is the Administrator, of course, of the Federal Railroad Administration; and Mr. Robert Chipkevich who is the Director of the Office of Rail, Pipeline, and Hazardous Materials Investigations at the NTSB.

Gentlemen, thank you both for coming. We have received your written testimony. If you would be so kind as to summarize in five minutes your observations for us today, we would appreciate it.

Administrator Boardman, welcome, and we look forward to hearing from you.

TESTIMONY OF THE HONORABLE JOSEPH BOARDMAN, ADMINISTRATOR, FEDERAL RAILROAD ADMINISTRATION; ROBERT CHIPKEVICH, DIRECTOR, OFFICE OF RAIL, PIPELINE, AND HAZARDOUS MATERIALS INVESTIGATION, NATIONAL TRANSPORTATION SAFETY BOARD

Mr. BOARDMAN. Good morning, Mr. Chairman. Thank you and Ranking Member Barrow and Committee members.

Human factor issues in rail safety bring all of the issues for safety together in one place. Your Committee has chosen the single most difficult issue that faces the railroad industry today. Railroads must manage their human assets to meet both customer expectations and stockholder expectations and do so within a socially acceptable environmental, safety, and security framework. This framework has safety as the base case for everything else that is demanded of railroads today. At the center of that base case are the humans.

Last month, I told you that human factors as a cause has increased by another percentage point to 38 percent of all causes for train accidents. The human factors that are leading the list of causes for accidents include switches improperly lined and shoving movements, in addition to things like leaving cars out to foul main tracks, improper handbrake use, and a few others that will be included on a new Federal rule now making its way through the clearance process. That new rule will make cardinal railroad rules become Federal rules and subject to Federal law if violated and not cared for.

Today a railroad must meet the demands of a 24-hour, 7-day-a-week global supply chain and logistics management industry to be successful and therefore profitable. Both railroads and their employees strive to meet those requirements and striving can contribute to taking shortcuts in these cardinal rules. Federal hours of service rules are nearly 100 years old and were last amended 35 years ago, but much has been learned that would assist in improving hours of service rules and management of the work force not only in the last 100 years but also in the last 35 and even in the last 10.

Biological rhythms and what we know now about them should improve the management of the safety of critical crew members. The hours of service law doesn't deal with the issue at all. FRA's lack of regulatory authority over duty hours unique to FRA among all the safety regulatory agencies in the Department, precludes the FRA from making use of such scientific learning on this issue. Now that doesn't mean that the FRA and the DOT have not attempted to rectify that.

Legislation was submitted four times in the last 15 years, and it is now in clearance again. In 1991, the legislation failed with opposition from both rail labor and rail management. In 1994, a bill was enacted but required labor-management petition and failed because a joint petition was received but became moot. In 1998, the bill was attacked as being too prescriptive and was not enacted. In 1999, the reworked 1998 bill was never granted a hearing. The FRA has another bill in for clearance, but I must say that the issue you are holding this hearing on will require more than just legislation to address effectively.

Hours of service raises objection from both unions, whose members want to maximize earnings, and rail companies, who must meet supply chain demands. But rules alone—no matter how well written or how well meaning—will not be sufficient to secure the base case of safe railroading. Voluntary efforts sponsored by the FRA, like the RSAC and the SACP, now RSOM, are helping to secure the kinds of joint labor-management-regulator discussions of fatigue management, technology use, and crew scheduling that can and are improving both our understanding of human factors and the things that can improve their performance. Continued research into things like close calls, ECP brakes, and PTC are also critical to reaching a base case of safe railroading.

My written testimony and, I believe, the testimony of everyone here today will convince you that the most important element needed for safety is a human safety culture that starts with this Government, the executive and legislative and judicial, and extends through management and labor on down to the individual railroader getting the job done with complete support for his or her safety and security.

Thank you.

Mr. LATOURETTE. I thank you very much, Administrator Boardman.

Mr. Chipkevich, welcome to you, and we look forward to hearing from you.

Mr. CHIPKEVICH. Thank you and good morning, Chairman LaTourette and members of the Subcommittee. Thank you for the opportunity to testify today.

Since 2001, the National Transportation Safety Board has investigated 28 railroad and 3 rail transit accidents involving collisions and over-speed derailments. Most of these accidents occurred after train crews failed to comply with control signals, to follow operating rules in non-signaled territories, or to comply with other specific operating rules. Our accident investigations have identified human performance failures related to fatigue, medical conditions such as sleep apnea, use of cell phones, use of after arrival track warrants in non-signaled territory, loss of situation awareness, and improperly positioned switches.

Although the Safety Board has made numerous recommendations to address human performance issues, we have repeatedly concluded that technological solutions such as positive train control systems have great potential to reduce the number of serious train accidents by providing a safety redundant system to protect against human performance failures. As a consequence, positive train control has been on the Safety Board's list of most wanted transportation safety improvements for 16 years.

Fatigue is a human performance safety issue that crosses all modes of transportation. The Safety Board most recently addressed this issue after a collision between two freight trains at Macdona, Texas. Train crew fatigue resulted in the failure of the engineer and conductor to appropriately respond to signals governing the movement of their train. Contributing to their fatigue was their failure to obtain sufficient restorative rest prior to reporting for duty because of their ineffective use of off-duty time and train crew scheduling practices which inverted their work/rest periods.

Minimum rest periods do not take into account either rotating work schedules or accumulated hours spent working in limbo time. Limbo time is most often associated with a crew member's time to their final release point after expiration of their 12 hour service limit. Time spent waiting for transportation can be significant and lead to very long workdays. The Safety Board has recommended that the FRA require railroads to use scientifically-based principles when assigning work schedules for train crews, which consider factors that impact sleep needs to reduce the effects of fatigue and to establish requirements to limit limbo time.

FRA certification requirements for locomotive engineers focus on specific vision and hearing acuity standards but do not provide guidance regarding medical conditions that should be considered in the course of an examination. The Safety Board has recommended that the FRA develop a standard medical examination form that can be used to determine the medical fitness of locomotive engineers and other employees in safety sensitive positions.

After two freight trains collided near Clarendon, Texas, the Safety Board recommended that the FRA issue regulations to control the use of cell phones. At Clarendon, the engineer of one train had used his cell phone for two personal calls the morning of the accident, one call for 23 minutes and the second call for 10 minutes. The engineer was on the second call as he passed the location at which he should have stopped and waited for the arrival of another train.

Non-signaled territory presents a unique problem for rail safety. There are no signals to warn trains as they approach each other, and the avoidance of collisions relies solely on dispatchers and train crews adhering to operating procedures. After several accidents, the Board has again recommended that the FRA prohibit the use of after-arrival track warrants for train movements in non-signaled territory not equipped with a positive train control system.

Finally, one of the most serious accidents in recent years occurred in Graniteville, South Carolina. After a freight train encountered an improperly positioned switch, the train was diverted from the main line onto an industry track where it struck a parked train.

Measures beyond additional operating rules, forms, or penalties are needed to prevent accidents such as the one in Graniteville. The Safety Board recommended that in non-signaled territory and in the absence of switch position indicator lights or other automated systems that provide crews with advanced notice of the position of switches, trains be operated at speeds that will allow them to safely stopped in advance of the misaligned switches.

Mr. Chairman, this completes my testimony. I will be happy to answer any questions.

Mr. LATOURETTE. Thank you very much, Mr. Chipkevich for your statement.

Administrator Boardman, I would like to start with you where Mr. Chipkevich talked about this medical examination. I think it would be hard for me to imagine that the Federal Aviation Administration would not have medical examinations for the pilots that fly airplanes. I have a good friend back home who had a heart attack and he has to go through a pretty rigorous set of tests in order to have his pilot's license renewed.

Can you tell us what the FRA's thinking is on medical examinations for people that drive locomotives?

Mr. BOARDMAN. The FRA has worked on and produced a report on medical conditions and standards for railroad employees and is working with the railroads at this point in time. The railroad industry itself, because it began being really self-regulated, usually had a medical director on staff. Now in recent years, many of those folks are no longer employed, and we are working with the railroads and with the industry to make sure that those standards are improved. We do have a drug and alcohol program, which I know you are well aware of, and it was the first in the country to really have it.

Mr. LATOURETTE. What about his observation about the engineer that was on the cell phone. Is the FRA dealing with the cell phone in the cab issue as well?

Mr. BOARDMAN. Well, we are looking at it as a part, and I don't have a specific answer to the cell phone. I know we are looking at a lot of the human factors and have had a lot of discussions. I will find out specifically what we have done about the cell phone and get back to you on that.

[The information received follows:]

INSERT FOR THE RECORD
JOSEPH H. BOARDMAN,
FEDERAL RAILROAD ADMINISTRATOR,
HEARING BEFORE SUBCOMMITTEE ON RAILROADS,
HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
July 25, 2006

[Insert after line 393 on pg. 20]

Thank you for the opportunity to provide this supplemental information on cell phone use in locomotive cabs. The National Transportation Safety Board (NSTB) has raised concern about cell phone use by railroad operating employees. Specifically, in NTSB Safety Recommendation R-03-01, the NTSB recommended that the Federal Railroad Administration (FRA):

> Promulgate new or amended regulations that will control the use of cellular telephones and similar wireless communication devices by railroad operating employees while on duty so that such use does not affect operational safety.

In a letter to the NTSB, dated August 18, 2006, FRA updated the NTSB on our response to this and other safety recommendations. Since our response to this safety recommendation covers your question as to how FRA is dealing with the issue of cell phone use in locomotive cabs, it is being excerpted, below.

> **FRA Response:** In a letter to the NTSB, dated May 26, 2004, FRA stated that it had canvassed the major railroads and obtained copies of their instructions, policies, and/or rules that place restrictions on the use of cellular telephones (cell phones). FRA=s review of this material indicated that despite some disparity with respect to the detail of prohibitions, all railroads canvassed did have a rule or instruction that prevents and/or limits cell phone use. FRA also stated that it believed that the railroad industry=s enforcement of its operating and safety rules governing cell phone use is sufficient to address the issue without the need for the intrusiveness of Federal regulations at this time.
>
> At a full RSAC meeting held in Washington, DC, on September 22, 2004, members came prepared to discuss the issue of cell phone use, whether their current instructions were for cell phone use, whether they needed to be improved, and whether this was a subject that should be tasked to a new RSAC Working Group. This is an issue that appears in all forms of transportation. FRA pointed out that the proliferation of cell phone technology has now made the device(s) a necessity, but also noted that there are many examples of how the use of these devices by railroad employees in locomotive cabs of moving trains can be distracting. It was also noted that distraction by use of mobile phones is by no means the only potential source of diversion from attention to duty.
>
> The RSAC members present at the meeting unanimously restated that virtually all of

them restrict cell phone use in one form or another, but also acknowledge that the use of this device allows more effective communication amongst employees, and that some railroads even provide cell phones to their employees. It was also pointed out that redundant communication devices are now required by Federal regulation (49 CFR Part 220), and cell phones are one acceptable example. The consensus of those members present at the meeting was that this is a complex issue and that they were not yet prepared to consider a Federal rule in this area.

Notwithstanding, while FRA has not yet decided what proposed course of action it will follow, FRA agrees to reexamine existing railroad rules and instructions on cell phone use and develop from that review what "best practices" emerge. FRA will then prepare a recommended "best practices" document and circulate it among RSAC members for comments prior to forwarding it on to the NTSB.

Therefore, based on the foregoing, FRA respectfully requests that Safety Recommendation R-03-01 remain classified "Open B Acceptable Action," until such time as FRA determines the proper direction to take at a subsequent full RSAC meeting.

Mr. LATOURETTE. OK, I appreciate that.

We are really here, I think, to talk about the hours of service, and your statement pretty well laid out the attempts since 1991 to modernize the Hours of Service statute. All of them have died in some form or another here on Capitol Hill. I think I heard you say and I happen to agree that it appears that both the labor side and the business side have a vested interest in keeping things the way that they are, and that has led to the inability to change this statute that has been around since 1907.

I just read in getting ready for the hearing, when this issue was addressed in 1998, the previous Chairman of this Subcommittee posed this question to NTSB back in 1998, and I would like to ask you what your answer is to this. Do you think that if the Congress were to offer a system of comprehensive anti-fatigue plans that were customized for various types of rail operations with these plans eventually superseding the current statute, or perhaps more importantly, Congress allowed both labor and management enough lead time to deal with the compensation and crew requirement issues in their next bargaining round, that would help break the deadlock that has so long prevailed. How do you feel about that?

Mr. BOARDMAN. I think it is very difficult. For example, that particular question, I think, summarizes all the reasons why the bills failed up here, and in particular that at times our plan was too prescriptive. I think 1998 was too prescriptive. We were looking for fatigue management plans from the railroads. Prior to that in 1991, we were actually going to repeal the hours of service law. So I think there were some leftover, probably, feelings or thinking at the time that those fatigue management plans might, in fact, just do that, and that probably got people riled up.

I think the hours of service should be taken out of the railroads. As somebody who holds a Class A driver's license and a pilot's license, I understand and have made a living from driving trucks. When I did that, I wanted the maximum number of hours that I could possibly get in, and so I wanted to be called, regardless. I didn't much care at the time whether I had what the requisite number of hours were. I didn't even know what the hours of service law was. I knew I wanted to work. I think that is the difficulty we are in here.

It is a legitimate concern that the unions have that their membership needs to and wants to gain the income that they feel they want to if they believe they can work.

I think there have been a lot of experiments that have occurred with railroads that have tried to figure out how can we give regular rest periods for folks? In fact, I think there is one railroad, and it may be a Canadian railroad, that really looked at a way for people that are from an "away" terminal to let them knock off to rest. The problem there was that those employees didn't want to be stuck at that "away" terminal and not be reassigned at the right time to get back home again. So it is a very difficult issue.

Mr. LATOURETTE. Sure, it is.

I think my last question is, as you told us either at the last hearing or the hearing before and you reminded us again today, the human factor side has ticked up 1 percent. Basically, the data that we have looked at is that even though I know Mr. Hamberger when he talks will talk to us about the greatly improved safety record of the railroads and we all applaud that, I think if you look at one thing that has plateaued, it is certainly the human factor, at least from my perspective.

We just had the full Committee mark up a pipeline bill a couple weeks ago, and there was some discussion about whether we impose hours of service for the people that sit in the terminals on pipelines. My own view is there are some people, based upon their medical condition and their health, who can work longer hours than other people. If you just look at hours of service, you really are not having a comprehensive fatigue plan for the railroad or for any industry, and I assume you agree with that and, Mr. Chipkevich, that you agree with that as well.

Mr. CHIPKEVICH. Yes, sir, there are multiple issues that need to be considered, not just the hours, the scheduling practices, the inverted schedules, things of that nature.

Mr. LATOURETTE. Sure. Thank you very much.

Mr. Barrow?

Mr. BARROW. Mr. Boardman, I would like to begin with you. First off, I want to thank you for having your staff meet with us last week. I appreciate that very much.

I understand from testimony we are going to hear later on today that data from just one of the four largest Class I railroads shows that in the first six months of this year alone for that one railroad alone, 224 crews worked in excess of 14 hours every day, 103 crews worked in excess of 15 hours a day, 46 crews worked in excess of 16 hours a day, and almost 20 crews every week worked more than 20 hours long. Are you all aware of those kind of numbers?

Mr. BOARDMAN. I am not specifically aware of those, but it doesn't surprise me, when you add in the limbo time like you talked about earlier, that those kind of numbers exist.

Mr. BARROW. Without moving into the trickier area of how we are going to change the Hours of Service Act and who is going to make the calls on that, what is the FRA doing to enforce the rules we have on the books?

Mr. BOARDMAN. I think one of the things that made it very difficult for us is that a person can work 12 hours a day and then there is limbo time beyond that. When the Supreme Court ruled that that limbo time was not considered work time, it fell outside the area of those 12 hours of work. We don't have the same authority that others have to make changes in that area. So we have to wait until a change in the hours of service law to get at it.

Mr. BARROW. So basically you are saying the Supreme Court has tied your hands with its interpretation of the Hours of Service law.

Mr. BOARDMAN. Yes, sir.

Mr. BARROW. Well, let me shift ground a little bit for a second. I want to address something to Mr. Chipkevich.

You know someone once said that if you have the ability to think about something without thinking about the thing to which it relates, you have the quality of mind to be a good lawyer. I am not exactly sure that was a compliment as a member of that profession, but I want to talk about something to which this problem of hours of service relates and that is staffing levels in general.

I gather, for example, that one of the human factors that contributed to the collision in Graniteville that caused a number of people to die just about the most ghastly death that you can experience was not fatigue but too few people trying to do too much work, working within compliance of the hours of service law, that switches were left in the wrong position because too few people having too much work to do had to knock off in order to comply with the act.

That sort of brings to my mind an unintended consequence or at least an unintended effect of a basic reform like an hurs of service rule when you apply it to different staffing levels. It seems to me that an hours of service rule makes perfectly good sense as an approach to how to ration and allocate the work to be done when you have enough people to ration it amongst, but you have a real problem with something like an hours of service law if you have too few people doing the work to begin with. Not only do you have the problem of people working too hard and getting tired, you also have not enough time for the work force to do the many things that have to be done. Applying an hours of service type methodology to a work force where you have more than enough people doing the work means you just have to spread it out amongst the right number of people, the right number of chores for the right number of people.

It is very problematic when you have too much work to do for the number of people you have. That problem can arise in either two contexts. Either there is not enough work out there to hire and you go out there and you can't buy it up because there is not enough of it, but you still have more than you can find people to do, or you have the problem of people trying to make too few people do to much work. We are actually clamping down on the manpower so much that you have so much to do that folks can't comply with the hours of service law and still get everything done.

I know that was a factor in Graniteville. You didn't have people who were too sleepy. You had folks who had to knock off on time and just had to get off the job too soon, and that was one of the factors that contributed to leaving a switch open, and you had a track speed collision with a parked train on a siding. These were folks were trying to comply with the law. I know that is not the general direction we are going in, but that is a problem. If you have staffing levels that are inadequate, this whole approach is going to hurt you in other ways besides the most fundamental way of people working too long until they are dropping at the wheel.

What is your concern about staffing levels? Are you all looking at that any? Is that an issue?

Mr. CHIPKEVICH. We certainly noted in the Macdona accident investigation that in the San Antonio area where there was a significant amount of business during the period of 2004 as well as problems with the number of crews available, that we identified 42 percent of the time in that particular area, crews were working greater than 12 hours and then some crews working certainly greater than 15 hours and some crews up to as much as 23 hours, considering the significant amount of limbo time that was added to their regular work time.

Compounding that problem was with all that additional limbo time, then those crews were not available again for another 10 hours or another period before they could be used again, which sort of exasperated the problem. That affected the scheduling practices of calling up crews earlier because other crews are not available because of limbo time and things of that nature.

So, yes, sir, we have seen that as a problem.

Mr. BARROW. Now going back to the subject I wanted to avoid in the beginning, I am just kind of interested in your assessment. How do you think we need to fix the Hours of Service Act? How do you think we go about doing that? Should Congress fix it legislatively and address the problems caused by the Supreme Court's interpretation of the act, or should it be addressed in the way it is with other Transportation Agencies by delegating rulemaking authority to the FRA? I want the Transportation Board's input on that in particular.

Mr. CHIPKEVICH. We have certainly supported the FRA going to the Congress to ask for changes in the legislation to give them some authority to require some changes in programs, fatigue management programs, to look at scheduling practices that affect crews being called.

Mr. BARROW. You have supported in the past the idea of delegating the rulemaking authority to the FRA. Is that still your position?

Mr. CHIPKEVICH. Yes, sir, that has not changed.

Mr. BARROW. How about you, Mr. Boardman? How do you think we ought to do it? Should Congress fix it in statute, or should Congress amend the statute to give the rulemaking authority to the FRA to fix the problem subject to Congress' monitoring and control?

Mr. BOARDMAN. I think that FRA could do the rulemaking if we were given the authority to do so.

Mr. BARROW. Thank you.

Mr. LATOURETTE. I thank the gentleman.

Mr. Petri, do you have any questions? I know you just got here. OK, thank you very much.

Well, gentlemen, thank you very much for your testimony. We appreciate not only your testimony but your answering our questions, and you go with our thanks. Thank you very much.

Our second panel this morning is going to be comprised of multiple witnesses: Dr. Martin Moore-Ede, who is the Chief Executive Officer of Circadian Technologies, Inc.; Mr. James Stem, who is the Alternate National Legislative Director for the United Transportation Union; Mr. Edward Hamberger who, of course, is the President and Chief Executive Officer of the Association of American Railroads; Mr. John Tolman, who is the Vice President and National Legislative Representative for the Brotherhood of Locomotive Engineers and Trainmen; Mr. Richard Timmons, who is the President of the American Short Line and Regional Railroad Association; and Mr. W. Dan Pickett, who is the International President of the Brotherhood of Railroad Signalmen.

I want to thank all of you for coming this morning. As with the previous panel, we appreciate your timely submission of your written testimony. We have had the chance to review it. If you would be so kind to summarize your testimony in five minutes, we would appreciate it very much.

Doctor, we are glad you are here, and we look forward to hearing from you.

TESTIMONY OF MARTIN MOORE-EDE, M.D., PH.D, CHIEF EXECUTIVE OFFICER, CIRCADIAN TECHNOLOGIES, INC.; JAMES STEM, ALTERNATE NATIONAL LEGISLATIVE DIRECTOR, UNITED TRANSPORTATION UNION; EDWARD HAMBERGER, PRESIDENT AND CHIEF EXECUTIVE OFFICER, ASSOCIATION OF AMERICAN RAILROADS; JOHN P. TOLMAN, VICE PRESIDENT AND NATIONAL LEGISLATIVE REPRESENTATIVE, BROTHERHOOD OF LOCOMOTIVE ENGINEERS AND TRAINMEN; RICHARD F. TIMMONS, PRESIDENT, AMERICAN SHORT LINE AND REGIONAL RAILROAD ASSOCIATION; W. DAN PICKETT, INTERNATIONAL PRESIDENT, BROTHERHOOD OF RAILROAD SIGNALMEN

Dr. MOORE-EDE. Thank you, Mr. Chairman. I appreciate the invitation to address the Committee.

Fatigue, as we all know, has been a safety hazard that has been recognized since the dawn of railroads, and indeed the railroads were the first transportation mode to put in rules and, in fact, the laws to do with hours of service. Other transportation modes followed quite some decades behind in some cases.

Of course, what has happened is that the work that those in the research community, like myself, did in the 1970's and 1980's demonstrated that the physiology of sleep and biological clocks and circadian rhythms was rather different than was envisaged by those who had written those original regulations and laws in the earliest part of the 20th Century. Indeed, the simple hourglass model of measuring the number of hours on duty and then number of hours of rest basically, fundamentally doesn't work. In fact, many other factors are rather more important than that in terms of determining whether an employee is going to be fatigued or not.

Over the years since then, tools have evolved and have been applied in a wide variety of industries, in fact, across virtually every industry that runs 24/7. Having experienced and worked in many of these industries including the railroads, I think the railroads are to be commended as one of the most progressive in terms of developing fatigue management tools and training programs and sleep apnea screening processes and so forth and systematically working at this issue and putting them into place.

The sobering fact, however, as has been mentioned earlier, is that when we look at the target which surely all these efforts should be addressing which is the number of human factors accidents corrected by the number of million train miles—so we are not just talking about aberrations based on the growth of the industry—that has been at a plateau since 1985. If you look at the more focused data on mainline and siting data for human factors accidents per million train miles, that has been at a plateau since 1995 for the last 10 years. Fatigue is still very much a factor, we all recognize that, and fatigue causes accidents. So for those particular reasons, it is not that the fatigue is not an issue.

The real problem, I believe, is that we are locked in a 100 year old paradigm of regulations and laws based on managing inputs rather than outputs. Indeed, if you look at any way of managing a business, you don't measure a business by the amount of raw materials it consumes. You measure it by the products that it produces and the bottom line results on its financial books.

Fixing the hours of service, however, is really not the answer. In other words, you could not write rules that would work without them being overly complex, and I think anybody who contemplates rewriting or tweaking the hours of services rules and regulations and laws should look very carefully at what is happening with the FMCSA right now and the trucking hours of service regulations which are under multiple attacks and are being tossed out in the courts and rewritten and tossed out again. Indeed, that is an ongoing process because writing prescriptive rules is a method that really doesn't work.

The solution, I believe, is to look at a new paradigm, and the paradigm that is actually pioneered into regulation by the Nuclear Regulatory Commission is called Risk-Informed Performance-Based Safety Management. What it means that you develop models which you determine that accurately predict risk and then you ask the industry to manage to reduce that risk, that measurable output risk, the risk being human factors accidents per million train miles, for example, as a target. This process of constantly feeding back as to whether any intervention is actually fixing that risk is the way you progressively learn and progressively improve.

It now is the wholesale way of managing risk in the nuclear power industry, in all sorts of fire standards for Federal buildings, a whole number of different ways by using risk models. It is possible to build risk models now, and certainly the science and the technology to do that is radically improved. The insurance industry relies on predictive risk models now. It is 25 percent better than the best human adjuster in underwriting, for example. Over 50 percent of the Fortune 100 use predictive risk models in business intelligence, using the vast amounts of data to predict what, in fact, are the outcomes, the best of the bottom line, i.e., the output.

We have actually taken the step and moved that into transportation in trucking. By building risk models which, first of all, model fatigue risk, we can demonstrate some very interesting rules, namely that it is only when you get to the extremes of fatigue risk that you get enormously, rapidly increasing levels of risk.

If you mine those nuggets of where the risk is and fix those particular areas, you get major improvements in performance. You can get 50 percent reductions in accident rates and personal injury, 70 percent reductions in financial losses. It works best when you don't just deal with fatigue in your risk models, but you actually recognize that fatigue interplays with many other aspects of safety, and if you put them together, you can get a 25 percent lift in performance of the models by building comprehensive models of human error risk and then having individual managers use their discretion, their knowledge, their individual situations and their local conditions in order to address it.

I think the time has come, Mr. Chairman, that we need to recognize hours of service regulation was the solution of the last century. It is 100 years old. In fact, the solution for the next century has to be predictive risk modeling. I don't think I am looking for wholesale abolition of hours of service or hours of service laws and regulations.

In fact, I think steps that have already been laid in the railroad industry to move in the right direction by building all these tools and developing experience with fatigue management. With the cooperation and very much the partnership of the unions in this as well as the railroad management, all sorts of tools have been developed.

I think the next step is to basically improve this process of risk managing to provide incentives to build risk models and then eventually as those become more and more effective, one has the ability to sort of wean the industry away from the hours of service laws.

I thank you for your time and consideration.

Mr. LATOURETTE. I thank you, Doctor, not only for your testimony this morning but for your very useful written testimony.

Mr. Stem, welcome, and we look forward to hearing from you.

Mr. STEM. Thank you, Mr. Chairman and Ranking Member Barrow. On behalf of the United Transportation Union, we appreciate the opportunity to appear today.

I am going to focus my remarks today in summary of my written testimony on training and the significant effect that inadequate training has on safety. I am also going to discuss the effects of acute and cumulative fatigue on situational awareness of safety-critical employees. Also in our testimony today, we will discuss the responsibility of both employees and railroad supervisors to comply with Federal law, Federal regulations, and operating rules that deal with safety issues.

I want to make the following major points in my testimony. Training of new employees working in safety-sensitive positions is inadequate and not focused on safe operations. New employees should not be allowed to work unsupervised until they accumulate at least one year's experience. Fatigue of safety-sensitive employees is not addressed in any rail operational safety plan.

We are asking Congress to take appropriate action to amend the Hours of Service Act to resolve this issue. Congress should act to restrict each tour of duty to 10 hours and no more, to also establish a cumulative total for covered service employees for each seven day period of time, and Federal law and Federal regulations apply to all railroad employees including railroad supervisors.

We are pleased to report to you that UTU considers ourselves to be FRA's partner working together to improve safety in our rail industry. We appreciate the positive relationship that Administrator Boardman, Associate Administrator for Safety Jo Strang, and their staff have developed with both labor and management. We believe that FRA is on the right track and fully comprehends the complex safety issues confronting our industry today. We also have a strong opinion that Congressional intervention is now warranted to give FRA more resources and more authority to have a more immediate impact on the increasing numbers of train collisions and major accidents that continue to occur.

Accidents caused by human factors account for about 38 percent of total train accidents. This category of accidents, as you already heard this morning, is increasing. Inadequate training programs for new employees, their lack of practical on the job experience, and absence of familiarity with the work place physical environment, substandard recurrent training requirements for existing employees, and the unacceptable prevalence of fatigue throughout the rail industry are the causes of these accidents.

We believe it is appropriate that we express our enthusiasm to the Committee this morning for the process that Administrator Boardman and FRA have established to address training issues. A working group consisting of representatives from the Brotherhood of Locomotive Engineers and Trainmen, UTU, FRA, all the railroads, and recognized training experts has been formed and will meet for the first time later today.

We are very optimistic that this proactive working group can move quickly to find and implement solutions that will have an immediate positive effect on the training and qualifications of operating crew members. We salute both FRA and the AAR for their willingness to contribute their resources in this effort to make training in the rail industry a safety advantage instead of the most significant safety issue today.

The rail industry will have more than 80,000 new employees in the next five years. The rail industry is also experiencing an unprecedented retention problem involving new employees. Based on reports from the field, new employees are resigning and leaving the industry because they are dissatisfied with the quality of training, they are uncertain of their skills and understanding of the work processes, and they are understandably uncomfortable with their level of responsibility. Exit interviews conducted with former new employees indicate that their training did not prepare them for service in what they believe is a dangerous work environment and they did not receive the opportunity to become accustomed to the realities of working a self-supervised position with irregular shift scheduling and uncertain rest day opportunity.

On fatigue, unless a human being knows well in advance what time they must report to work, they cannot arrange to be rested and fit for duty. The railroad industry functions on a 24/7 schedule with continuous operations from coast to coast. This is not an excuse for the current position of the railroads holding that their employees do not require advance knowledge of the time they must appear for their next assignment in order to manage their lives and obtain sufficient sleep before reporting for work.

In summary, Mr. Chairman, UTU today is calling on Congress to act to amend the Hours of Service Act to permit only 10 hours of service. This means that from the time an employee reports for service and is then released at the final terminal will not exceed 10 hours. If the Supreme Court offered an interpretation of language in the statute, then we obviously aren't going to argue with the Supreme Court, but we are here today, asking you to change that language. We thank you for the opportunity to appear.

Mr. LATOURETTE. Mr. Stem, I thank you very much.

Mr. Hamberger, welcome to you, and we look forward to hearing from you.

Mr. HAMBERGER. Mr. Chairman, on behalf of the member of the Association of American Railroads, thank you for the opportunity to discuss issues surrounding rail safety, the Hours of Service Act, and fatigue in the rail industry.

The railroad industry places extraordinary importance on safety, and our safety record bears that out. Since 1980, railroads reduced their overall train accident rate by 65 percent and the rate of employee casualties by 79 percent. In 2005, in fact, the employee casualty rate was the lowest in history. The railroads have lower employee injury rates than other modes of transportation and most other major industry groups. In addition, U.S. railroads have employee injury rates well below those of most major European railroads. Having said that, we certainly are not content to rest on our laurels.

We are particularly concerned about accidents related to human factors which were responsible for the largest number of train accidents over the past five years. Although the overall accident rate involving human factors has remained fairly constant in recent years, most involve low speed yard accidents. In fact, the rate of human factors-caused accidents involving freight trains on main and siding tracks in 2005 was 75 percent below the 1980 level and 46 percent below its level in 1990.

Clearly, it is not in the best interest of railroads to have employees too tired to perform their duty safely, and that is why railroads have long partnered with their employees to gain a better understanding of fatigue-related issues and find effective, innovative solutions to them.

I salute you, Mr. Chairman, for placing me between Mr. Stem and Mr. Tolman because it is only by working together with our unions that we can come up with effective solutions. The solutions to fatigue are inextricably linked to our collective bargaining agreements, as Mr. Boardman pointed out, and it is therefore necessary that we go forward to address that issue together.

One lesson we have learned is that factors which can result in fatigue are multiple, complex, and frequently intertwined. Because of this, there is no single solution. Scientific research to date suggests that flexibility to tailor fatigue management efforts to address local circumstances is key to the success of these programs. Significant variations associated with local operations, local labor agreements, and other factors require customized measures. Consequently, as Dr. Moore-Ede pointed out, a one size fits all Government approach is unlikely to succeed as well as cooperative efforts tailored to the individual railroads.

Combating fatigue is a shared responsibility. Employees need to provide an environment that allows the employee to obtain necessary rest during off duty hours, and employees must set aside time when off duty to obtain the rest they need.

Mr. Barrow referred to an earlier NTSB report and questioned what the industry has done. I refer you again to Dr. Moore-Ede who indicates that we are in the forefront of industries in addressing fatigue management programs. A number of different approaches have indeed been developed. For example, napping is permitted for train crews under certain circumstances. Sleep apnea screening is also conducted to identify employees with sleeping disorders.

Recognizing that some employees might be reluctant to come forward for treatment, management and labor jointly produced and circulated a statement saying that sleep disorder will be addressed in the same way as any other medical condition. Rail has provided improved lodging at away from home facilities including blackout curtains, white noise, and increased soundproofing. Railroads and unions have agreed in some cases to additional scheduling tools such as providing more predictable calling windows between shifts to provide an improved opportunity for rest.

All AAR member railroads offer fatigue education programs for employees and their families, as Mr. Barrow suggested. The importance of education in this area cannot be overstated since the success of fatigue-related initiatives is highly dependent upon the actions of employees off duty. Railroads favor continued research on the subject and will continue to work with rail labor to find and implement new ways to combat fatigue. For example, we are cooperating with the FRA on a project to develop a fatigue model that could be used to improve crew scheduling. One railroad has already adopted such a model that has been in use in Australia.

We are also developing new technology that offers promise to reduce the number of human factors accidents including those related to fatigue. For example, several major railroads are currently developing and testing train control systems that prevent accidents by automatically stopping trains before they exceed authority.

Our commitment to safety is absolute, but again, combating fatigue is a shared responsibility. Railroads recognize they must provide their employees with sufficient opportunity to rest. For their part, employees must use a sufficient amount of the time made available to them for that rest.

In sum, the industry recognizes the importance of continuing to focus on eliminating all human factors accidents including fatigue-related incidents. We will continue to work with the FRA and our unions to build on the progress we have made to date.

Thank you, Mr. Chairman.

Mr. LATOURETTE. Mr. Hamberger, thank you very much for your excellent written testimony and also your testimony this morning.

Mr. Tolman, welcome to you, and we look forward to hearing from you.

Mr. TOLMAN. Thank you, Mr. Chairman and members of the Subcommittee.

My name is John Tolman. I am a Vice President of the Brotherhood of Locomotive Engineers and Trainmenm, Division of the Teamsters Rail Conference. The Brotherhood of Locomotive Engineers and Trainmen represents 33,000 members, and there are 70,000 members in the Teamsters Rail Conference.

My written testimony addresses three major subjects: technology, training, and fatigue.

The subject I would like to discuss today is fatigue and how the railroad's manipulation of the Hours of Service Act and the FRA regulation adds to the problem. Even worse, the railroads are in denial that they are part of the solution.

For a few minutes, I would like to focus on one aspect of fatigue, and that is the widespread abuse of limbo time and leaving crews on their trains for outrageous lengths of time. Operating employees are prohibited from working more than 12 hours in any 24 hour period with limited exceptions. If a train cannot reach its destination with 12 hours, the crew must cease all work prior to expiration of the 12th hour, at which point they are considered outlawed. Currently, time spent in deadhead transportation from duty assignment to the place of final release is neither time on duty nor off duty, meaning the outlawed crew is in limbo status with respect to the hours of service while deadheading from their stop point to the final off duty point.

The statute is clear concerning the time consumed during the actual deadhead but is silent about the time waiting for transportation to arrive. Although a crew's hours of service status is in limbo, its obligation under the railroad operating rules are not. Crews are often left on trains until their relief has arrived. The crews must obey the operating rules requiring that they remain alert and observant and they must take action to protect the train against unanticipated mechanical problems or vandalism.

By the mid–1990's, a dispute over how to classify the time an outlawed crew spends waiting for deadhead transportation to arrive had reached the courts. The Supreme Court resolved this conflict in 1996 in holding that Congress had intended that the time spent waiting for deadhead transportation from a duty site should be limbo time. The ensuing decade has seen both a number of crews stranded, waiting for transportation and the length of limbo time increase. A November 2001 FRA opinion letter stated that requiring a crew to attend to its train up after 12 hours is limbo time if the crew is permitted to leave the train when its relief arrives. After the issuance of this opinion letter, the incidents of limbo time skyrocketed.

Over the past nine months, the BLET has received thousands upon thousands of reports of excessive work hours which we are assembling into a usable form. The preliminary information from these reports is shocking. Data prepared by one of the four largest Class I railroads shows that in 2002, the average number of about 90 crews a day had duty hours longer than 14 hours and 33 had tours of duty over 15 hours. Last year, the number of crews exceeding 14 hours had more than doubled to over 218 per day, and the average number of crews exceeding 15 hours had more than tripled to 105 per day.

Things are no better this year as Ranking Member Barrows referred to. The number of crews are almost the same with a slight increase in the first six months of 2006. One point I would like to make is almost 20 crews every week for the first six months of this year had worked a tour of duty more than 20 hours long. That is 12 hours of work followed by 8 hours of limbo work.

Three weeks ago, the NTSB determined the 2004 Macdona, Texas, collision and toxic chlorine release in which three people were fatally injured was caused by a fatigued crew. The crew was criticized for not obtaining sufficient rest prior to reporting for duty, and UP was criticized for crew scheduling practices that inverted work/rest patterns.

Last Thursday, the NTSB issued a safety recommendation urging the FRA to establish requirements that require train crew member limbo time to address fatigue.

In 2002, the Collision Analysis Work Group reviewed 65 accidents. The group found that fatigue was a factor or a contributing factor in 30 percent of the accidents. Given the 1996 Supreme Court ruling as interpreted by the FRA, we are unsure whether the FRA can address this recommendation via regulation alone. Indeed, it may develop that the only solution to the limbo time crisis is legislative. In either case, the elimination of abusive limbo time is one fatigue-fighting option to implement today, and we fully support that effort.

Thank you, Mr. Chairman.

Mr. LATOURETTE. I thank you very much, Mr. Tolman.

Mr. Timmons, welcome to you, and we look forward to hearing from you.

Mr. TIMMONS. Thank you, Mr. Chairman, and good morning to you and Committee members. I appreciate the opportunity to appear this morning on behalf of the American Short Line and Regional Railroad Association.

As many of you know, nationwide there are over 500 short line railroads operating nearly 50,000 miles of track and employing over 23,000 individuals.

As I will discuss in a moment, there are differences in the operating environments of the short line railroads and their Class I counterparts, and those differences make this somewhat easier for us to discuss in the short line industry. Notwithstanding those differences, I want to emphasizes our support for many of the points made by Mr. Hamberger in his remarks. As I have said previously in each of these hearings, the efficiency, competitiveness, and profitability of the small railroad industry is directly related to the efficiency and competitiveness of our Class I connections.

Mr. Hamberger's observations on fatigue and hours of service are very important, and I hope the Committee will take those observations to heart.

The tempo of short line railroading is different than that of the Class Is and that difference affects how we think about the issues you are considering today. Short lines are generally operating in a much smaller geographic area than the Class I railroads. These shorter distances combined with slower speeds and smaller consists produce more predictable work schedules and more routine patterns of interchange and delivery. We are better able to anticipate workloads, design train and car trip plans, regularize train crew schedules, plan for maintenance crew operations, and right of way equipment inspection programs.

This more routine and predictable tempo has contributed to what we believe is an impressive and improving safety record as documented by the FRA's safety statistics. In 1990, the Class II and Class III industry experienced 651 human factors accidents. Last year, we had 242 and to date this year, we have had 63. Any accident, of course, is one too many and tireless effort is required to continue to improve our record, but the trend line for small railroads has been headed in the right direction for some years now.

Our improving record is also evidenced by another set of numbers used by short lines. Class II and Class III railroads rely on a severity index to assess our safety performance. We believe this more accurately measures our progress and allows us to target resources in areas where they can do the most to alleviate the worst. For example, 10 years ago, the injuries among short line railroads totaled 1,426. In 2005, the serious injuries totaled 25, and the non-severe were 746.

While I believe the nature of our operations contributes to our favorable safety record, there are two other factors that have contributed. First, we take safety training very seriously, and we at the association are constantly looking for ways to enhance existing training and to encourage individual short lines to do more of it. In January of 2005, we entered into a new partnership with the National Academy of Railway Sciences to facilitate short line use of this outstanding training facility. Short line attendance has increased steadily since the new partnership was announced.

Second, the short lines are making every effort to improve our track. As you know, the short line industry inherited the worst of the Nation's track infrastructure when we began taking over these properties in the 1980's. Today short lines plow almost a third of their annual revenues back into the infrastructure improvement programs that they all have. This is more than any other industry in the Country. Beginning in 2005, we have been able to increase that investment thanks to the new rehabilitation tax credit that so many of you were helpful in securing. AS our track improves, our safety record will improve, and we think the statistics I mentioned bear that out.

I am encouraged by our improving record, and I am optimistic that continued attention to safety training and track upgrades will help us to continue that improvement well into the future, but there are other factors that we must focus on to continuously avoid accidents. I will not dwell on these in any detail but believe that it is important to highlight them very briefly.

Drug and alcohol testing for the short lines must be steadily pursued with serious determination. This is an ongoing human factors aspect of all work forces today, and we take it very seriously.

Failure to comply with established rules and procedures is a critical human factor dimension that requires constant attention. To counter this compels consistent and tireless emphasis and correction by supervisors. Taking shortcuts and ignoring established rules must be corrected through observation, counseling, and retraining.

Ensuring adequate supervisory oversight is the most challenging and in some respects, the most important human factors consideration for the small railroad industry. Not checking, not validating, not compelling compliance, and not taking appropriate corrective actions all lead to bad habits, potential accidents, and poorly managed railroads. To counter this requires vigilance by supervisors at every level. When problems are identified, they must be corrected immediately.

Recently, the ASLRRA has initiated the SAVE program. The Safety and Validation Evaluation inspection places our most experienced operating staff members on the short line system for several days to assess and educate short line railroaders at their work sites. While a small step, the initial returns are significantly improving operating procedures and compliance with rules.

Short line operations are different than those of Class I railroads, and those differences have made our job somewhat easier when it comes to the human factors issues. Nonetheless, we are far from immune from human errors and such issues as fatigue. It is for this reason that we introduced the fatigue program for Class II and Class III railroads in March of 1999. We are proud that our numbers are improving, but of course we strive to do better.

I thank you, Mr. Chairman, for your attention and would be pleased to answer any questions that you may have at the appropriate time. Thank you, sir.

Mr. LATOURETTE. Thank you very much, Mr. Timmons.

Last but certainly not least, Mr. Pickett, thank you for coming, and we look forward to hearing from you.

Mr. PICKETT. Thank you, Mr. Chairman and members of the Committee.

Railroad signalmen install, maintain, and repair the signal systems that railroads utilize to direct train movement. Signalmen also install and maintain the grade crossing signal systems used at highway-railroad intersections.

Before discussing the role that human factors play in rail safety, it should be noted that the BRS believes that many of the accidents and fatalities that are attributed to human factors are actually due to other factors. As you have heard today, over one-third of all rail accidents are attributed to human factors. Railroads often list the cause of an accident to human factors. However, when the facts are reviewed, the facts show that it was not human factors after all.

For example, signalmen currently work under an hours of service law that was first implemented for railroad signalmen in 1976. It was written as a 12 hour maximum service law during a 24 hour period, and an exception was made that in the case of an emergency, then an signal employee could work up to 4 additional hours in a 24 hour period.

The law worked well for years, and railroads would limit signal workers to 12 hours of work in a 24 hour period. Now, however, signal employees have seen the law become a 16 hour law. Many railroads have policies that state that any signal problem is an emergency.

Railroads tend to focus on the financial bottom line. As such, the railroads have allowed staffing levels to fall below the minimum needed to perform basic safety functions. Railroad signalmen levels have shrunk over the last decade. Railroads are not keeping up with the basic attrition, let alone preparing for the increase in retirements that are going to occur over the next 10 years.

While the railroads are reducing manpower levels, they are also trying to increase the use of contractors to perform signal work. Railroads reduce the staffing levels to a point where the remaining signal employees cannot perform all of the work required, and then the come to us, crying that they need to contract out more signal work.

Some people may argue, incorrectly I feel, that contracting out is a solution for the railroads. In reality, it will only cause more accidents, collisions, and deaths. What the railroads do not mention when they plead that they need more contracting out is that contractors are not properly trained and are not covered by the Hours of Service Act and many other laws and regulations governing railroad workers.

The answer to reducing or eliminating human factors-caused signal accidents is not to hire contractors, but it is to prepare for the future by hiring and properly training signal employees to ensure the signal systems are safe. Training and education is a key preventive measure that needs to be considered. Rail labor considers it equally important to provide advanced training to improve the skills of the professional men and women who install and maintain safety systems for the rail industry. Training can and will improve safety.

Under an FRA initiative, the Brotherhood of Railroad Signalmen recently participated in a study entitled: Work Schedules and Sleep Patterns for Railroad Signalmen. The study collected two weeks of data from a random sample of actively working U.S. railroad signalmen. Most of the fatigue comments were related to being on call 24 hours a day, 7 days a week, travel, unscheduled work, and poor sleep. Also mentioned during the study were the difficulties of achieving meaningful sleep when sleeping away from home. A major disrupter of sleep was the unscheduled or emergency work situations that arise during the night.

There is little question that more must be done to reduce human factors accidents in the rail industry. The rail industry, the FRA, and rail labor must continue to explore the true cause of accidents and stop taking the easy route of blaming the individuals. Humans do make mistakes. That is indeed the essence of being human.

However, when a signal employee makes a mistake while working at a railroad crossing or on train signals, it is not always his fault. When you examine events leading up to the mistake, we often find that there were contributing factors that were ignored and not addressed. When conditions are such that it is just a matter of time that a signal employee will fail, to blame the individual for the mistake does not get to the real reason as to why an accident happened, and it definitely will not get to the cause in order to prevent the mistake from ever happening again.

There is much to accomplish to make the Nation's railroads safer. I hope we can work together to see that the improved safety and practices become a reality.

On behalf of all rail labor, I thank you for the opportunity to testify before this Committee.

Mr. LATOURETTE. Mr. Pickett, thank you and thank you all for your testimony and your coming here today.

Doctor, I think I would like to start with you. There is some at least anecdotal evidence that fatigue is a greater factor following a day off or for someone returning from vacation. When you were talking about the application of your Risk-Informed Performance-Based Safety Management to the trucking industry, I noticed in your testimony, you discuss telematics to track the time off that the truck drivers have.

In the risk management type program that you are describing, how do you ensure that somebody who has time off is really resting as opposed to doing things that actually add to the fatigue? Is there a medical test that can determine whether or not a person is actually fatigued, despite the fact that he or she may have had time off?

Dr. MOORE-EDE. Well, first of all, of course, what people do in their own time is hard to control. The first part of the answer is in predictive risk modeling, one can, in fact, have pretty good models on how people on average behave, and you can get a lot of safety improvement by using that.

In other words, we can predict that an individual coming off a shift at 11:00 a.m., for example, is unlikely to sleep more than four or four and a half hours, just because of the way the body clock works, whereas an individual coming off at shift at 11:00 at night has a much greater probability of sleeping seven or eight hours, but whether they actually do it or not, of course, is always an issue and that is hard to manage.

The second part of your question relates to technologies that are emerging about fitness for duty testing. The fitness for duty concept, of course, is being most useful when you are talking about drug and alcohol testing because, in fact, the deterioration, the level of impairment improves with time. The problem with fatigue testing is the level of impairment increases with time. You can be perfectly fit at the start of a duty period, but six or eight hours later, you might be unfit for duty. So that technology is a bit more limited.

As I say, considerable strides can be made in predictive modeling by building proper factors that can estimate what the average employee is able to obtain in terms of rest and obviously by reinforcing that by training programs of the sort that are quite widely used now in the industry.

Mr. LATOURETTE. You talked about the application of the Risk-Informed Performance-Based Safety Management to the Nuclear Regulatory Commission and also the trucking industry. Turning to the nuclear industry first, have these strategies been in place long enough to have measurable results relative to performance and safety improvement or lack thereof?

Dr. MOORE-EDE. I think there have been very good reviews back in terms of the flexibility that has enabled local managers to respond to it. I don't have a very good recent update and exact numbers on that.

I do have much more relevant data, direct data from the trucking applications where we have seen very significant improvements, and we have monitored this now over multiple years. So we have actually had about four or five years of experience now of operating trucking fleets where you are continuously feeding back the risk of every employee.

In fact, we are now at a stage where we can do predictive risk of who should you call in next, who will in fact be likely to be impaired when called in now, and who is likely not to be impaired. Certainly, these tools have quite substantially reduced accident rates and risks and costs, a 50 percent to 70 percent reduction in costs and so forth. We certainly have the track record of understanding that Risk-Informed Performance-Based safety processes do work.

Mr. LATOURETTE. That 4 to 5 years and the 50 to 70 percent reduction in accidents, is that included some place in your testimony?

Dr. MOORE-EDE. Yes, it is in the testimony. It also has been reported in various scientific meetings including meetings sponsored by the Department of Transportation, and recently, it certainly has been reported as scientific results.

Mr. LATOURETTE. I know you were in the room when Administrator Boardman talked about the fact, and I think you talked about this hours of service thing as sort of being an hourglass, a type of measurement, and the fact that there have been attempts to change this for the last 15 years since 1991.

Based upon your research and understanding, are the things that you have applied to the trucking industry and the nuclear industry, things that will require the Congress to make changes in the hours of service statute, or do you think that they could be implemented by the industry?

Dr. MOORE-EDE. Well, the first stage is, as I say, I wouldn't throw away the safety net of the Hours of Service Act instantly. However, I think we are not going to get away from this plateau, and I think we can look at the improvements that were quite dramatic 20 odd years ago, but really when you get to a plateau like that, you have got to change the game and changing the game means not just saying, well, this is just too difficult to do. There are all the collective bargaining agreements. We have got the regulations. We can't do anything.

Instead, it is to actually create an environment where, in fact, there are rewards as it were for those pioneer and move in safety-based management. One model of that, for example, is in the Australian trucking industry where much more flexible business arrangements are allowed for companies who put fatigue management plans and processes of managing that risk and can demonstrate improved ways of doing it.

So, basically, I think the strategy there is to say if a railroad were to come to you and demonstrate that predictive modeling was in place, then there will be certain ways that it could deal with such issues such as the limbo problem. I mean the limbo problem is perfectly, directly modelable as a risk, and we could actually figure out where, in fact, the risk boundaries are rather than dealing with an issue where quite frankly it is very hard to correlate the data to know where the right balance is. I think that is just scientifically determinable, and as I say, the predictive risk models are exactly the way to look at how you manage that sort of issue.

Mr. LATOURETTE. Thank you very much.

It is my intention to do a couple of rounds.

Ms. Johnson?

Ms. JOHNSON. Thank you very much.

Pilots with airlines are allowed to fly so many hours and they must take off so many, and truck drivers are pretty much the same way. It seems to me that the people who have no rest requirement are more likely to have these accidents. Has there been an effort to give attention to that and what is the outcome, Mr. Hamberger?

Mr. HAMBERGER. Good morning, Congresswoman Johnson. Thank you.

Indeed, there has been an effort, and I would ask the permission of the Committee to insert for the record a compendium that we are producing. We hoped to have it ready today, but it will be in a couple of days. It lists a wide array of approaches that the industry has taken. My testimony mentions several of them, again, napping policies, checking for apnea sleep disorders, arranging for longer periods of time off. The industry has moved in many carriers to a 10 hour minimum time off after a tour of duty.

We are working on models, as Dr. Moore-Ede talked, both at the FRA and individual companies in trying to assess where the risks are and working with the unions, trying to figure out appropriate approaches at the local crew district level as well.

Ms. JOHNSON. I apologize for not being here earlier. Is there some type of historical document that determines the condition or the hours after there is an accident?

Mr. HAMBERGER. The hours worked by each employee would be maintained by the company, yes.

Ms. JOHNSON. Are the accidents at a higher rate when there are people who have not rested?

Mr. HAMBERGER. I don't have a specific answer for you on that. I know that there are studies out there, some of which were indicate that and others which are inconclusive. So some studies would indicate that a greater risk would be at 2:00 in the morning. Other studies indicate that there is a higher risk factor at 9:00 in the morning. But I will be glad to get you some data for that on the record.

Ms. JOHNSON. When someone does have a sleep disorder and admits to it, what actions are taken?

Mr. HAMBERGER. Well, if they come forward, it is treated like any other medical condition. They are offered treatment for it, and if it cannot be corrected, it would end up being a cause for a disability.

Ms. JOHNSON. The contractor employees, there is hardly any way, I guess, to determine how many hours they have been off since they just come in as required.

Mr. HAMBERGER. The contractors, of course, are not our employees. So it is impossible for us to determine if they were at a different job site the day before. That is correct.

Ms. JOHNSON. Any comparison of accidents between the contract employees and regular full time employees?

Mr. HAMBERGER. I am unaware of any. Let me check on that and get back to you for the record.

Ms. JOHNSON. Anybody else in here aware of any difference?

Mr. PICKETT. We haven't done a study on the difference in the contracting. We have stated that there are times that the people who are there because they are not under the hours of service, they continually work.

The problem arises after they leave. Then our people are the ones. The rail signalmen, then at that time, becomes the one who is having to correct the problem, hopefully finds the problem if they did leave something that wasn't set properly before something drastic happens. The problem is there. It is just something that we have never run a study on it, no.

Ms. JOHNSON. Thank you.

Mr. STEM. Congresswoman Johnson, may I comment on that also?

Ms. JOHNSON. Yes.

Mr. STEM. In answer to your previous question, one of the main sources of data that applies to the industry today was an FRA sponsored working group, the collision analysis working group. We submitted a copy of this report with our testimony. That study, in which labor, management, and the FRA participated equally, shows that about 30 percent of main line collisions have a major contributing factor of fatigue, and the main issue involved there is not just work schedules, but it is lack of notification of a reporting time.

What you are talking about is a group of people who are working 70 or 80 hours a week. They get off work at 10:00 in the morning and have no clue what time they will be expected to report for work again. It could be eight hours. It could be 28 hours. That is the issue. That is the main issue.

Ms. JOHNSON. Thank you very much. My time is up.

Mr. HAMBERGER. If I may, Mr. Chairman, I am asking unanimous consent to put stuff in the record. DAR did not endorse the report to which Mr. Stem referred, and we do have a critique of the statistical analysis in there which I would ask be included in the record as well.

Mr. LATOURETTE. We would be glad to receive it.

Ms. Schwartz, do you have any questions?

Ms. SCHWARTZ. Thank you. If I may, I appreciate the opportunity to participate.

I am sorry, I did not hear the initial testimony but following up on some of the questions, one of the reasons that I am here is because there was recently a rail accident in my District, a regional rail accident. It just happened. So it will be months before we actually see the report, and the reason there is already reaction that technology could have helped in preventing that accident. Again, we don't know exactly what happened. So I am not sure how that conclusion has already been made.

My question really has to do with, my guess is that there would be some combination of technology and the talents and training of the rail personnel and their ability to function, both in response to the technology and also their own alertness. Fatigue has been a big issue that has been talked about a good bit.

Could you just speak to the training that personnel gets now in preparing for their own fatigue, their own difficulty in managing the time? Secondly, could you speak to the relationship between the new technology and the training that personnel would get in the use of new technology and how that would assist them in preventing accidents?

I don't know if you are aware of the one that happened in my District. It was a regional rail. There were injuries, fortunately no deaths, but it was in a very suburban area where two trains actually hit each other. So it is obviously a concern. Fortunately, it doesn't happen too often, but when it does, it is a huge concern especially in sort of a neighborhood setting like that. The railway is going through really a very local suburban area, and it was quite distressing to many of my constituents that such a thing would happen in this day and age.

Mr. HAMBERGER. If I could take a first shot at that, Congresswoman Schwartz, thank you.

With respect to the education, each of the AAR members has very comprehensive fatigue training information, both for employees and their families. It is very important that they understand the role that fatigue plays and the role that they play in combating fatigue. Working with the unions, I believe we are putting together a web site which will be available to each employee which will have training and detailed information on what they should be looking for and how they should be proceeding with their time off.

With respect to the technology, there is a meeting this afternoon, working on some of the technology issues. There is a remote control operating in the train yards for which there is a special training proceeding that I don't believe had anything to do with your accident.

The new technology that is being developed by the industry is train control technology which would prohibit a train from exceeding its authority. What that means is in the case of a truck on a highway, for example, it would not be allowed to run the red light. So if the engineer did not begin to slow the train down before the computer calculated that it would exceed its authority, that is, go past the red light up the track, it will throw it into a penalty application, that is to say it will stop it before it goes past where it should, and therefore would avoid the collisions that you are referring to, if I understand what may have happened up there.

Ms. SCHWARTZ. Mr. Stem, I don't know if you want to add anything to that.

Mr. STEM. Yes, ma'am, I would like to have an opportunity.

The training that you are talking about is operational training. Fatigue management training is virtually non-existent in the rail industry.

The web site opportunity that Mr. Hamberger discussed in his comments to you, I am not aware that our union or other unions are willing to participate in that because it does not deal with the core problem. The core problem is operational training. There are a multitude of reasons behind an accident occurring, one of which would be fatigue, but the initial level of training, the recurrent training of the existing employees, the discipline that a well trained employee exercises in the performance of his duties, all of those are major issues.

As far as train control technology, the United Transportation Union fully supports the development of that technology and, unfortunately, it is our opinion that without some Congressional intervention with a major source of funding, we are decades away from implementation of that technology in the industry.

Mr. TIMMONS. If I may, let me make a comment about your concerns about the accident in your District. I am interested primarily in Class II and Class III railroads, small railroads and regional railroads.

Let me make a distinction between the Class Is, the Class IIs and the Class IIIs in terms of training and the fatigue issue. The fatigue issue for the small railroads is not the same as it is for the larger railroads. Our general area of operations is smaller, slower trains, smaller consists, and what all that does is generates a very consistent and predictable pattern of work day schedules. In other words, when a small railroader goes to work, he knows what time he is going to start generally and what time he is going to get off the job, and he knows that day in and day out.

The predicament of hours of service that the Class Is have been struggling with and that most of our discussion this morning has been related to is not the same for the small railroads. So we don't run into the fatigue issue to the same degree that the big guys do.

I would also say that from a training standpoint, all of these railroad engineers go through a very, very extensive training program and then must go through certification programs. They go through physical recertification at the three year point. If they are not on the job for 30 days, they must have a back to work physical. So from a medical standpoint, although there are no good railroad medical standards for railroad hours of service employees, there are medical procedures that they go through to make sure they are reasonably healthy when they come back on the job.

This issue of fatigue is very, very complex, as I am sure you are aware, but for the small railroads, the predicament is just not the same.

Ms. SCHWARTZ. I appreciate that. Again, we don't have yet information about what caused this crash. So I don't want in any way to jump ahead here. There was some discussion in today's paper in Philadelphia that, in fact, the underfunding of the regional rail system in the Philadelphia area and the fact that there has been such slow capital improvements, the new equipment. I am not talking about new technologies now, just keeping up on the standard equipment plays a role potentially as well. They talked about the delays in getting the upgrades that are needed on the rails and on the cars themselves and whether that has played a role. They are questioning that. Obviously, we will know more as we see the details about this.

Certainly, I think on this Committee we have been concerned about the lack of funding for the major rails, but there is the regional rail service that I know many of my constituents rely on every day to get back and forth to work. As someone who would like to encourage use of public transit and would like to see more use of rail service, not making that kind of investment in equipment is a concern. We don't know whether this, in fact, was not about new technologies, not about fatigue but really just a breakdown of old equipment. So that is potentially a factor as well, that I don't want to dismiss.

Estimates to do some of the upgrades even on the cab signals could be 8 to 10 years. I am just talking about the regional rail system in my District. So that is a really long time for us to be dealing with virtually antiquated equipment, I believe. It is maybe a topic for another given day, but it certainly has something to do with the safety for our workers and our passengers on both regional and major rail.

Thank you.

Mr. LATOURETTE. Thank you.

Mr. Tolman, do you have something you wanted to say?

Mr. TOLMAN. Yes, thank you, Mr. Chairman.

I would just like to comment on two things, training and fatigue. You know there has been a lot of discussion, number one, about fatigue and whether we should change the hours of service. I think we are putting the cart before the horse on this. I think you need to look at the fatigue abatement issues that we can implement, and one, limbo time, needs to be addressed. Years ago, when limbo time was not in force, basically you could work 12 hours. You were relieved and brought to your resting place immediately. That is what we need to go back to.

We need to go back to look at where there are opportunities where employees can work five days on and two days off. We need to provide employees the opportunity for employee empowerment. If you are tired and you don't feel as though you can go to work, you can't be held accountable. You can't be held under the availability policy under the railroad industry. We need to address those issues.

There are a million tools in the toolbox. We need to address those tools first and then look at the hours of service. As the Doctor said, we need to change the game.

I don't think, with all due respect to my colleagues here, all of us work with the NTSB on a major rail accident, and that one was a regional. We didn't work on that particular accident. However, our concerns are your concerns, and the public's concerns. Try to find out what happened in the accident, address it, work together, come to a conclusion, and correct it. However, sometimes the corporate profit gets before addressing some of the issues.

I don't think the fatigue issue will be resolved unless Congress gets involved in it personally.

As far as training is concerned, years ago, training programs were superb. You had enough employees in the industry that you could provide a prolonged amount of time for an individual to be out there whether he is operating an engine or as a conductor or as a trainman. I think that needs to be addressed. Training needs to be constantly looked at, constantly observed. There should be mandated oversight in training to make sure there are enough qualified people in the industry as well as enough qualified people to support people that need a little bit more training.

Thank you, Mr. Chairman.

Mr. LATOURETTE. Thank you very much, Mr. Tolman. As I indicated, we will have one more round of questions, and I don't think I will take five minutes.

One thing that I wanted to ask the folks from labor and also you, Mr. Hamberger, is about lot of the collective bargaining agreements in the past. If you look at Dr. Moore-Ede's testimony, he has a lot of different factors in his risk-based approach, but clearly hours of service is just one thing to look at. There are things like noise and vibration and weather conditions and everything else. A lot of collective bargaining agreements have mileage rather than hours of service.

Could you all tell us why we went away from mileage in terms of what the rail and labor agreed to and now concentrate so heavily on Hours of Service? Could anybody share their thoughts with me?

Mr. Stem?

Mr. STEM. Mr. Chairman, I welcome the opportunity to offer an answer to that question.

The mileage regulations that you discussed are still in the agreement. They have a collective bargaining agreement with their employees that says that each employee will be expected to work X amount of miles per month. They have totally abused that. They have effectively eliminated that and in fairness to the industry, the employees themselves were complicit in that. To the point that they have maximized their earnings, it was all about money.

As far as Congressional action is concerned, there are two minor changes that the industry could make that would eliminate this debate. Number one, a 12 hour call giving a human being 12 hours notice that I am expecting you—it is now 11:40 a.m.; you are on duty at 11:40 p.m.—and then living by the law that says 12 hours of service.

Now labor and Mr. Hamberger are all in agreement about that solution, but we cannot implement it on the property without you. We have tried this for 15 years ourselves. Unless you take strong significant action, give FRA the authority and the resources to do that, then we will be here next year and the year after that, talking about fatigue.

Mr. HAMBERGER. May I just say that I am unaware that I am in agreement?

[Laughter.]

Mr. LATOURETTE. Before I give you the opportunity to express your agreement, I just wanted to say to Mr. Stem, I do find when Dr. Moore-Ede is talking about predictability and all the factors that go into it, it does seem to me that, if I am correct and maybe you can tell me how this crew calling system works, that people have to wait by the phone and be ready when the call comes to go within two hours. I don't know how you can do risk management. It is my understanding, right, that you need to stay by the phone and if you get a call, you are off to work.

This is the only job I have ever had where I don't know what the schedule is on a day to day basis, and sometimes I get tired. I will tell you that.

Is that correct? Is that how the crew calling thing works?

Mr. STEM. Yes, sir, that is exactly how it works, and I came through that system before there was a cell phone, before there was a pager. Thank the Lord I was able to keep my employment.

Today in times of technology when the industry comes before you and testifies that we have a computer system that will allow us to know where every one of our trains is instantaneously and control the movement of that train, they still cannot give an employee who they consider to be a safety-sensitive employee more than a two hour notice, and it is worse than no notice. They are aggravating the issue by the fact that they will tell that employee that we are expecting you to go to work in 12 or 14 or 16 hours and most of the time, a majority of the time, those lineups that they give the employees are totally inaccurate.

So, without that 12 hour notice and without living up the hours of service law by the elimination of limbo time, then there is no solution.

Mr. LATOURETTE. I am still going to get to you, Mr. Hamberger, but I am glad you brought up the complicity element because I thought it was instructive when Administrator Boardman was here, and he was talking about his commercial driver's license, and

I think he admitted to us that he drove when he wasn't supposed to drive, so he could maximize his earnings.

One of the things I hear from some of the younger railroaders are that you have these mileage hogs that like to drive the long distance trains and maximize their earnings. Nobody can fault them for that, but perhaps if we went back to some of these other things, we would do a little bit better.

Mr. Hamberger, would you want to express your agreement with Mr. Stem or your disagreement?

Mr. HAMBERGER. I do not believe that we share his desire to change the hours of service. What we are trying to do and what most of our members have moved to is a 10 hour guaranteed rest period after the employee leaves service to allow for an opportunity for rest. We are trying to do what we can, using the technology, using the internet to give as much notice as possible, to try to predict the first in, first out lineup, when the employee will need to be back, looking at the lineup for the trains coming.

As I pointed out in my testimony, it is an inexact science. There are lots of things that come into play, affecting the schedule, but we are trying to move a scheduled railroad in many cases, so that there is more predictability.

With respect to limbo time, we believe that the Supreme Court had it right. When the employee is dead on the log, they are not performing safety-critical functions at that point and their rest period does not begin until they return to the terminal, so that the rest is not affected at that point. And so, we believe that the Supreme Court had it right.

Mr. LATOURETTE. I thank you.

Mr. Tolman or Mr. Pickett, do you want to say anything about mileage before I yield to Ms. Johnson?

Mr. PICKETT. My only comment is on Mr. Hamberger talked about technology, the technology of stopping a train. That technology has been there for many years. If that is what he is waiting on, we can assure him that can be installed today. I mean we don't need a meeting this afternoon to find out if it is there.

The adequate work force is the biggest thing. Our system, our setup, we are one of the non-operating railroad unions, and our members are under the Hours of Service Act, and they are on call 24 hours a day, 7 days a week, especially if they are in maintenance. I mean you could get off at 4:00 in the afternoon and possibly go to bed at 11:00 at night, be called at 12:05, and you are considered rested. You are considered rested for the next 12 to 16 hours, whichever one that railroad has implemented at that time.

We feel that the 12 hour law needs to be strictly enforced, that it is 12 hours and that is what it should be.

Then on the subject of dark territory that was brought up earlier, one of the things is there is not enough there for the railroads to put in a signal system. There is no question that the only purpose for the signal system is for safety. When you can run trains at 49 miles per hour in dark territory, they are not going to put in a signal system. They are willing to take that chance of running that train with a switch that is thrown in the wrong direction and no one knowing it. You get on a train running at 49 miles per hour and try to stop if a switch is aligned improperly, it is not possible. You can't do it.

So there are solutions out there for railroads who are committed to really looking at it.

Mr. LATOURETTE. Thank you.

Mr. Tolman, the question was on collective bargaining agreements and mileage as opposed to service. Is there any thought you have?

Mr. TOLMAN. Yes, thank you, Mr. Chairman.

The collective bargaining agreements first were changed when it was a 100 mile a day rule, and that was changed to 130 miles. It just simply comes down to productivity. The railroads thought that they could get more out of the crews if they allowed them to work under the hours of services versus the mileage component.

There is also one issue regarding that which is if a crew is outlawed after 12 hours, they are not necessarily paid while they are under limbo time, and that is one of the arguments that the carriers always throw at us. In some of the pools, unless you work beyond the mileage component which still comes into play on the National Freight Agreement, then you won't be paid until you get to your final resting point.

My colleague, Mr. Hamberger, mentioned about the limbo time, and I need to go back to that again because it is a little misleading to say that safety is not diminished because crews are not performing service during the limbo time. The unfortunate thing is, as the good doctor pointed out, it is very disruptive to the human circadian rhythm if you constantly are working 12 hours and then are in limbo time for an extended amount of time. It is not just that they are not performing service. In fact, they are performing service. They do have to be alert. They are under the operating rules as I stated. I don't mean to get off the point here.

Thank you, Mr. Chairman.

Mr. LATOURETTE. I thank you.

Mr. Hamberger?

Mr. HAMBERGER. I neglected to answer your question actually because I was so thrown off by agreeing with Mr. Stem.

When you were asking about mileage and complicity, Administrator Boardman mentioned and there is a railroad that did offer its employees a guaranteed 10 hour rest period after they left service, but that had to be agreed to. It had to be voted upon crew district by crew district, and it was agreed in many crew districts to accept that 10 hours off at the home terminal, but they did not want to have 10 hours off at an away terminal, so that they could take an earlier train to get back home irrespective of the impact that may or may not have had on their fatigue. It was impossible, under the collective bargaining agreement, for the railroad to impose that.

With respect to mileage in a crew district, it is my understanding that over the years, the mileage is both a minimum and a maximum and has been arrived at, as Mr. Stem indicated, in negotiations with the local union leadership. And so that is an agreement that once it is reached, it has to be negotiated again to change.

Mr. LATOURETTE. Thank you very much.

Ms. Johnson tells me she doesn't have any more questions.

Ms. Schwartz doesn't have any more questions

Well, then I want to thank you all for coming and answering our questions today. Mr. Hamberger, thank you for giving me the compliment about where we seated you, but actually how that came about is the last time Mr. Stem was here, he had so many important things to say that his testimony took about 20 minutes. I thought if I put you next to him, maybe we could keep you both to about five, and we did that today.

[Laughter.]

Mr. LATOURETTE. So I thank you very much.

There being no further business, we are adjourned.

[Whereupon, at 11:49 a.m., the subcommittee was adjourned.]

PREPARED STATEMENT OF JOSEPH H. BOARDMAN, FEDERAL RAILROAD ADMINISTRATOR, BEFORE THE SUBCOMMITTEE ON RAILROADS, HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

July 25, 2006

Good morning, Mr. Chairman, Ranking Member Brown, and other members of the Subcommittee. Thank you, on behalf of the U.S. Department of Transportation, for holding this hearing on the issue of human factors, a subject of critical importance to the Federal Railroad Administration's (FRA) safety program. Last month we testified, first, about current issues in the transportation of hazardous materials by rail and, second, about implementation of our May 2005 National Rail Safety Action Plan as well as recent passenger safety initiatives. This hearing provides an important opportunity to focus more sharply on human factors affecting rail safety and what FRA is doing to understand and address them.

In the context of industrial safety, the term "human factors" refers broadly to the role of human participation in any system and to the ways in which human beings contribute toward system performance, both positively and negatively. Central to any discussion of human factors is the role of the individual, but it is seldom possible to discuss the actions of the individual without reference to involvement with peers, management structures, and supervisory personnel, established rules and procedures, training, technology required to accomplish a task, and technology that may be used to monitor a task and compensate for deviations from rules or procedures. None of us really does his or her job alone, and that is particularly true in the inherently risky and highly choreographed field of rail transportation.

Human factors are present in all areas of railroading. For instance, car repair employees need to be alert to a wide range of hazards when inspecting rolling stock. Production gangs performing track maintenance need to take care to leave track in the proper geometry. Signal employees must exercise good judgment and follow the software management plan when replacing failed circuit boards.

However, our principal focus today will be on a critically important, but somewhat narrower aspect of human factors--the role of operating employees--those engaged in making up, breaking up, and operating trains. Decades of work by the railroads, labor organizations, suppliers, and government have sought to make the railroad as safe a place to work as possible and to keep railroad operations from adversely affecting the communities abutting railroad facilities. We have come a long way, but we have a good way to go.

Statistics on Railroad Accidents Caused by Human Factors

Before I review with you the data regarding human factors accidents, please note five points.[1] First, a railroad must report to FRA on each of its accidents/incidents. The term "accident/incident" means—

(1) "[a]ny impact between railroad on-track equipment and [a motor vehicle], bicycle, farm vehicle or pedestrian at a highway-rail grade crossing";

(2) "[a]ny collision, derailment, fire, explosion, act of God, or other event involving operation of railroad on-track equipment (standing or moving) that results in reportable damages greater than the current reporting threshold . . . "; and

(3) "[a]ny event or exposure arising from the operation of a railroad, if the event or exposure is a discernable cause of . . ." (a) death to any person, (b) injury to any person that results in medical treatment, (c) injury to a railroad employee, or occupational illness of a railroad employee, that results in a day away from work, restricted work activity or job transfer, or loss of consciousness, (d) occupational illness of a railroad employee that results in medical treatment, (e) "significant injury" or "significant illness" of a railroad employee, or (f) injury or illness of a railroad employee that meets certain "specific case criteria."[2]

Second, it is important to emphasize that the second category of occurrence, which we call a "train accident," is defined as an event involving on-track equipment that results in railroad property damage exceeding the reporting threshold. For the years 2003 through 2005, for reasons related to a statutory mandate, FRA made no inflation adjustments to the train accident reporting threshold. That threshold was increased from $6,700 (the inflation-adjusted figure for the year 2002, carried over through 2005) to $7,700 for the year 2006. Accordingly, there was probably a slight upward drift in all of the train accident numbers as a result of the growth of railroad costs during that period. At the same time, the results for 2006 will probably appear a little more favorable than those for 2005 because a single, rather large adjustment to the reporting threshold was made all at once.

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[1] The numbers plotted in the charts in this testimony reflect accident reports from the railroads, which are submitted to FRA pursuant to a Federal statute and FRA regulations. 49 U.S.C. 20901; 49 CFR section 1.49 and part 225. After audit checks for consistency, the reported data are entered in the Railroad Accident/Incident Reporting System (RAIRS). FRA periodically audits the reporting process, particularly for the larger railroads that generate a large percentage of railroad activity; however, careful examination of data sometimes detects individual events reported under cause codes other than those FRA might have chosen. Whenever we are examining any subject matter within the field of railroad safety, FRA consults all of the available data, including results of its own investigations, reports of the National Transportation Safety Board (NTSB), and other available information, as well as data from the RAIRS.

[2] See 49 C.F.R. 225.11, the definition of "accident/incident" at 49 C.F.R. 225.5, and the primary groups of accidents/incidents at 49 C.F.R. 225.19.

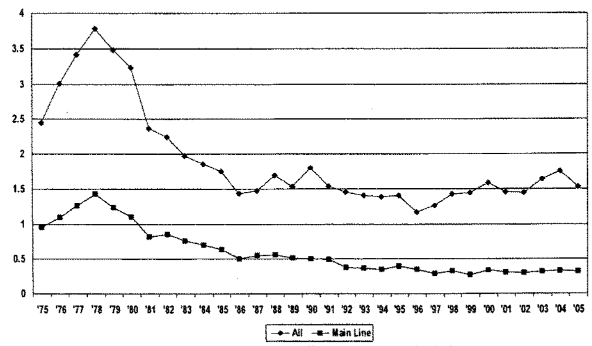
Third, the results for 2005 remain tentative. FRA has been conducting reporting audits of major railroads that may result in some late-filed or corrected reports, and railroads are filing ordinary updates. These processes seldom result in major changes to the national numbers, but the numbers will change slightly as we move toward a "final" status later this year.

Fourth, it is critical, as we look at these charts, that we recognize the difference between simple counts and rates. Simple counts represent the number of events reported without adjustment. When we report on a rate basis, we normalize the results by using an activity-based divisor. When the data in question are employee on-duty casualties, the accepted divisor is 200,000 work hours. When the data in question are train accidents, the accepted divisor is a million train miles (although in some contexts use of railroad ton miles may be justified).

Fifth, we should note that on some of the charts, two different vertical scales are used (one for injuries and another for fatalities). This is done to allow the reader to view trends. On the second chart, for example, the injuries-only scale is from one to 100,000, and the fatalities scale is from zero to 500.

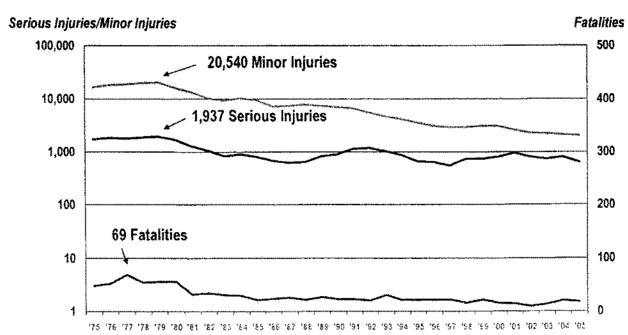
With that background, let's look at the long-term trend in train accidents caused by human factors and in the on-duty injuries of train and engine employees.

All Human-Factor-Related Accidents
Rate Per Million Train Miles (1975-2005)



Note: Main line train miles are not reported to FRA; therefore, to calculate main line train miles FRA used the total train miles minus yard switching miles, which equals main line train miles

All Train & Engine Employee
Serious Injuries/Minor Injuries/Fatalities (1975-2005)

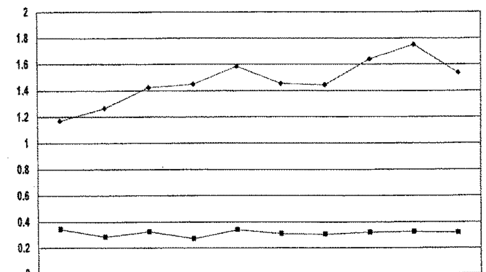


Note: A serious condition is one that meets the SOFA criteria for serious injuries, causes employees to lose 180 days from work, or causes serious harm to body, e.g. fracture, amputation, internal injury, concussion, etc.

These results indicate a general longer-term decline in these measures since FRA began keeping this information in this format in 1975.

However, when we focus more sharply on results for the past ten years, we see a less encouraging picture.

All Human-Factor-Related Accidents Rate Per Million Train Miles (1996-2005)

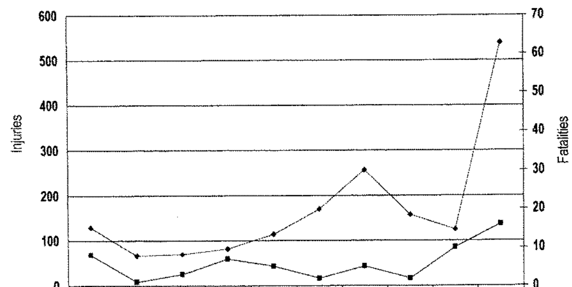


	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05
All	1.167	1.263	1.422	1.447	1.587	1.455	1.441	1.641	1.752	1.535
Main Line	0.343	0.286	0.325	0.269	0.339	0.31	0.301	0.317	0.325	0.32

Note: Main line train miles are not reported to FRA; therefore, to calculate main line train miles FRA used the total train miles minus yard switching miles, which equals main line train miles

The chart above shows human factor train accidents, and, as you can see, there was some increase in the rate over the period of the decade. Essentially all of the increase is in the yards and on the industry tracks, while human factor train accidents on main line tracks have remained stable.

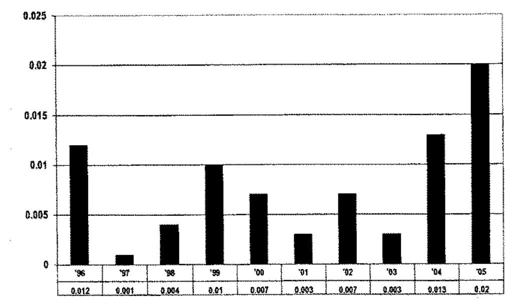
All Human-Factor-Related Accident Injuries & Fatalities (1996-2005)



	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05
Injuries	129	68	71	83	114	170	257	158	125	539
Fatalities	8	1	3	7	5	2	5	2	10	16

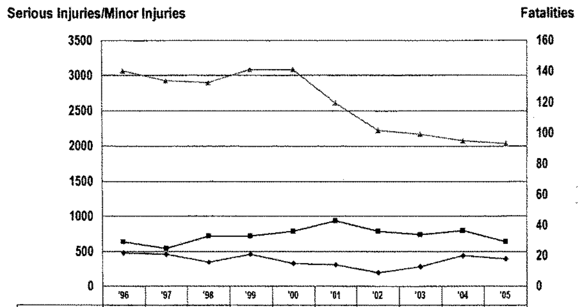
The chart above describes the human consequences of human factor train accidents. This information is displayed on a total count basis. These casualties are to railroad personnel and to the public. Again, please note that two different vertical scales are used, to permit the reader to view trends. Further, the spike in 2005 derives largely from one event, the collision with release of chlorine at Graniteville, South Carolina, on January 6, 2005, which claimed nine lives and resulted in over 292 reported injuries.

All Human-Factor-Related Accident Fatalities Rate Per Million Train Miles (1996-2005)



This chart shows the fatality rate for human-factor train accidents per million train miles. Again, because the fatalities are few in number, individual events powerfully influence the results. In 2004, for example, in Macdona, Texas, a Union Pacific Railroad Company (UP) train and a Burlington Northern and Santa Fe Railway Company (BNSF) train collided. The westward UP freight train, operating at an estimated 45 mph, failed to stop and struck the side of an eastward BNSF freight train while it was entering the siding. A chlorine leak from a tank car ensued, an evacuation was ordered, and the UP conductor and two members of the general public were found dead at the scene. This accident resulted in 30 percent of all fatalities due to human-factor-related train accidents reported in 2004.

All Train & Engine Employee
Serious Injuries/Minor Injuries/Fatalities (1996-2005)



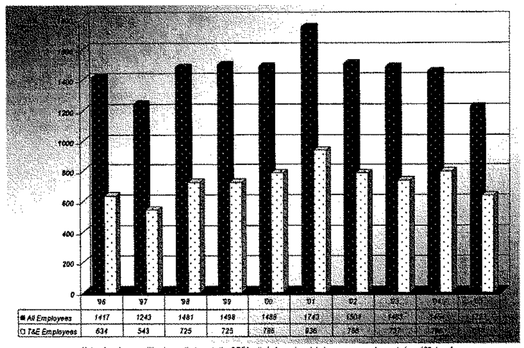
	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05
Serious Injuries	634	543	725	725	786	936	786	737	796	636
Minor Injuries	3,070	2,925	2,901	3,089	3,092	2,611	2,227	2,174	2,077	2,039
Fatalities	22	21	16	21	15	14	9	13	20	18

Note: A serious condition is one that meets the SOFA criteria for serious injuries, causes employees to lose 180 days from work, or causes serious harm to body, e.g. fracture, amputation, internal injury, concussion, etc.

The chart above is limited to train and engine employee casualties that involve minor injuries, serious injuries, or fatalities. These can result from train accidents, from train incidents (not involving damage above the reporting threshold), from non-train incidents (such as motor vehicle accidents while employees are on duty), or from highway-rail collisions where the employee suffers injuries. For purpose of this display, a "serious injury" is an injury that causes an employee to lose 180 days from work or that causes serious harm to his or her body (e.g., fracture, dislocation, amputation, internal injury, concussion, hernia, or loss of eye).

It is very disappointing to us that fatalities in this category have failed to decline despite the heavy emphasis placed on the "SOFA [Switching Operations Fatality Analysis] Lifesavers." These are basic safety lessons derived by a labor-management-FRA working group conducting Switching Operations Fatality Analysis. At the same time, the fatality numbers reflect the significant volatility associated with very low absolute numbers and unusual events that affect them.

All Employees On-Duty Serious Injuries vs.
All Train & Engine Employees Serious Injuries
(1996-2005)



Note: A serious condition is one that meets the SOFA criteria for serious injuries, causes employees to lose 180 days from work, or causes serious harm to body, e.g. fracture, amputation, internal injury, concussion, etc.

This final graph shows the relationship, again on a non-normalized basis, between serious injuries to train and engine personnel compared to tòtal serious injuries to all railroad employees. There is some hope here that this metric may point to a decline in risk going forward if we can build on some of the efforts put in place over the past few years. This is particularly true because train miles and ton miles grew throughout the decade, and train and engine employment began to rise in 2004-2005, so the generally positive direction of movement for this indicator is encouraging.

As you know from prior hearings and from review of the National Rail Safety Action Plan, over one-third of train accidents are reported as having resulted from human factors. (Attachment 1 sets out the human factor cause codes and the distribution of derailments, collisions, and other train accidents (excluding highway-rail crossing accidents) that occurred in 2001-2005 and were caused by human factors.) It is generally accepted that human factors contribute in some way to a majority of events resulting in personal injury to railroad employees on duty, although of course in many cases the circumstances may be wholly outside the control of the employee who is injured (e.g., injury to locomotive cab occupants in highway-rail grade crossing accidents or injuries resulting from improperly maintained equipment).

What Is Needed to Prevent Railroad Accidents Caused by Human Factors

The temptation in approaching this subject matter is to say that "people are going to make mistakes" or "accidents happen." But the real situation is neither that simple nor, happily, that hopeless. In fact, we can conduct complex transportation processes safely if we go at it with devotion, knowledge and creativity. In the discussion that follows, I would like to set out what is needed to accomplish that, and I will report some of the actions underway or planned to address those needs.

1. The task needs to be well defined, and the rules and procedures for its accomplishment must be effective, clear, and unambiguous.

Over-the-road railroading requires precise adherence to the safety and operating rules that make it possible to control the movement of heavy trains in anticipation of conditions at locations not yet in view, and that account for factors such as grade, curvature, and speed limitations over diverging routes. Management of in-train forces is sometimes a major challenge.

Maintaining safety in yard and industry switching operations is also a considerable trial. At any given time, multiple movements may be underway within a confined yard or terminal environment, and each movement will typically be required to move at restricted speed (prepared to stop within one-half the range of vision). Particularly in older facilities, close clearances may present an additional demand on crews, and railroad radio frequencies may be filled with instructions and acknowledgments involving a significant number of personnel. These are merely examples.

Railroads handle these kinds of challenges by establishing a wide range of requirements contained in railroad operating rules, safety rules, train handling rules, power brake instructions, timetable special instructions, and bulletins. FRA's role has been to verify that these requirements are suitable and to reinforce the message of key requirements by adopting them as Federal regulations.

FRA rules directly governing railroad operating practices include—

- Specific requirements to keep trains out of work areas, including protection of workers when on, under, or between rolling stock (49 C.F.R. part 218) and protection of roadway workers (49 C.F.R. part 214, subpart C);
- Requirements for radio communications (49 C.F.R. part 220);
- Specific prohibitions on violation of cardinal rules applicable to the duties of locomotive engineers, such as observing speed restrictions and following signal indications (49 C.F.R. part 240); and
- Explicit requirements for the conduct of brake tests and for securement of equipment (49 C.F.R. part 232).

As I have previously noted before this Subcommittee, FRA is developing proposed rules that would "Federalize" additional key operating rules. An important part of that activity is to ensure that these rules as adopted are clear and that their observance is not eroded due to vague exceptions that may tend to weaken their impact. I think the extensive discussion that our staff undertook with the agency's Railroad Safety Advisory Committee (RSAC) Working Group helped clarify some of these issues. Our proposed rule is now in clearance, and we expect to publish it in September.

2. Rules and procedures must be well understood, and skills must be practiced.

When the public looks at railroads and their roots in the 19th century, the impression often taken is that the duties of railroad employees are simple. The reality is different. While certain tasks are relatively straightforward, in fact the inherent difficulty associated with operating rail equipment safely translates into extensive and often complex requirements that must be internalized by the work force and reinforced by supervisors. The pace of change in railroad operations raises the degree of difficulty.

Hence, effective training and operational testing are critical to successful safety outcomes. Shortly after enactment of the Federal Railroad Safety Act of 1970, FRA issued rules requiring railroads to instruct their employees in the railroad's operating rules and to conduct periodic operational (efficiency) tests and inspections to determine the extent of compliance with the railroad's operating rules. When the time came to require certification of locomotive engineers, FRA required submission of written training programs for FRA review; and virtually every major regulatory project that FRA has launched over the past decade has included a strong element devoted to training.

At the last hearing you heard questions raised concerning the adequacy of training. The precise issues currently presented in the industry are the rapidity with which employees are promoted to conductor, the process for qualifying conductors as remote control locomotive operators (a form of locomotive engineer service), and the process for certifying locomotive engineers for over-the-road service. In effect, apprentice positions and the former normal career progression of employees from train service (brakemen, switchmen, and conductors) to engine service (firemen and engineers) have disappeared, and training must be accelerated. Broadened seniority rights, together with more extensive joint operations, also contribute to concerns regarding familiarity with the territory over which crewmembers operate.

This situation did not happen overnight. It followed from several rounds of collective bargaining in which those now declaring a crisis fully participated. The situation has been made more urgent by a wave of retirements made possible by Railroad Retirement Act amendments that flowed from a labor-management agreement and by an increase in rail traffic. This situation has left railroads strapped for operating employees. Along the way, railroad employment has become comparatively less favored by the younger generations in the workforce, because it involves long hours and often unpredictable schedules. As a result, retention of younger employees has declined.

Accordingly, efforts to strengthen training must negotiate these strong currents that labor, management, the economy, and the changed expectations of younger workers have unleashed over the past years. FRA has endeavored to address this situation through its review of locomotive engineer training programs, which now affect most new operating employees. In fact, as representatives of the United Transportation Union and the Association of American Railroads (AAR) pointed out at the last hearing, FRA had scheduled for today the beginning of a conference to work out strengthened training requirements for new employees. The beginning of that conference has been deferred to this afternoon, since several participants needed to be here this morning.

FRA takes seriously its responsibility for promoting the safety of railroad operations; and effective training, including recurrent training that addresses new challenges, is essential for safety. Let me point out, however, that railroad operations vary considerably across the Nation; and training requirements will vary, as well. Railroads need to conduct training by starting with task analysis and building curricula and test instruments that work in those different environments. Hands-on acquisition of skills and reinforcement of those skills are necessary elements of any training program. Introduction of new technology needs to be accompanied by suitable training. Taken altogether, this is a big job, and railroads make strong efforts, most of the time and in most respects, to address this need. When rail labor or FRA identifies apparent deficits in the quality or breadth of training, FRA needs to take a positive role by describing the deficit and suggesting practical means of addressing it.

I have appended to this testimony a brief description of minimum training, testing, qualification, and certification requirements applicable to railroad operating employees, as provided by FRA and Pipeline and Hazardous Materials Safety Administration regulations (Attachment 2). As always, we will be pleased to answer any specific questions that the Subcommittee may have about these requirements or their oversight.

3. Everyone must be accountable.

Good discipline is not the final answer to all questions about safety. As I will discuss further in a minute, many accidents are caused by mistakes that are wholly unintended. However, if we do not start with basic accountability for following the rules, we have no place to go but down on any rating of safety performance.

We cannot talk about employees being accountable without talking about everyone else doing his or her job, as well. FRA needs to set reasonable expectations and diligently verify that they are being met. Carrier officers, who have the very difficult job of putting programs in place and making sure that they maintain their integrity in the midst of changing circumstances, must ascertain that commands issued at the system level get executed down in the yards and terminals.

Line officers need to model safe behaviors and hold employees accountable—not encourage shortcuts or ignore rule violations when things get busy.

While developing a proposed rule to strengthen compliance with the railroad operating rules, in conversation with labor and management through the RSAC, FRA has discussed how we might establish systems that ensure accountability up and down the line. I hope that you will see clear evidence of that in our forthcoming notice of proposed rulemaking.

4. The organization must nourish a positive safety culture.

Over the past several decades, the railroad industry has progressed from a time when nominally strict rules and stern enforcement constituted the major component of any safety program to the present, more constructive environment, in which everyone--from the railroad's chief executive officer to the most junior employee--recognizes his or her role in contributing to the safety of co-workers and the communities through which the railroad conduct operations. This progression is what is known as "building a strong safety culture."

An organization with a positive safety culture treats safety as more than a slogan and more than the responsibility of the safety department. The organization tries to design a workplace that is conducive to safety and to engender an atmosphere of trust that empowers every worker to identify hazards and suggest remedies. Particularly in an industry with a strong union presence, a positive safety culture requires constructive engagement between labor and management, not only at the organizational level, but also at the interface between the worker and that person's supervisor.

FRA has tried to contribute to the emergence of a positive safety culture in the railroad industry by opening clogged lines of communication and helping to facilitate solutions to specific safety issues. For the period of about a decade (1995-2005), FRA employed the Safety Assurance and Compliance Program (SACP) model to draw management and labor closer together; and the program had notable successes. I think the effort was worthwhile, but last year we took stock and decided that SACP purposes had been largely fulfilled and that we should be more selective in the meetings we attend and the issues we take on—taking to heart the recommendations regarding resource allocation provided by the Department's Office of the Inspector General.

FRA continues to respond to requests for assistance in bridging the gap between management and labor and addressing areas of concern not subject to regulation. We have assigned a Railroad System Oversight Manager to each of the major freight railroads and to Amtrak, and we can provide facilitation services on request. The major industry associations, including the AAR, the American Short Line and Regional Railroad Association, and the American Public Transportation Association also play a strong role in helping their members build sound safety programs. Each of the rail labor organizations views promoting safety as a vital part of their service to their members. All of these parties join together in the RSAC to share experiences and to help determine future directions for the industry working together.

FRA supports advances in safety culture by supporting human factors research and demonstration programs. One example of an FRA-sponsored human factors demonstration program is called "Changing At-risk Behavior." This pilot project was begun in cooperation with UP in April 2005 in the UP's San Antonio Service Unit to demonstrate an exposure-reduction strategy that FRA has entitled, "Clear Signal for Action." Key driving forces of the Clear Signal for Action method include proactive safety leadership by carrier management, confidential peer-to-peer feedback by labor, and strong labor-management relations in continuous improvement efforts. Changing At-risk Behavior grew out of a collaborative, exposure-prevention effort called "Cab Red Zone," which had been initiated by UP management and local labor unions early in 2004. The Cab Red Zone initiative focused attention on improving safety practices in the locomotive cab, such as conducting proper radio communications, calling signals, and maintaining vigilance. In May 2004, FRA funded a consultant to 1) evaluate the Cab Red Zone rules and the targeted at-risk practices; 2) support the development of a Clear Signal for Action process, focused on Cab Red Zone rules and practices; and 3) evaluate its implementation and impact for potential applications across the railroad industry. The Changing At-risk Behavior demonstration project at UP is in the implementation phase. Evaluation activity is also underway to assess its overall impact on safety and safety culture and its potential benefit and application to the railroad industry. The evaluation process is systematically identifying opportunities for improvements as each step of the implementation is carried out in addition to assessing impacts at the conclusion of the study. Results of the evaluation will be published and, if appropriate, FRA will support further implementation of this Clear Signal for Action method in the industry. In a moment, I will talk about another program—the "close call" system—which is intended to strengthen safety culture through employee-driven successes.

5. All personnel must learn how to work constructively together.

Rail transportation operations are a complex interaction between technology and human performance. This relationship between technology and human performance is defined by a rules-based environment that is highly dependent upon operators' and employees' adherence to specific policies, procedures, and rules. Tragically, many rail accidents are the result of human errors that can be divided into three basic categories: skill-based errors; rule-based errors; and knowledge-based errors.

The rail industry, like other transportation modes, has increased the use of automation to reduce the probability of human error. However, the dependency on human operators has, to a large degree, resulted in a shift in the type of errors being committed. Automation has been advanced to the largest extent by the aviation industry, where a recent study by the University of Texas indicates that 31 percent of the human errors being committed are related to the use of the very automation put in place to reduce human error. Although we must continue to encourage advancements in technology, we must also focus our efforts on the actions and behaviors of the humans operating within the various transportation systems.

One method that has been found to be effective in reducing human errors within complex operating systems is Crew Resource Management (CRM). This method has been effective in reducing human errors by improving how workers interact with each other, how information is shared, and how decisions are made within the operating environment. CRM focuses on improving skills in the areas of decision-making, assertiveness, mission or task analysis, communications, leadership, adaptability and flexibility, and situational awareness. These factors serve to produce a shared vision of reality, thereby decreasing the probability of human error. Furthermore, these essential operating elements have been found to be effective in reducing human error in such diverse operating environments as the aviation and maritime industries, hospitals and surgery rooms, nuclear power plant operations, oil drilling and recovery operations, as well as a wide array of military operations.

FRA has actively been encouraging the incorporation of CRM into rail operations for several years. FRA has worked with the academic and research community and other transportation modes to adapt the concepts of CRM to the railroad environment. To date, FRA has produced a series of CRM training programs for railroad operating crews, mechanical personnel, and engineering and maintenance employees. These programs will soon be available for use by the industry. We have also developed a business case for CRM that demonstrates that CRM is not only effective in improving safety, but also decreases the operational cost to those organizations that provide their employees with CRM training. Furthermore, we are currently in discussions with a major Class I railroad about the possibility of beginning a CRM demonstration project to establish the viability of CRM in the rail industry.

6. Individual employees must be fit for duty.

Presenting ourselves fit for duty is a basic responsibility that each of us must discharge in any work setting. For a railroader, a single slip can lead to the loss of a limb or worse, and a brief unplanned period of sleep can result in disaster for the railroader and the public in the surrounding community. Thus, we all have a stake in railroad operating employees' being fit for duty. For a railroad operating employee, being fit for duty means that the employee is rested, free from impairing substances, and free from any disabling medical conditions. What follows is a brief survey of threats to fitness.

a. Fatigue

(1) Fatigue in general

Each of us requires sleep of an appropriate quality and quantity (about eight hours per day for most of us) to function at peak physical and mental performance. In order to sleep well, we need to have appropriate physical circumstances (e.g., darkness and quiet) and avoid circumstances and conditions that interfere with sound sleep (e.g., disorders such as sleep apnea, clinical depression, and excessive use of alcohol). Factors that threaten our ability to receive adequate rest (apart from too little time to take our rest while addressing other necessary activities of life) include lack of information needed to schedule rest appropriately and biological rhythms (particularly attempting to sleep during periods of the day when our body clock causes us to be wakeful).

When adequate sleep is not achieved, employees' alertness on the job may be compromised. Alertness can be compromised by extended periods of wakefulness, but studies in the area have generally not shown long hours on duty in a single work shift to be a major issue by itself (given the constraints of current law). Of greater concern would be acute fatigue aggravated by other factors (e.g., inability to plan rest) or cumulative fatigue[3]—particularly combined with the effects of biological rhythms.

(2) The limits of the Federal hours of service law

The hours of service law,[4] which was originally enacted in 1907 and last amended as to the hours of railroad operating employees in 1969, deals only with acute fatigue, not with cumulative fatigue. The specified maximum hours on duty and minimum periods off duty, coupled with provisions related to "limbo time,"[5] clearly function to permit the occurrence of cumulative fatigue. Let us be clear that the hours of service law does not *cause* cumulative fatigue, but neither does it prevent it. (The law permits working 11 hours and 59 minutes followed by eight hours off duty and another 11 hours and 59 minutes on duty, perpetually.) Because science related to biological rhythms had not been applied to the railroad workplace when the Congress last addressed this issue, the hours of service law simply does not deal with the issue.

The NTSB has identified fatigue as a causal or contributing factor to at least 14 major rail accidents since 1984. FRA's analysis of data gathered by the Switching Operations Fatality Analysis (SOFA) Working Group indicates that fatigue (largely related to biological rhythms or time of day) was likely responsible for more than 22 percent of the risk of SOFA severe incidents from 1997 through 2003. Today, FRA is officially publishing the Collision Analysis Report, which also identifies compromised alertness as a significant factor in the problem of train-to-train collisions. (The report is being posted to FRA's Web site, which is at http://www.fra.dot.gov.)

The Department of Transportation has on four occasions formally submitted legislation to repeal or reform the hours of service law or at least supplement it with fatigue management requirements. The 1991 rail safety reauthorization bill proposed to repeal the hours of service statute and to authorize the Secretary (or the Secretary's delegate, FRA) to prescribe regulations on fatigue in light of current scientific knowledge. Currently, the statute contains no substantive rulemaking authority over duty hours. FRA's lack of regulatory authority over duty hours, unique to FRA among all the safety regulatory agencies in the Department, precludes FRA from making use of almost a century of scientific learning on the issue of sleep-wake cycles and fatigue-induced performance failures. FRA's general safety rulemaking power under 49 U.S.C. 20103

[3] If a person gets less sleep than is required, he or she begins to acquire a "sleep debt." If the sleep debt becomes an issue with respect to performance, we refer to it as "cumulative fatigue."
[4] In 1994, Public Law No. 103-272 repealed the Hours of Service Act and revised and reenacted its provisions without substantive change as positive law at 49 U.S.C. 21101 et seq.
[5] This is time scored as neither "on duty" nor "off duty" time. It includes time waiting for transportation at the end of the duty tour and time in deadhead transportation. See 49 U.S.C. 21103(b)(4) and 516 U.S. 952 (1996).

provides ample authority to deal with the entire subject of maximum work periods and minimum rest periods in light of current research on those subjects. However, the hours of service laws effectively preclude such a rational regulatory initiative because the chapter 201 authority may be used only to supplement the pre-1970 railroad safety statutes, not to supplant them. Where the hours of service laws set a rigid requirement, e.g., maximum on-duty and minimum off-duty periods for train crews, signal maintainers, and dispatchers, a regulation could not lawfully vary from it. Despite the need for reform, the 1991 proposal was vigorously opposed by both rail labor and management and was not enacted.

The Department's 1994, 1998, and 1999 bills did not seek repeal of the hours of service statute. Instead the agency proposed to keep the statute in place, except for comparatively minor adjustments. FRA's 1994 bill, which was enacted, authorized FRA's waiver of the statute for two-year periods upon joint labor-management petition; however, only one formal petition was received, and it became moot. In the 1998 and 1999 bills, in addition to fairly minor proposed amendments, FRA also sought to add a new provision intended to supplement the statutory protections by requiring each major passenger and freight railroad to develop, adopt, and comply with a comprehensive "fatigue management plan." Both the 1998 and 1999 bills required that the railroad describe the means by which it would reduce the fatigue of its employees subject to the hours of service laws. Each plan had to discuss specified topics, such as employee training on factors affecting fatigue, identification of sleep disorders, scheduling practices, work-rest cycles, alertness strategies, and lodging facilities; however, the approaches selected were left to the railroads, in consultation with their employees, to devise. To encourage rail-management cooperation, the bills proposed to authorize the Secretary to grant waivers of the statute for any specified time period upon joint petition by labor and management. During Congressional hearings, the 1998 bill was primarily attacked as too prescriptive and likely to stifle creative, voluntary efforts to develop fatigue countermeasures, including the efforts of the FRA-sponsored clearinghouse on fatigue, the North American Rail Alertness Partnership. Based on dialogue with rail labor, rail management, Hill staffs, and others, FRA reworked the 1998 provisions in an effort to develop a more acceptable bill. Nevertheless, the 1999 bill was also rejected. No hearings on the 1999 bill were held, so it is difficult to know the exact reasoning for the opposition, beyond economic concerns.

Chastened by the reaction my predecessors encountered, I do not have a fresh approach for you today, but I will note that FRA does enjoy authority to "follow the data" in other areas of our work. Other comparable agencies, such as the Federal Aviation Administration and the Federal Motor Carrier Safety Administration, do have plenary authority to regulate in this field.

I want to quickly add that this is an issue that requires more than legislation to address effectively and that any new approach to crew scheduling—whether approached from the public or private sector—will need to recognize the wide variety of circumstances under which operating employees do their work.

(3) Voluntary efforts to address fatigue

Significant progress has been made in the railroad industry in communicating to employees the basics of sleep hygiene and stressing their responsibility to take advantage of opportunities for rest. Railroads and labor organizations have also aggressively explored various options for ensuring that employees have the ability to prevent the accumulation of an excessive sleep debt. Some of these experiments have held, but most have fallen by the wayside, either because of express objections from the companies or the labor organizations. Others have simply not been utilized, as labor organizations and employees have sought to maximize earnings and total employee compensation rather than taking more rest.

Several railroads have tried with some success to schedule their operations in a way that creates predictability with respect to reporting times, and, in at least one case, efforts have been made to swap crews on the line of road so that crews return daily to their home terminals. Sleep that we get in our own beds tends to be of higher quality.

At any given time it is difficult to know precisely the degree of fatigue prevalent in the industry, in part because we cannot know how most employees spend their off-duty time. However, snapshots that we have taken in joint labor-management-FRA projects, certain data available at the railroad system level, and information collected anecdotally following train accidents, provide a rather more hopeful picture than one would suspect from the extreme (but nevertheless valid) examples of unacceptably long hours and extreme fatigue. That may mean that finding remedies for the fatigue that remains is very feasible if we are well enough informed and if railroad management systems can be made to function more acceptably.

FRA is working with several railroads to encourage further non-regulatory action, such as the pilot Fatigue Risk Management System (FRMS) by UP, which is designed to reduce fatigue-related risk. This risk-based system includes varying levels of controls for mitigating fatigue, with shared responsibilities for both employees and the company, to ensure safe levels of alertness when operating trains. Some of the controls for mitigating fatigue include policy development, system wide monitoring of critical factors that provide adequate sleep opportunities, such as the use of fatigue modeling software, self-assessment methods for identifying individual sleep disorders with accompanying provisions for alternatives to discipline, and measures of effectiveness.

The conceptual framework of the FRMS was presented to a scientific review committee for critical analysis and recommendations for enhancement in November 2005. Senior representatives of FRA, the Brotherhood of Locomotive Engineers and Trainmen, AAR, the United Transportation Union, and the NTSB present at this meeting offered comments and suggestions for improvement. The stakeholders *generally* agreed that its conceptual framework appeared, on the surface, to be a practical, innovative, and evidence-based program that supports both organizational goals and scientific goals alike, while operating within the boundaries of the current hours of service statute. However, concerns were raised regarding the validity of implementation plans to measure adequately the success of FRMS from a scientific perspective.

This pilot, risk-based approach to fatigue is being considered for implementation by at least one other carrier, and may serve as a possible model FMRS for the entire railroad industry to follow. FRA has pledged to support the implementation of this fatigue risk management process in whatever ways it can. In April 2006, the Executive Vice-President, Operations of UP issued a policy statement supporting the FRMS and applicable implementation plan.

(4) FRA-sponsored research to develop fatigue models that could be used to improve the scheduling of work by train crews and the investigation of railroad accidents

Currently, FRA is completing a research study that attempts to find out whether a fatigue model that was originally developed for the U.S. Army and U.S. Air Force to predict and manage the fatigue of military personnel should be used to predict and manage the fatigue of railroad workers, and if so, to what extent the original model should be adapted to deal with the special circumstances of various types of railroad operations. A fatigue model offers the possibility of objectively assessing and forecasting fatigue so that employees and employers can schedule work and rest to avoid fatigue. The fatigue model used for this study--the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model--predicts potential fatigue based on an analysis of work schedules. The model has been adopted by the Department of Defense as the standard warfighter fatigue model and has been incorporated by the U.S. Air Force Research Laboratory into a useful fatigue assessment tool called the Fatigue Avoidance Scheduling Tool (FAST), which takes information about a person's work schedule and typical sleep habits and estimates the amount of sleep that would occur under the schedule and the effects of that sleep pattern on cognitive effectiveness.

A useful fatigue model needs to be calibrated to the demands of a particular job so that the numbers from the model can be related to the risk of meaningful failures of human performance. One important part of calibration of a fatigue model for use as a fatigue management tool is an assessment of whether the tool can predict an increased likelihood of making a human factors error or causing an accident. FRA's study, in partnership with five Class I freight railroads, examines two-and-a-half years of data on accidents to attempt to make this connection. The study is collecting 30-day work histories prior to a sampling of accidents reported as caused by a human factor, with comparison to a control group of work histories prior to accidents reported as caused by something other than a human factor. An objective of the study is to analyze all work histories to determine, based solely on the model, the predicted effectiveness of the operators at the time of the accidents. The results so far from the two-and-a-half years of data are revealing that low levels of cognitive effectiveness are related to an elevated likelihood of human factor accidents.

The virtue of having a validated fatigue model (especially if it is calibrated so that we know how to relate the model to accident likelihood) is that it could be used by a carrier to do a self-assessment of fatigue across its system. By evaluating work histories on a terminal-by-terminal basis and using the scores from the model as a metric, the carrier could determine which terminals are experiencing schedules that might be generating fatigue in the operators. Perhaps none of the terminals have a problem; perhaps just a few. In any case, the carrier would be in a position to use this objective assessment as a way to focus its fatigue management efforts where there would be the greatest payoff. Further, after changes are made in operations or crew calling to reduce schedule induced fatigue, the carrier could revisit that terminal to assess whether the initiatives have been productive in eliminating or reducing the problem. For the first time, an objective tool could be applied to solve this elusive but safety-related problem. From the industry's perspective, it would be a non-prescriptive, performance-based approach that would not impose a "one-size-fits-all" regulatory solution and could, therefore, enhance productivity. From the public's perspective, it would have the promise of actually making a difference for the safety of the industry and the public.

A final report regarding the validation and calibration of the FAST model is anticipated by later this summer. It is inherent in the study design that products of this effort will be tools to assess the rough order of magnitude of fatigue as a contributing factor in accidents.

If FRA is successful, this model can be embodied in a scheduling tool that railroads can use to better plan their crew-calling practices and evaluate their staffing needs. The model can also be used with greater confidence for accident investigation purposes. FRA is indebted to the cooperation of the railroads and labor organizations in structuring this study, supported by the human factors staff of the NTSB.

(5) FRA and industry action to address sleep disorders

No amount of good scheduling or attention to limiting hours of service will completely ameliorate the fatigue issue if employees are subject to sleep disorders. FRA has issued a Safety Advisory on sleep disorders that emphasizes early screening and diagnosis facilitated by appropriate reassurances to employees asked to declare their own symptoms. Peer involvement would also be encouraged. (See Notice of Safety Advisory 2004-04; Effect of Sleep Disorders on Safety of Railroad Operations (Oct. 1, 2004; 69 Fed. Reg. 58995).) Every major railroad has taken some form of action consistent with the Advisory, but none has embraced it entirely and in an aggressive manner. However, FRA is cooperating with a major carrier in the development of screening protocols for identifying and treating employees in safety-sensitive positions (locomotive engineers) with sleep disorders. At the same time, we are also working with this carrier in addressing the problems associated with depression and diminished performance. In both cases, FRA's support includes funding assistance.

FRA is taking a number of additional actions to develop tools addressing fatigue that space limitations do not permit us to address in this prepared statement. I would encourage Subcommittee staff to set aside time for a detailed briefing.

b. Impairment by Alcohol and Other Drugs

When FRA issued its regulations on Prohibition of Alcohol and Drug Use in Railroad Operations in 1986, the agency became the first to require pre-employment, post-accident, and "reasonable suspicion" chemical testing, prompting litigation that went all the way to the U.S. Supreme Court. (See 49 C.F.R. part 219.) Shortly thereafter, random testing was added to the arsenal. FRA continues to aggressively administer this program, under which considerable progress has been made. It has since been largely replicated by other modes of transportation and improved in material respects under the leadership of the Office of the Secretary of Transportation.

Nevertheless, prohibited substances continue to show up in occasional post-accident tests, and FRA continues to encourage railroads to pursue education and awareness programs, including cooperative programs designed for employees to "bypass" discipline and receive access to an employee assistance program where an individual affected by a substance abuse disorder self-reports or is referred by a co-worker.

More recently, FRA has tasked its contract post-accident laboratory to conduct a blind study of samples collected for post-accident toxicology to determine if drugs other than those on the current panel for reporting are present in archived specimens. The FRA post-accident toxicology panel includes the five drug groups tested in most occupational programs (marijuana, cocaine, phencyclidine (PCP), amphetamines, and opiates) and certain other controlled substances that have a high potential for abuse and for compromise of alertness (benzodiazepines and barbiturates). There are many additional compounds, including many not considered controlled substances, that are known to have a potential to adversely affect performance. Some of these "other drugs" are dispensed by prescription, while others are sold over the counter. All of them have legitimate medical uses, but they have primary or secondary effects that may be inimical to safety.

Results of this blind study indicated that 11 percent of the urine specimens tested in all post-accident events for the period surveyed tested positive for these other drugs. The compounds varied from the powerful synthetic narcotic oxycodone to common over-the-counter drugs such as diphenhydramine (the generic name for a sedating type of antihistamine). These findings should neither be ignored nor taken out of context. Some of these positives appear to have involved other than human factor accidents, while in other cases the employee who was positive may have done nothing to contribute to the occurrence of the accident. In some cases, the drugs involved may have been taken under careful regulation by a treating physician who was well aware of the employee's occupation. FRA and the railroads have made efforts to address this issue (see, e.g., Safety Advisory: Safe Use of Prescription and Over-the-Counter Drugs (Dec. 24, 1998; 63 Fed. Reg. 71334)). But, given the prevalence of therapeutic drug use and the potential for abuse, we need to consider what additional actions may be appropriate.

c. Impairment by Other Medical Conditions

FRA's regulations for Qualification and Certification of Locomotive Engineers (49 C.F.R. part 240) require engineers to pass periodic visual and hearing acuity tests. Engineers must be free of active substance-abuse disorders. However, apart from these requirements and the prohibitions on alcohol and drug use described above, FRA—unlike the Federal Aviation Administration, the Federal Motor Carrier Safety Administration, or railroad regulatory agencies in Canada and Mexico—does not have a requirement for broad medical standards programs for safety-critical railroad employees.

The reasons for this are rooted in a strong tradition of industry action. Railroads for many years maintained vital medical programs that included pre-employment, return-to-work and periodic medical examinations. The programs were adequately staffed, and there appeared to be no need to duplicate this effort with FRA-imposed requirements. However, over the past decade, many of the railroads' medical functions have been outsourced, and periodic medical examinations have been largely discontinued. The AAR abolished its medical committee, so that individual railroads were left to act independently. Further, passage of the Americans with Disabilities Act has raised questions (given the absence of Federal medical standards) regarding the line-drawing that is necessary for this function.

Recognizing these developing trends, FRA commissioned a study that resulted in the report entitled "Medical Standards for Railroad Workers," which was introduced to the RSAC in January of 2005. FRA noted at that time that effective management of medical conditions that can affect safety (which include such disparate conditions as sleep apnea and seizure disorders) should be undertaken within the framework of a mature medical program. FRA asked RSAC member organizations to consider the study's findings and engage FRA in a dialogue regarding further steps. We have recently been advised that the major railroads are prepared to initiate that dialogue, and we will be seeking the cooperation of other RSAC parties to get it underway.

7. Technology must be part of the solution, not part of the problem.

a. Human-Centered Design

The first rule of medical science is "do no harm," and the same notion should be applied to technology deployment. Very often we think that if a technology is "new," it must be an improvement. Applying the principles of human-centered design will make it more likely that this is the case. Failure to do so may set traps that defeat the user and defeat the purposes the design was intended to serve.

Through our Office of Research and Development and with the assistance of the Department's Volpe National Transportation Systems Center, FRA has been on the forefront of this issue, providing extensive guidance materials for use by the railroads and the supply community. Recent results include a simple tool for evaluation of any new human-machine interface by our Office of Safety and other users.

b. Positive Train Control Migration

Technology can also be a tremendous aid to safety, providing a safety net when human beings err or become incapacitated. Since the 1920s, train control systems providing speed control functions, in-cab signal indications, and continuous or intermittent train stop functions have contributed significantly to safety in the territories where they were installed. Contemporary positive train control (PTC) systems can provide even more advanced functions, including prevention of train collisions (with positive stop protection), prevention of overspeed derailments, and protection of roadway workers within their authorities; and they can do this at less cost.

As traffic levels rise and traffic densities increase (particularly in non-signaled territory), the risk of collisions will rise. If PTC systems are built to be interoperable and are integrated into other business systems, we believe they can be an affordable response that will contribute to increased safety. In March 2005, we issued a final rule setting out Performance Standards for Processor-Based Signal and Train Control Systems that provides a means for qualifying new technology and facilitating the migration to safer train operations. (See 49 C.F.R. part 236.) The response is already strong. We have given approval to Railroad Safety Program Plans for two railroads, and we have the first Product Safety Plan under review (BNSF Railway's (BNSF) Electronic Train Management System).

As we move toward wider application of PTC, we need to garner as many of the benefits as possible using forward-looking, compatible technology—i.e., technology that will become part of the PTC system. Determining that switches are properly positioned is a high priority in light of the tragic Graniteville, South Carolina, accident in January 2005 and other events. In order to address this need, FRA initiated with BNSF a pilot project to demonstrate a Switch Position Monitoring System (SPMS). The SPMS project began in September 2005, and work was completed in early November 2005 to equip 49 switches on 174 miles of the Avard Subdivision in Oklahoma, which extends between Avard and Tulsa. At this writing, the system is functioning as intended, promptly providing dispatchers with warnings for misalignment or maladjustment. We believe that this technology should be extended to other non-signaled territory where risks are high because of train speeds and hazardous materials shipments.

c. Electronically Controlled Pneumatic (ECP) Brakes

In 2005, 14 percent of main track, human factor accidents involved improper train handling or misuse of the automatic braking system. A significant number of these events might have been avoided if locomotive engineers were given a more suitable train air brake system to use as a tool. Current railroad instructions to crews discourage use of the Federally-mandated automatic brake in favor of newer extended-range dynamic brakes because of the inherent limitations of the automatic brake related to fuel consumption, train handling, and the possibility of undesired emergency applications (which themselves may cause derailment).

During the 1990s, the AAR led an industry effort to develop ECP brakes, which use an electronic train line to command brake applications and releases. ECP brakes apply uniformly and virtually instantaneously throughout the train, provide health status information on the condition of brakes on each car, respond to commands for graduated releases, and entirely avoid runaway accidents caused by depletion of train line air pressure. ECP brakes shorten stopping distances on the order of 40 to 60 percent, depending on train length and route conditions. In turn, shortened stopping distances mean that some accidents that occur today might be avoided entirely, and some others might be reduced in severity (e.g., giving a person in a stalled motor vehicle crucial seconds to exit the vehicle and get clear of the grade crossing before the train arrives). Without question, this system will provide new and improved train-handling options that are expected to reduce the number of derailments now charged to the actions of locomotive engineers.

As the freight railroads have hesitated to implement this powerful but initially costly technology, the question has become, "where to start?" FRA set out to answer that question, and the answer is very timely in light of current capacity constraints affecting some market segments.

FRA is preparing to release a study entitled, "ECP Brake System for Freight Service," which was prepared for our Office of Safety by the firm of Booz Allen Hamilton, in consultation with an expert panel drawn from the community of railroads and shippers that have implementation of this technology under consideration. The report identifies and quantifies significant business benefits that could be realized with this technology and suggests a migration plan that would start with unit train operations, logically focused initially on the Powder River Basin coal service. Yesterday I met with the board of the National Coal Transportation Association (NCTA) at their request, to begin the discussion regarding how we promote this important transition to more capable technology. The value that ECP brake technology can add across the rail transportation sector is clearly evidenced by NCTA's interest in this opportunity. Coal shippers want to seize this opportunity because it will improve their service and the utilization of their coal cars. Railroads and their suppliers created the technology for similar reasons. The Nation can benefit as well, both in terms of service and safety. As major markets are served using the technology, it will also contribute materially to optimization of system capacity.

8. Impediments to working safely must be identified and removed.

Most of us agree that people generally want to perform their work well. Sometimes we are guilty of sloth or carelessness that comes from the desire to cut corners or from a poor attitude toward work. But in a very large number of cases, mishaps occur because of other factors. In most cases, the mishaps will have been preceded by many errors that did not result in harm. Perhaps machinery does not respond as anticipated, or distractions cause one to lose situational awareness. Perhaps skills taught in training some months ago have not been practiced, and performance suffers. Again, most of the time these lapses will ***not*** result in serious harm, and that presents an opportunity. We can learn from our mistakes before the mishap occurs.

"Close calls" are unsafe events that do not result in a reportable accident but could have done so. FRA is working to better understand these phenomena. In March 2005, FRA completed an overarching Memorandum of Understanding (MOU) with railroad labor organizations and management to develop pilot programs to document the occurrence of close calls. In other industries, such as aviation, adoption of close-call reporting systems that shield the reporting employee from discipline (and the employer from punitive regulatory sanctions) has contributed to major reductions in accidents. In August 2005, FRA and DOT's Bureau of Transportation

Statistics (BTS) entered into an MOU stipulating that BTS will act as a neutral party to receive the close-call reports and maintain the confidentiality of the person making the report. In October 2005, a contract to evaluate the close-call data was awarded to Altarum Institute of Alexandria, Virginia. Four railroads have expressed interest in taking part in this project. Educational efforts are under way to ensure that key stakeholders (local rail management and labor) at each potential site understand the purpose of the program and what would be required of them. Specifically, participating railroads will be expected to develop corrective actions to address the problems that may be revealed. Aggregated data from these projects may also provide guidance for program development at the national level. An Implementing MOU involving the first site is awaiting signature by all parties, and data collection is expected to begin in the near future.

Note on Railroad Staffing

At the June 27th hearing, I was asked about the current issue in collective bargaining with respect to one-person freight crews. Apart from expressing greater or lesser degrees of commitment to positive train control (depending on the railroad), railroads have not shared with FRA how they would meet all of the safety requirements that are addressed currently by conductors. Accordingly, FRA is not in a position to comment on the merits of this proposal; nor should we wade into the deep and murky waters of a collective bargaining matter.

I think all of us need to take this issue as it comes, paying careful attention but being sure not to prejudge. Some of our staff still working at FRA came to the agency at a time when the five-person crew was standard. As time went on, remaining fireman positions were eliminated, dropping the engine crew to a single person. Then the caboose was eliminated, and with it went a brakeman; the conductor moved up front. Soon the front brakeman was gone, as well. Through all of this change, safety improved, although not always in the seamless way one would have liked. We acknowledge that FRA took too long to require two-way end-of-train telemetry to ensure that a brake application could be initiated from the rear if the train line was blocked. The Congress had to prod the agency and the railroads to get that done, and in the meantime we had some spectacular runaways.

For a government agency, we are still fairly young, but we can learn from experience. So you can expect that FRA will be carefully looking at the issue with safety as our lodestar, should the railroads gain additional flexibility in the current round of talks or thereafter. In the meantime, the railroads need to maintain a strong focus on crew resource management, stressing the positive role that the conductor needs to play in over-the-road operations today and encouraging the locomotive engineer and conductor to function as a team, in concert with the dispatcher and others who contribute to the safety of operations. The various branches of labor, management, and FRA should also strive to keep our voices at a moderate volume so that we can listen to one another and strive to create an environment in which safety is truly our highest value.

Conclusion

Human factors have to do with people, organizations, and processes and the ways that technology is used to undermine or support human performance. Issues like maintaining freight cars to stay on track, or determining track geometry that will support high-speed passenger operations, are surprisingly complex, but they cannot compare in complexity to management of human factors issues. As a railroad safety community, we can do better in this field of endeavor, and we are taking a broad range of actions that will support that outcome.

Thanks again for the opportunity to testify on this important topic. I would be happy to respond to any questions from the Subcommittee.

Attachments

Attachment 1:

Train Accidents Caused by Human Factors, by Most Frequently Reported Cause

Note: The column headed "Acc %" shows the accumulated percentage. See also all train accident cause codes by category and subcategory in the FRA Guide to Preparing Accident/Incident Reports, Appendix C, "Train Accident Cause Codes," including "Train Operation – Human Factors."

	Cause	Total	% Of Total	Acc %	2001	2002	2003	2004	2005
1	Switch improperly lined	965	16.44	16.44	156	168	225	218	198
2	Shoving movement, absence of man	658	11.21	27.65	111	89	147	171	140
3	Shoving movement, failure to control	268	4.57	32.22	33	42	54	67	72
4	Buff/slack action excess, trn handling	255	4.34	36.57	54	37	75	58	31
5	Cars left foul	242	4.12	40.69	47	49	50	46	50
6	Switch previously run through	238	4.06	44.74	37	36	47	68	50
7	Fail to secure car hnd brk -rr emp	201	3.42	48.17	48	36	40	42	35
8	Fail to apply suff. hand brakes -rr emp	201	3.42	51.59	34	51	42	41	33
9	Passed couplers	180	3.07	54.66	36	28	38	38	40
10	Derail, failure to apply or remove	157	2.68	57.34	28	40	27	36	26
11	Other general switching rules	125	2.13	59.46	24	25	26	23	27
12	Coupling speed excessive	121	2.06	61.53	29	28	23	18	23
13	Failure to comply with restricted speed	102	1.74	63.26	24	35	11	12	20
14	Switch not latched or locked	98	1.67	64.93	25	11	15	25	22
15	Fail to apply car hnd brks -rr emp	96	1.64	66.57	9	20	14	25	28
16	Failure to comply with restricted speed or its equivalent not in connection with a block or interlocking signal.	91	1.55	68.12	0	0	21	35	35
17	Failure to couple	89	1.52	69.64	15	16	15	25	18
18	Other train operation/human factors	80	1.36	71.00	16	20	20	11	13
19	Kicking or dropping cars, inadequate precautions	79	1.35	72.35	0	0	8	32	39
20	Independent brake, improper use	68	1.16	73.50	12	14	16	16	10
21	Instruction to trn/yd crew improper	67	1.14	74.65	13	11	19	18	6
22	Buff/slack action excess, trn make-up	66	1.12	75.77	9	16	11	17	13
23	Car(s) shoved out & left out of clear	59	1.01	76.78	9	12	13	16	9
24	Failure to secure engine- rr empl	53	0.90	77.68	12	9	8	13	11
25	Failure to stop train in clear	50	0.85	78.53	15	10	7	9	9
26	Lat DB force on curve xcess trn hndlng	50	0.85	79.38	9	11	10	10	10
27	Radio communication, failure to comply	48	0.82	80.20	9	13	7	8	11
28	Other train handling/makeup	40	0.68	80.88	7	12	6	8	7
29	Excessive horsepower	39	0.66	81.55	9	6	9	10	5
30	Motor car/on-trk rules, fail to comply	38	0.65	82.19	16	4	8	4	6
31	Switch movement, excessive speed	38	0.65	82.84	6	11	7	10	4

	Cause	Total	% Of Total	Acc %	2001	2002	2003	2004	2005
32	Retarder, improper manual operation	37	0.63	83.47	7	13	6	9	2
33	Throttle (power), improper use	37	0.63	84.10	9	12	7	5	4
34	Lat drawbar force-short/long car combo	36	0.61	84.72	12	4	10	5	5
35	Automatic block or interlocking signal displaying a stop indication - failure to comply.*	35	0.60	85.31	0	0	10	12	13
36	Fail to release hand brk - rr emp	32	0.55	85.86	5	5	8	7	7
37	Use of brakes, other	32	0.55	86.40	5	5	7	8	7
38	Failure to stretch cars before shoving	31	0.53	86.93	3	5	6	11	6
39	Lat DB force on curve excess, make-up	31	0.53	87.46	4	4	8	7	8
40	Speed, other	31	0.53	87.99	8	5	5	4	9
41	Other main track authority causes	27	0.46	88.45	8	11	6	2	0
42	Fail to secure equip - not rr emp	24	0.41	88.86	5	5	2	3	9
43	Improper train make-up	24	0.41	89.27	2	10	6	3	3
44	Spring Swtch not clear before reverse	24	0.41	89.67	2	5	3	6	8
45	Human factors - track	24	0.41	90.08	9	5	4	4	2
46	Skate, failure to remove or place	23	0.39	90.48	3	3	3	8	6
47	Fail to allow air brks to release	23	0.39	90.87	3	2	3	6	9
48	Human factors -motive power & equipment	23	0.39	91.26	6	3	3	8	3
49	Fail to ctrl car spd use hnd brk-r emp	22	0.37	91.63	5	7	5	2	3
50	Fail to comply with trn order, etc.	22	0.37	92.01	4	2	2	9	5
51	Use of switches, other	21	0.36	92.37	5	6	2	4	4
52	Radio communication, improper	20	0.34	92.71	5	3	4	4	4
53	Radio comm., failure to give/receive	20	0.34	93.05	4	6	5	3	2
54	Block signal, failure to comply	19	0.32	93.37	8	9	2	0	0
55	Improper train inspection	18	0.31	93.68	3	4	2	2	7
56	Train outside yd limits(nonblk),exc spd	18	0.31	93.99	2	5	2	3	6
57	Employee asleep	17	0.29	94.28	6	5	3	1	2
58	Dynamic brake, too rapid adjustment	16	0.27	94.55	2	6	1	5	2
59	Motor car or other on-track equipment rules (other than main track authority) - Failure to Comply.	16	0.27	94.82	0	0	7	4	5
60	Failure to comply with failed equipment detector warning or with applicable train inspection rules.	15	0.26	95.08	0	0	4	4	7
61	Movement without authority - rr emp	15	0.26	95.33	2	3	4	4	2

	Cause	Total	% Of Total	Acc %	2001	2002	2003	2004	2005
62	Train inside yard limits, excess speed	15	0.26	95.59	5	2	5	1	2
63	Manual intervention of classification yard automatic control system modes by operator	14	0.24	95.83	0	0	1	5	8
64	Bottling the Air	12	0.20	96.03	4	2	2	2	2
65	Moving cars-load ramp,etc, not in pos	12	0.20	96.23	2	2	3	2	3
66	Improper train make-up at init term	12	0.20	96.44	0	1	3	7	1
67	Interlocking signal, failure to comply	11	0.19	96.63	6	2	3	0	0
68	Fixed signal (other than automatic block or interlocking signal), failure to comply.	11	0.19	96.81	0	0	2	6	3
69	Automatic brake, excessive	11	0.19	97.00	0	3	2	3	3
70	Train outside yd limits, excess speed	11	0.19	97.19	1	2	1	4	3
71	Fixed signal, failure to comply	10	0.17	97.36	7	3	0	0	0
72	Automatic brake, other improper use	10	0.17	97.53	3	4	0	1	2
73	Automatic block or interlocking signal displaying other than a stop indication - failure to comply.*	9	0.15	97.68	0	0	0	5	4
74	Dynamic brake, excessive	9	0.15	97.84	2	2	1	3	1
75	Human factors - signal	9	0.15	97.99	1	3	3	0	2
76	Throttle (power), too rapid adjustment	8	0.14	98.13	1	1	3	1	2
77	Failure to actuate off independent brk	8	0.14	98.26	2	0	1	2	3
78	Oversized loads or Excess Height/Width cars, mis-routed or switched.	8	0.14	98.40	0	0	2	4	2
79	Trn orders, trk warrants, radio error	7	0.12	98.52	0	0	3	2	2
80	Dynamic brake, other improper use	7	0.12	98.64	1	1	2	1	2
81	Humping or cutting off in motion equipment susceptible to damage, or to cause damage to other equipment	6	0.10	98.74	0	0	3	2	1
82	Switch improperly lined, radio controlled	6	0.10	98.84	0	0	0	1	5
83	Absence of fixed signal (Blue Signal)	5	0.09	98.93	0	1	2	2	0
84	Dynamic brake, excessive axles	5	0.09	99.01	1	0	2	0	2
85	Impairment because of drugs or alcohol	4	0.07	99.08	0	0	2	1	1
86	Flagging, improper or failure to flag	4	0.07	99.15	0	0	1	3	0
87	Hand signal, failure to comply	4	0.07	99.22	3	1	0	0	0
88	Portable derail, improperly applied	4	0.07	99.28	1	0	1	0	2
89	Trn orders, trk warrants, written err	4	0.07	99.35	0	0	2	2	0
90	Improper placement of cars in train	4	0.07	99.42	0	1	1	2	0

	Cause	Total	% Of Total	Acc %	2001	2002	2003	2004	2005
91	Automatic brake, insufficient	4	0.07	99.49	1	0	1	2	0
92	Hand signal, failure to give/receive	3	0.05	99.54	1	1	0	0	1
93	Fail to obs hand sig at wayside insp	3	0.05	99.59	1	2	0	0	0
94	Other signal causes	3	0.05	99.64	0	0	3	0	0
95	Retarder yard skate improperly applied	3	0.05	99.69	1	1	0	1	0
96	Moveable point trk frog improper lined	3	0.05	99.74	0	1	0	0	2
97	Flagging signal, failure to comply	2	0.03	99.78	0	1	1	0	0
98	Fail to cut-in brake valves-loco	2	0.03	99.81	0	0	2	0	0
99	Tampering - safety/protective device	2	0.03	99.85	1	0	1	0	0
100	Hand signal improper	1	0.02	99.86	0	0	0	0	1
101	Fixed signal (other than automatic block or interlocking signal), improperly displayed.	1	0.02	99.88	0	0	0	1	0
102	Hazmat regs, failure to comply	1	0.02	99.90	0	0	1	0	0
103	Auto brake, fail to use split reduction	1	0.02	99.91	0	0	0	0	1
104	Fail to cut-out brake valves-loco	1	0.02	99.93	0	0	0	1	0
105	Automatic cab signal, fail to comply	1	0.02	99.95	1	0	0	0	0
106	Op. of loco by uncert/unqual person	1	0.02	99.97	0	0	1	0	0
107	Human Factor - Signal - Train Control - Operator Input On-board computer incorrect data provided	1	0.02	99.98	0	0	0	0	1
108	Computer system configuration/management error (non vendor)	1	0.02	100.00	0	0	0	0	1
		5,869	100.00	9294.5	1,035	1,050	1,220	1,350	1,214

Attachment 2

Federal Railroad Administration (FRA) and Pipeline and Hazardous Materials Administration (PHMSA) Regulations Requiring Training, Testing, Qualification, or Certification of Certain Railroad Employees

I. Overview

The following chart provides an overview of FRA and PHMSA regulations that establish minimum requirements for the training, testing, qualification, or certification of railroad employees who make up trains, break up trains, or operate trains or locomotives (collectively, "railroad operating employees"). FRA is the primary agency of the U.S. Department of Transportation (DOT) responsible for enforcing PHMSA's regulations in the rail mode, including the PHMSA regulations cited below. 49 C.F.R. 1.49. (Please see applicability section of each regulation, e.g., 49 C.F.R. 217.3, for further details as to railroads covered. The FRA regulations cited are limited to railroads that operate on the general railroad system of transportation. See discussion of FRA jurisdiction at 49 C.F.R. part 209, appendix A. Also, many of the FRA requirements cited apply not only to railroad operating employees but also to certain additional railroad employees and to certain additional non-railroad employees.)

DOT agency that issued cited regulation	49 C.F.R. part or section	Type of training, testing, qualification, or certification required
FRA	sec. 217.9, 217.11	Each railroad is required to have a written program of instruction concerning the meaning and application of the railroad's operating rules and to instruct periodically each of the railroad's employees who is governed by those rules in accordance with that program. Each railroad is also required to conduct periodic operational tests and inspections to determine the extent of each such employee's compliance with those rules.

FRA	part 219	Control of alcohol and drug use in railroad operations. Applies to railroad employees who perform service covered by the hours of service law (including railroad operating employees). Prohibits such employees from being impaired by alcohol or drugs while on duty. Sec. 219.101. Prohibits the use of controlled substances at any time, with exceptions. Sec. 219.102. Requires removal from covered service for violating either prohibition. Sec. 219.104. Requires disqualification for unlawful refusal to provide breath or body fluid specimen or specimens when required by the railroad under a mandatory provision of the part. Sec. 219.107. Requires consent to certain alcohol and drug tests as a condition of continued service. Sec. 219.11. Requires passage of return-to-service test if suspended from service pursuant to part 219. Requires pre-employment drug tests. Sec. 219.501. Requires that railroad supervisors be trained to recognize the signs and symptoms of alcohol and drug influence in employees. Sec. 219.11(g).
FRA	sec. 220.25	Instruction and operational testing on the use of radio communication in a railroad operation. Each employee whom the railroad authorizes to use a radio in connection with a railroad operation must be--(1) provided with a copy of the railroad operating rules governing the use of radio communication in a railroad operation; (2) instructed in the proper use of radio communication as part of the program of instruction under sec. 217.11; and (3) periodically tested under the operational testing requirements of sec. 217.9.
FRA	sec. 232.203	Training, qualification, and designation program for employees and contractors that perform brake system inspections, tests, or maintenance.

FRA	sec. 236.921, sec. 236.923, sec. 236.927	Training and qualification program, general; Task analysis and basic requirements; Training specific to locomotive engineers and other operating personnel Persons who operate trains or serve as a train or engine crew member subject to instruction under 49 C.F.R. part 217 on a train operating in territory where a train control system subject to 49 C.F.R. part 236, subpart H, "Standards for Processor-Based Signal and Train Control Systems," is in use must be trained by their employers in accordance with the Product Safety Plan for the product involved. The training component of the Plan must address six specified topics, including familiarization with train control equipment on the locomotive.
FRA	sec. 238.109	Training, qualification, and designation program for employees and contractors who perform inspections, tests, or maintenance of passenger equipment.
FRA	sec. 239.101 (a)(2)	Employee training and qualification on passenger train emergency preparedness. Train crewmembers must be trained initially and then periodically every two years on the applicable plan provisions. At a minimum, training must include the following subjects: rail equipment familiarization; situational awareness; passenger evacuation; coordination of functions; and "hands-on" instruction concerning the location, function, and operation of on-board emergency equipment.
FRA	part 240	Qualification and certification of locomotive engineers. Prescribes numerous requirements applicable to railroad operating employees who operate a locomotive or train. See also discussion at Section II of this Attachment 2.

PHMSA (Technically, the cited regulations were issued by the Research and Special Programs Administration, PHMSA's predecessor agency.)	part 172, subpart H	Safety and security training program for employees involved in hazardous material transportation (including railroad operating employees involved in hazardous material transportation). Two types of safety training are required: general awareness and function-specific. Employers that handle certain types and quantities of hazardous material are required to give their employees two types of security training: security awareness training and in-depth security training. Training is also recurrent; employees must get the required training at least every three years.
FRA	part 209, subpart D	Disqualification procedures. Provides for disqualification of individuals in safety-sensitive service, after notice and opportunity for a hearing, for violation of a railroad safety regulation, order, or statute that demonstrates unfitness for safety-sensitive service. A willful violation triggers a rebuttable presumption of unfitness; however, willfulness need not be shown as a predicate for disqualification.
		Prohibits individuals who are subject to a disqualification order from working for any railroad in a manner inconsistent with the order. Prohibits railroads from employing a person subject to a disqualification order in any manner inconsistent with that order. (In other words, if the order prohibits the individual from serving as an operating employee for a specified time period, the individual may not serve as an operating employee for any railroad for that period.)

II. More detailed discussion of FRA's minimum training, testing, qualification, and certification requirements for locomotive engineers (49 C.F.R. part 240)

- Each railroad must have a written program to certify the qualifications of its employees who operate a locomotive or a train. The program, and any subsequent material modification to the program, must be approved by FRA. See 49 C.F.R. part 240, subpart B.

- The program must provide for certain initial and continuing training. 49 C.F.R. 240.123. For example, a railroad that chooses to train a previously untrained person must provide initial training that covers personal safety, railroad operating rules, mechanical condition of equipment, train handling procedures, familiarization with physical characteristics [of a territory] including train handling, and compliance with Federal regulations. This training must be under the supervision of a qualified instructor engineer and permit the student to acquire familiarity with the physical characteristics of a territory.

- Through the program, each railroad must make four principal determinations in certifying a person as qualified to operate a locomotive or a train. Each person must have the requisite–

  (1) visual and hearing acuity, as demonstrated by passage of a test or a medical officer's decision;
  (2) knowledge, as demonstrated by passage of a written exam;
  (3) skills, as demonstrated by passage of a performance skills test; and
  (4) background, as demonstrated by past conduct concerning the operation of both a train/locomotive and a highway motor vehicle.

  See 49 C.F.R. part 240, subpart B.

- In particular, the skills performance test must address the person's application of knowledge of the railroad's operating practices, equipment inspection practices, train handling practices, and compliance with Federal railroad safety laws. 49 C.F.R. 240.127.

- Once certified, a locomotive engineer must be given at least one operational monitoring observation by a qualified supervisor of locomotive engineers annually and at least one unannounced compliance test annually. 49 C.F.R. 240.303.

- A certified locomotive engineer is subject to revocation of his or her certification and civil penalties for violating any one of five, cardinal operating rules. Generally stated, these fundamental operating rules concern--

  (1) failing to obey a stop signal;
  (2) exceeding a speed limit by at least 10 mph;
  (3) failing to adhere to certain procedures for the safe use of train or engine brakes;
  (4) occupying main track without authority; or

(5) tampering with a locomotive safety device.

See 49 C.F.R. 240.117 and 240.305.

- A certified locomotive engineer is also subject to revocation of his or her certification for violating Federal alcohol and drug use prohibitions. Generally, these prohibitions concern use, possession, or impairment while on duty. See 49 C.F.R. 240.117(e)(6) and 219.101.

- A person who has an active substance abuse disorder shall not be currently certified as a locomotive engineer. See 49 C.F.R. 240.119(b).

- A locomotive engineer may petition FRA's Locomotive Engineer Review Board (LERB) in response to a decision by a railroad to revoke his or her certification. 49 C.F.R. part 240, subpart E. A person who is a candidate to become a locomotive engineer may also challenge a decision by the railroad to deny certification. The LERB reviews the record of the railroad's decision to determine whether the revocation or denial of certification was proper under FRA's regulations. The LERB may overturn or uphold the railroad's decision. Either party may request a *de novo* hearing on the matter before an administrative hearing officer. The decision of the administrative hearing officer may be appealed to the FRA Administrator. The final decision of the Administrator may be reviewed in the appropriate U.S. Court of Appeals. 49 U.S.C. 20114(c).

National Transportation Safety Board

Bob Chipkevich
Director
Office of Railroad, Pipeline and Hazardous Materials Investigations

Testimony of Bob Chipkevich, Director
Office of Railroad, Pipeline and Hazardous Materials Investigations
National Transportation Safety Board
before the
U.S. House of Representatives
Committee on Transportation and Infrastructure
Subcommittee on Railroads
July 25, 2006

Good morning Chairman LaTourette, Ranking Member Brown, and Members of the Subcommittee. My name is Bob Chipkevich. I am the Director of the National Transportation Safety Board's Office of Railroad, Pipeline and Hazardous Materials Investigations. The Safety Board's Acting Chairman, Mark Rosenker, asked me to represent the Board today to discuss Human Factors Issues in Rail Safety. The Acting Chairman is unable to be here today because the Board has a previously scheduled Sunshine Act meeting to deliberate on the probable cause of a marine accident.

Since 2001, the National Transportation Safety Board has investigated 28 railroad and 3 rail transit accidents involving train collisions and over-speed derailments. Most of these accidents occurred after train crews failed to comply with train control signals, failed to follow operating procedures in non-signaled (dark) territories, or failed to comply with other specific operating rules such as returning track switches to normal positions after completing their work at track sidings. Our accident investigations have identified human performance failures related to fatigue, medical conditions such as sleep apnea, use of cell phones, use of after-arrival track warrants in dark territory, loss of situational awareness, and improperly positioned switches.

Although the Safety Board has made numerous safety recommendations to address specific human performance issues, we have repeatedly concluded that technological solutions, such as positive train control systems, have great potential to reduce the number of serious train accidents by providing safety redundant systems to protect against human performance failures. As a consequence, positive train control has been on the Safety Board's most wanted list of transportation safety improvements for 16 years.

Fatigue

Fatigue is a human performance safety issue that crosses all modes of transportation. Although fatigue has been identified as a safety issue in many railroad accidents over the years, the Safety Board most recently addressed this issue in its investigation of a collision between two freight trains at Macdona, Texas on June 28, 2004. As a result of that accident, 3 people died from chlorine gas inhalation after a tank car was punctured.

The Safety Board determined that the probable cause of the collision of the Union Pacific Railroad train with a BNSF Railway train at Macdona, Texas, was Union Pacific Railroad train crew fatigue that resulted in the failure of the engineer and conductor to appropriately respond to wayside signals governing the movement of their train. Contributing to the crewmembers' fatigue was their failure to obtain sufficient restorative rest prior to reporting for duty because of their ineffective use of off-duty time and Union Pacific Railroad train crew scheduling practices which inverted the crewmembers' work/rest periods. Contributing to the accident was the lack of a positive train control system in the accident location.

The Safety Board concluded that the Union Pacific engineer had experienced microsleeps followed by a deeper descent into sleep and that the conductor was most likely asleep during most of the trip. Admittedly, work as a train crewmember entails an unpredictable job schedule that can make it difficult for employees to effectively balance their personal and work lives. During periods when the demand for crews exceeds the supply, the additional pressure on available crewmembers can make achieving such a balance particularly difficult. The Board concluded in the Macdona report that the unpredictability of Union Pacific train crewmembers' work schedules may have encouraged them to delay obtaining rest in the hope that they would not be called to work until later on the day of the accident.

The Safety Board also found that the minimum rest periods prescribed by Federal regulations do not take into account either the rotating work schedules or the accumulated hours spent working and in limbo time. Limbo time, the time when a crew is neither operating the train nor yet released from duty, is most often associated with a crew's travel time to their final release point after the expiration of their 12-hour service limit. The time spent awaiting that transportation can be significant and can lead to very long workdays. For example, in June 2004, over 42 percent of the Union Pacific Railroad train crews in the San Antonio, Texas area spent greater than 12 hours on an assignment, over 24 percent spent greater than 13 hours, and 5 percent (or 760 train crews) spent greater than 15 hours.

As a result of the Macdona accident investigation, on July 20, 2006, the Safety Board recommended that the Federal Railroad Administration (FRA) require railroads to use scientifically based principles when assigning work schedules for train crewmembers, which consider factors that impact sleep needs, to reduce the effects of fatigue (R-06-14). The Board also recommended that the FRA establish requirements that limit train crewmember limbo time to address fatigue (R-06-15). Further, the Board recommended that the Union Pacific Railroad, the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union use the Macdona accident as a fatigue case study to illustrate the responsibility of the carrier to provide an employee the opportunity for adequate sleep and the responsibility of the employee to acquire sleep sufficient to work at a safe level of alertness, and the options available if adequate sleep is not obtained (R-06-16 and 17). As these safety recommendations have just recently been issued, they are classified "Open–Await Response."

The Safety Board also identified inadequate sleep as a safety issue in a recent rail transit accident. On November 3, 2004, a Washington Metropolitan Area Transit Authority (WMATA) Metrorail train rolled backwards 2,246 feet and struck another train at a speed of about 36 mph at the Woodley Park-Zoo/Adams Morgan station in Washington, D.C. The Board found that the train operator had become disengaged from some critical train operations and that his reduced alertness was likely due to inadequate sleep. The Board found WMATA's practice of allowing train operators to return to work after having as few as 8 hours off between shifts following prolonged tours of duty does not give train operators the opportunity to receive adequate sleep to be fully alert and to operate safely. On April 19, 2006, the Board recommended that the Federal Transit Administration (FTA) require transit agencies to ensure that the time off between daily tours of duty, including regular and overtime assignments, allows train operators to obtain at least 8 hours of uninterrupted sleep (R-06-03).

On June 6, 2006, the FTA responded that it shared the Safety Board's concerns regarding the importance of adequate rest between shifts for train operators and is determining if it can require the action requested as a condition of grants or through other authority. The Safety Board is evaluating the information provided by the FTA and the safety recommendation is classified "Open – Response Received."

Medical Conditions

Safety Board accident investigations have also identified inadequate requirements for identifying and addressing potentially incapacitating medical conditions of railroad employees who carry out safety sensitive duties. The Safety Board found that the probable cause of a collision between two Canadian National (CN) freight trains near Clarkston, Michigan on November 15, 2001, was train crewmembers' fatigue (for the train that did not stop for a stop signal), which was primarily due to the engineer's untreated and the conductor's insufficiently treated obstructive sleep apnea.

Both crewmembers of the train that passed the stop signal had been told by their private physicians that they had (or likely had) obstructive sleep apnea, but neither employee informed the CN of his potentially incapacitating condition. Company physical exams did not include questions about sleeping disorders or other chronic problems that might cause performance-impairing fatigue. FRA certification requirements for locomotive engineers focus on specific vision and hearing acuity standards but do not provide guidance regarding medical conditions that should be considered in the course of an examination. The Board also found that no standard medical examination form exists in the railroad industry.

On November 27, 2002, the Safety Board recommended that the FRA develop a standard medical examination form that includes questions regarding sleep problems and require that the form be used to determine the medical fitness of locomotive engineers, and that the form also be available for use to determine the medical fitness of other employees in safety-sensitive positions (R-02-24). The Board also recommended that the FRA require that any medical condition that could incapacitate, or seriously impair the performance of, an employee in a safety-sensitive position be reported to the railroad in a timely manner (R-02-25). Further, the Board recommended that the FRA require that, when a railroad becomes aware that an employee in a safety sensitive position has a potentially incapacitating or performance-impairing medical condition, the railroad prohibit that employee from performing any safety-sensitive duties until the railroad's designated physician determines that the employee can continue to work safely in a safety-sensitive position (R-02-26).

In response to these safety recommendations, in 2004 the FRA issued a safety advisory to highlight the relationships between medical conditions (particularly sleep problems) and impaired performance. Further, a study completed by a contractor for the FRA on the need for and options for implementing medical standards was completed in January 2005 and presented to the Railroad Safety Advisory Committee. The report concludes that there is a need for a consistent industry-wide medical standard program for railroad workers and recommends that the FRA expedite the development of a medical standard program for the industry. The safety recommendations are classified "Open—Acceptable Response."

Use of Cell Phones

On May 28, 2002, two BNSF Railway freight trains collided head-on near Clarendon, Texas. The Safety Board determined that the probable cause of the accident was the coal train engineer's use of a cell phone during the time he should have been attending to the requirements of the track warrant his train was operating under, and the unexplained failure of the conductor to ensure that the engineer complied with the track warrant restrictions. Contributing to the accident was the absence of a positive train control system that would have automatically stopped the coal train before it exceeded its authorized limits.

Locomotive engineers commonly use the locomotive radio to communicate with the dispatcher or other railroad employees. At the same time, cell phones are becoming more prevalent, and all four crewmembers involved in this accident had personal cell phones with them. The engineer of the coal train had used his cell phone for two personal calls the morning of the accident, one call for 23 minutes and then a second call for 10 minutes shortly before the accident. The engineer was on the second call as he passed the location at which he should have stopped and waited for the arrival of another train. The Safety Board concluded that the engineer's cell phone use likely distracted him to the extent that he did not take proper note of the after-arrival stipulation imposed by a track warrant and thus was unaware of the need to prepare to bring his train to a stop.

As a result of an unrelated collision on a different BNSF subdivision, the railroad issued instructions to operating employees on June 18, 2002, that prohibit locomotive engineers from using cell phones and laptop computers while operating the controls of a locomotive.

Cell phone use interferes with the perception process during the performance of operational tasks. A crewmember who is on a cell phone may miss information broadcast on the locomotive radio from a dispatcher, wayside defect detectors, or train crews from a passing train. When used by either the engineer or conductor, a cell phone may distract the other crewmember or terminate the normal interaction between the two. Further, one employee may wish to ask a question or offer a reminder but may choose to not disturb the employee who is using the phone. Additionally, an incoming call may be a significant distraction to a person who is engaged in a particular task at a critical time.

Federal regulations do not prohibit a locomotive engineer from using a cell phone while at the controls of a moving train. On June 13, 2003, the Safety Board recommended that the FRA promulgate new or amended regulations that will control the use of cellular telephones and similar wireless communication devices by railroad operating employees while on duty so that such use does not affect operational safety (R-03-1).

The FRA responded that by and large, railroads across the country have promulgated, or are promulgating, operating rules that prohibit or severely restrict cell phone use by employees moving equipment and in other situations, such as switching activities or when inspecting passing trains. FRA noted that the railroad industry's enforcement of its operating rules governing cell phone use is sufficient to address the issue without the need for Federal regulations. However, the Safety Board does not share the FRA's confidence that the railroad industry has taken sufficient steps to prevent the use of cell phones for personal matters when crewmembers should be attending to the operation of the train. The Board is concerned that the risks of complacency and attention deficiencies associated with cell phone use are not sufficiently understood or recognized. Unlike some other distractions to operating crewmembers, cell phone use has the potential to distract crewmembers for a considerable length of time, and is avoidable. The FRA acknowledged concern and issued instructions to its staff to watch for use of cell phones, and has asked railroad members of the Railroad Safety Advisory Committee to provide information about their instructions for use of cellular phones before determining what actions, if any, the FRA should take. The safety recommendation is currently classified "Open – Acceptable Response."

After-Arrival Track Warrants in Non-Signaled (Dark) Territory

Non-signaled (dark) territory presents a unique problem for rail safety. In dark territory there are no signals to warn trains as they approach each other, and the avoidance of collisions relies solely on dispatchers and train crews adhering to operating procedures. Issuing after-arrival track warrants under these conditions exacerbates an already potentially tenuous and contingent work situation. (An after-arrival track warrant is a conditional authority given to a train crew by a dispatcher. It authorizes the train crew to proceed ahead only after another specifically identified train that is en route to their location has arrived.) While the railroad industry contends that after-arrival track warrants facilitate the expedient and efficient movement of trains, and the FRA has seen merit in the industry's logic, ultimately, the role of human error and the cost of human casualties also must be considered in this equation.

The Safety Board has investigated a number of accidents involving after-arrival track warrants in non-signaled territory. In 1996, in Smithfield, West Virginia, the Board investigated a head-on collision between two CSX Transportation freight trains operating under after-arrival operating procedures. CSX Transportation subsequently discontinued the use of after-arrival authorities in non-signaled territory. In 1997, the Board investigated a collision between two Union Pacific Railroad freight trains in Devine, Texas. As a result of the Devine investigation, the Board recommended that the FRA permanently discontinue the use of after-arrival orders in non-signaled territory (R-98-27). The safety recommendation was classified "Closed–Unacceptable Action" on June 29, 1999.

After investigating the 2002 head-on collision between two BNSF trains in Clarendon, Texas, the Safety Board recommended that the FRA limit the use of after-arrival orders in non-signaled territory to trains that have stopped at the location at which they will meet the opposing train (R-03-2). The safety recommendation was classified "Closed–Unacceptable Action" on August 6, 2004.

On May 19, 2004, the Safety Board investigated yet another head-on collision between two BNSF freight trains near Gunter, Texas. Again, the trains were being operated under track warrant rules on non-signaled territory. The Safety Board has concluded that informal communications between the dispatcher and train crews regarding authority limits, train names, and meeting or stopping points may lead to misunderstandings and errors. In the opinion of the Board, the use of after-arrival track warrants for train movements in dark (non-signaled) territory creates an unacceptable risk of collision. The Board also concluded that had the FRA required railroads to permanently discontinue the use of after-arrival orders in dark territory as advised in Safety Recommendation R-98-27, this accident would not have happened. Further, the Board concluded that had a positive train control system with collision avoidance capabilities been in place and operational on the subdivision at the time of the accident, the collision would not have occurred. On June 29, 2006, the Board again recommended that the FRA prohibit the use of after-arrival track warrants for train movements in dark (non-signaled) territory not equipped with a positive train control system (R-06-10). The Board is awaiting a response from the FRA.

Loss of Situational Awareness

The Safety Board has investigated accidents in which the loss of situational awareness was a factor. In its investigation of the collision of an Amtrak train with a Maryland Rail Corporation (MARC) train in Baltimore, Maryland in 2002, the Safety Board concluded that a factor in the accident was the engineer's unfamiliarity with equipment. Specifically, the Amtrak engineer, with about 6 months of operating experience over the territory, had a train that was pulled by two locomotives of a type she had never operated. In addition, she had had limited experience operating locomotives as multiple units. As the engineer was approaching Baltimore station, she became overly concerned with and focused on maintaining her speed; as a result, she did not see either the cab or wayside signals indicating that she should stop. She continued past the signals and collided with a MARC train near the station.

On October 12, 2003, a Northeast Illinois Regional Commuter Railroad (Metra) train derailed in Chicago, Illinois at a speed of about 68 mph as it traversed a crossover from track 1 to track 2. The maximum authorized speed through the crossover was 10 mph. There were 375 passengers and a crew of 3 onboard; 47 passengers were transported to hospitals.

During interviews with Safety Board investigators, the engineer discussed some operational concerns he had had soon after he began the trip. None of the fundamental tasks (train handling, signal recognition, and operating rules) faced by the engineer on the day of the accident was beyond his capabilities. However, when his belief that he was operating on clear signals was coupled with his unresolved concerns about the location of a work crew, when he would be crossed over, and other tasks, his ability to operate the train safely was affected.

The engineer was confronted with a number of tasks that he should have handled more effectively. Training programs should help prepare students for "real-world" situations and teach them how to effectively prioritize conflicting tasks. The Safety Board concluded that the cumulative operating concerns of the engineer likely diverted his attention from the safety-critical task of observing and complying with signal indications. The Board also concluded that the Metra accident is another in a series of accidents that could have been prevented had there been a positive train control system at the accident location. On November 23, 2005, the Safety Board recommended that the FRA develop guidelines for locomotive engineer simulator training programs that go beyond developing basic skills and teach strategies for effectively managing multiple concurrent tasks and atypical situations (R-05-9).

On May 26, 2006, the FRA responded that it agreed that developing guidelines for locomotive skill development that contribute to good situational awareness is worthy of consideration, both as a further contribution to the quality of existing training programs and as a means of benchmarking the various programs. The FRA noted that while it did not currently have funding available to initiate this action, it would try to identify resources to undertake the work. The safety recommendation is classified "Open – Response Received."

Improperly Positioned Switches

One of the most serious hazardous materials train accidents in recent years occurred in Graniteville, South Carolina on January 6, 2005, after a Norfolk Southern Railway Company freight train, while traveling 47 mph, encountered an improperly positioned switch that diverted the train from the main line onto an industry track, where it struck an unoccupied, parked train. The track through Graniteville was non-signaled (dark) territory. Nine people died as a result of chlorine gas inhalation after a tank car was punctured during the accident.

The investigation determined that the improperly lined switch had most recently been used by the crew of a local train about 8 hours before the accident. The crew had lined the switch for an industry track in order to place two cars at a local plant and then park their train. No crewmember remembered relining the switch for the main line before they boarded a taxi and returned to the terminal. The Safety Board concluded that the local train crew failed to reline the main line switch for one or more of the following reasons: (1) the task of relining the switch was functionally isolated from other tasks the crew was performing, (2) the crewmembers were rushing to complete their work and secure their train before reaching their hours-of-service limits, (3) the crew had achieved their main objective of switching cars and were focused on the next task of securing their equipment and going off duty, and (4) the switch was not visible to the crew as they worked, leaving them without a visual reminder to reline the switch.

The Safety Board was concerned as early as 1974 about the issue of train speeds in areas not under a form of centralized traffic control. As a result of its investigation of an accident in Cotulla, Texas involving a misaligned switch in non-signaled territory, the Board recommended that the FRA determine and assess the current risks of train accidents involving misaligned switches, collisions, broken rail, and other route obstructions on main track where automatic block signal systems do not exist, and to promulgate regulations that detail the major risks and controls assumed, set guidelines for safe operations below the maximum operating speed, and assign responsibility to the carrier for safe operations. Because the FRA' actions did not satisfy the Safety Board's intent that new regulations specify circumstances that required that trains be operated below the allowable maximum speed, Safety Recommendation R-74-26 was classified "Closed – Unacceptable Action."

Measures beyond additional operating rules, forms, or penalties, are needed to ensure that accidents such as the one in Graniteville do not recur. On December 12, 2005, the Safety Board recommended that the FRA require that, along main lines in non-signaled territory, railroads install an automatically activated device, independent of the switch banner, that will, visually or electronically, compellingly capture the attention of employees involved with switch operations and clearly convey the status of the switch both in day and in darkness (R-05-14). In a letter dated June 30, 2006, the FRA acknowledged that additional actions are needed to protect the safety of trains in dark territory and that over time, positive train control will serve this function. However, it noted concern that any system that requires power at the switch location will involve significant costs, simply because of the number of switches involved. The letter advises that the FRA has initiated a project to evaluate a system that it believes will be able to detect and report switch point gapping for switches on main line tracks located within dark territories as an alternate action. The safety recommendation is classified "Open–Response Received."

The Safety Board also recommended that the FRA require railroads, in non-signaled territory and in the absence of switch position indicator lights or other automated systems that provide train crews with advance notice of switch positions, to operate those trains at speeds that will allow them to be safely stopped in advance of misaligned switches (R-05-15). In its June 30, 2006, letter the FRA states that it does not believe the recommendation is feasible for operational and economic reasons and may also increase the risk of derailments. The FRA hastened to add that there are undoubtedly certain situations where requiring trains to approach switches prepared to stop would be practical and an appropriate safety response, and that railroads should consider this option as they conduct risk assessments of their hazardous materials routes. However, the FRA states that it is not aware of any means to describe how this strategy could be applied in a safe and cost-effective manner. The FRA requested that the Safety Board classify the Safety Recommendation as "Closed–Reconsidered." The safety recommendation is currently classified as "Open–Response Received" and the Board is evaluating the information provided by FRA.

Summary

Actions need to be taken by the FRA to address train crew fatigue, to assess the medical fitness of train crews, to control the use of cellular phones, to prohibit the use of after-arrival track warrants in dark territory, to improve situational awareness training for train crews, and to prevent trains from being misdirected through improperly lined switches. Most importantly, the FRA should take aggressive action to require railroads to install positive train control systems as soon as possible, so that train accidents caused by human factors can be prevented.

Mr. Chairman, this completes my statement, and I will be happy to respond to questions at the appropriate time.

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: July 20, 2006

In reply refer to: R-06-17

Mr. Don M. Hahs
National President
Brotherhood of Locomotive Engineers and Trainmen
1370 Ontario Street
Cleveland, Ohio 44113

Mr. Paul C. Thompson
International President
United Transportation Union
14600 Detroit Avenue
Cleveland, Ohio 44107

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses train crew fatigue. The recommendation is derived from the Safety Board's investigation of the June 28, 2004, collision of a Union Pacific Railroad (UP) train with a BNSF Railway Company (BNSF) train in Macdona, Texas, and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Board has issued four safety recommendations, one of which is addressed to the Brotherhood of Locomotive Engineers and Trainmen and the United Transportation Union. Information supporting this recommendation is discussed below. The Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.[1]

About 5:03 a.m., central daylight time, on Monday, June 28, 2004, a westbound UP freight train traveling on the same main line track as an eastbound BNSF freight train struck the midpoint of the 123-car BNSF train as the eastbound train was leaving the main line to enter a parallel siding. The accident occurred at the west end of the rail siding at Macdona, Texas, on the UP's San Antonio Service Unit. The collision derailed the 4 locomotive units and the first 19 cars of the UP train as well as 17 cars of the BNSF train. As a result of the derailment and pileup of railcars, the 16th car of the UP train, a pressure tank car loaded with liquefied chlorine, was punctured. Chlorine escaping from the punctured car immediately vaporized into a cloud of chlorine gas that engulfed the accident area to a radius of at least 700 feet before drifting away from the site. Three persons, including the conductor of the UP train and two local residents, died as a result of chlorine gas inhalation. The UP train engineer, 23 civilians, and 6 emergency

[1] For additional information, see National Transportation Safety Board, *Collision of Union Pacific Railroad Train MHOTU-23 With BNSF Railway Company Train MEAP-TUL-126-D With Subsequent Derailment and Hazardous Materials Release, Macdona, Texas, June 28, 2004,* Railroad Accident Report NTSB/RAR-06/03 (Washington, DC: NTSB, 2006).

responders were treated for respiratory distress or other injuries related to the collision and derailment. Damages to rolling stock, track, and signal equipment were estimated at $5.7 million, with environmental cleanup costs estimated at $150,000.

The National Transportation Safety Board determined that the probable cause of the June 28, 2004, collision of UP train MHOTU-23 with BNSF train MEAP-TUL-126-D at Macdona, Texas, was UP train crew fatigue that resulted in the failure of the engineer and conductor to appropriately respond to wayside signals governing the movement of their train. Contributing to the crewmembers' fatigue was their failure to obtain sufficient restorative rest prior to reporting for duty because of their ineffective use of off-duty time and UP train crew scheduling practices, which inverted the crewmembers' work/rest periods. Contributing to the accident was the lack of a positive train control system in the accident location. Contributing to the severity of the accident was the puncture of a tank car and the subsequent release of poisonous liquefied chlorine gas.

The Safety Board's investigation determined that in June 2004, the UP engineer worked at least part of 22 days and that his time on duty ranged from 9 hours to more than 18 hours. Eleven of his work days were longer than 14 hours, with 1 day totaling 22 hours (12 hours on duty and 10 hours of paid limbo time). The engineer's schedule reflected several demanding periods of work, but they were offset by breaks from service. For example, he was off duty for 57 consecutive hours during the first week of June, 69 hours the next week, and 41 hours the third week.

The periods of on-duty and off-duty time for the engineer during the month of June would have put his circadian processes in a state of continuous readjustment. Based on the release-from-duty times shown on the engineer's work schedule, he would have had to obtain much of his post-work recuperative sleep primarily during the daytime. Research has determined that daytime sleep is typically shorter in duration and is degraded in quality as compared with nighttime sleep.[2] For the remainder of the month of June, the engineer's rest would have included nighttime sleep, either when he worked during the day, or when he had multiple-day breaks in service. Such frequent changes in work/sleep patterns have been shown to disrupt circadian rhythms in a way that can degrade work performance.[3]

A complicating factor in the case of the UP engineer was that he did not have a residence of his own. Because he was staying with a fellow engineer but spending all his waking hours elsewhere, he did not have the usual relaxation time preparatory to sleeping that would have contributed to his obtaining recuperative rest. The combined effects of intermittent day and night work and the obstacles the engineer faced in obtaining adequate rest because of his living arrangements likely led to his developing a cumulative sleep loss, or sleep *debt*. Sleep debt occurs when an individual does not obtain sufficient restorative sleep over time.[4] According to

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[2] A. J. Tilly, R. T. Wilkinson, P. S. G. Warren, B. Watson, and M. Drud, "The Sleep and Performance of Shift Workers," *Human Factors* Vol. 24, No. 6 (1982): 629-641.

[3] D. Kripke, M. Marler, and E. Calle, "Epidemiological Health Impact," in C. Kushida ed., *Sleep Deprivation, Clinical Issues, Pharmacology, and Sleep Loss Effects* (New York: Marcel Dekker, 2005) 203.

[4] W.C. Dement, *The Sleepwatchers*, 2nd ed. (Menlo Park, CA: Nychthemeron Press, 1996).

one prominent sleep researcher, the tendency of an individual to fall asleep increases progressively in direct proportion to the increase in the sleep debt.[5]

In the 3 days immediately before the accident, the UP engineer engaged in an intense concentration of work followed by time spent in personal activities on Sunday. Work records show that he had only 9 3/4 hours off duty (after his tour) on Friday, June 25, and 9 1/2 hours off duty on Saturday, June 26. Based on his statements to investigators, he obtained only about 1 1/2 hours of bed rest (in addition to napping on a sofa while watching television) in a 31-hour period between his being called for work on Saturday evening, June 26, and the time of the accident. This lack of recuperative sleep would have increased the sleep debt the engineer was already experiencing because of his work schedule and living arrangements. Under these circumstances, the engineer would be expected to experience notably high sleep pressure with a resulting reduction in his ability to resist falling asleep.

The Safety Board therefore concluded that the UP engineer's combination of sleep debt, disrupted circadian processes, limited sleep through the weekend, and long duty tours in the days before the accident likely caused him to start the accident trip with a reduced capacity to resist involuntary sleep.

This is not to say that, despite his intense work schedule in the days before the accident, the engineer did not have ample time to obtain rest. Had he been determined to do so, the engineer could have obtained recuperative rest after his tours on Friday and Saturday before the accident. And with some effort, he could have obtained even more rest on the Sunday before the accident.

The Safety Board notes that when the engineer went off duty on Sunday, he requested 12 hours' uninterrupted rest. But when he left the work site, he did not return to his temporary residence to seek rest. Instead, he drove to the home of his estranged wife where he intended to spend time with his daughter. He said that he did nap on the couch while watching television before his daughter arrived, but such napping would not be expected to fully ameliorate the effects of the engineer's sleep debt. Similarly, when the engineer left his wife and daughter at about 8:30 p.m., he could have gone back to where he was staying to go to bed. This would have given him several hours of additional sleep before his call to work. But instead of going home, he went to visit a friend and played cards for several hours.

The engineer said that he had expected to get more sleep because he did not believe he would be called to work until later on Monday morning. But the engineer was well aware of the unpredictability of work in pool service. As he acknowledged during the public hearing on this accident, "I could be 15 times out and miss calls because they rolled the board and put me first out." He made no calls to the voice response system on Sunday to get up-to-date information on his standing or on job vacancies, although he may have accessed this information through the UP Web site.

A review of the conductor's schedule in the 10 days before the accident showed that he had had 4 days off followed by 6 consecutive work days leading up to the day of the accident.

[5] Dement, 1996.

His duty times for the 6 work days would have allowed him to continue the nighttime sleep pattern that he probably had adhered to during the preceding 4 off days. The conductor's call for the accident trip shortly after midnight on June 28 therefore inverted the work/sleep cycle he had developed over the previous 10 days. Such a disruption would be expected to produce "severe effects" for sleepiness and performance.[6]

On Saturday, June 26, after working until 10:50 p.m., the conductor had 26 hours off duty before reporting for the accident trip. His housemate said that the conductor had stayed up until about 4:00 a.m. Sunday morning and slept until about 1:00 p.m. Sunday afternoon. He was then active until some time after 9:00 when he returned from the home of a friend. Based on the statements of his housemate, the conductor apparently did not go to bed immediately after returning home. Thus, at the time the conductor was called for the accident train early Monday morning, he had had, at most, only a few hours of sleep in the previous 11 hours. This limited amount of sleep could have exacerbated the effects of the conductor's inverted work/sleep cycle and could have made it more difficult for him to remain alert in the hours before the accident.

Postmortem toxicological tests of the conductor were negative for drugs but positive for ethanol (alcohol). The alcohol concentrations were 0.013 percent in the blood, 0.051 percent in the urine, and 0.029 percent in the vitreous humor. Although the small concentrations of alcohol in the blood and urine could be explained as natural byproducts of decomposition, the finding of 0.029 percent alcohol in the vitreous humor offers evidence that the conductor had ingested alcohol before reporting for work.[7] This finding was consistent with the housemate's statement that the conductor may have consumed some quantity of beer after he returned from his friend's home.

The Safety Board does not consider the conductor's alcohol use, in and of itself, to be causal to this accident. However, alcohol has been shown to have a sedating effect after use or after the concentration of alcohol in the body has begun to decrease.[8] Thus, the Safety Board concluded that the UP conductor's lack of sufficient rest before reporting to work, the disruption to his previous work/rest pattern that resulted from his change in work schedule, and his alcohol consumption on the evening before the accident likely combined to reduce his capacity to remain awake and alert during the accident trip.

The National Transportation Safety Board therefore makes the following safety recommendation to the Brotherhood of Locomotive Engineers and Trainmen and the United Transportation Union:

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[6] M. Rosekind, *et al.*, in National Transportation Safety Board consulting report "Analysis of Crew Fatigue Factors in AIA Guantanamo Bay Aviation Accident," pp. 3-4, referenced in National Transportation Safety Board, *Uncontrolled Collision with Terrain, American International Airways Flight 808, Douglas DC-8-61 N814CK, U.S. Naval Air Station Guantanamo Bay, Cuba, August 18, 1993*, Aviation Accident Report NTSB/AAR-94/04 (Washington, DC: NTSB, 1994).

[7] D. Canfield, T. Kupiec, and E. Huffine, "Postmortem Alcohol Production in Fatal Aircraft Accidents," *Journal of Forensic Sciences* July (1993): 914-917. Also D. and V. DiMaio, *Forensic Pathology* (Boca Raton, FL: CRC Press, 1993) 446-450.

[8] T. Roehrs and T. Roth, "Sleep, Sleepiness, and Alcohol Use," *Alcohol Research and Health* Vol. 25, No. 2 (2001): 101-109.

> Use this accident as a fatigue case study to illustrate the responsibility of the carrier to provide an employee the opportunity for adequate sleep and the responsibility of the employee to acquire sleep sufficient to work at a safe level of alertness, and the options available if adequate sleep is not obtained. Present this case study to your members at meetings, through written materials, and other appropriate methods. (R-06-17)

The Safety Board also issued safety recommendations to the Federal Railroad Administration and the Union Pacific Railroad. The Board also reiterated previously issued safety recommendations to the Federal Railroad Administration. In addition, the Board reclassified safety recommendations to the Federal Railroad Administration.

In your response to the recommendation in this letter, please refer to Safety Recommendation R-06-17. If you need additional information, you may call (202) 314-6177.

Acting Chairman ROSENKER and Members HERSMAN and HIGGINS concurred in this recommendation.

[Original Signed]
By: Mark V. Rosenker
Acting Chairman

Statement by Congressman Jerry F. Costello
Committee on Transportation and Infrastructure
Subcommittee on Railroads
Hearing on Human Factors Issues in Rail Safety
July 25, 2006

Thank you, Mr. Chairman, for calling this important hearing on human aspects related to rail safety. I would like to welcome today's witnesses.

Our economy, supported by businesses and its workers, continues to run twenty-four hours a day, seven days a week. We see this quite often as the rail industry is a round-the-clock business. Railroads support businesses that depend upon the timely shipment of goods and materials across the nation. Unfortunately, this results in irregular hours of work and long shifts, often with little notice.

The Federal government has recognized that disregarding adequate rest can and will result in serious injuries, including death, and major property damage. As such, railroad workers are subject to hours-of-service standards which are specifically laid out in statute rather than adjusted by administrative regulation. These statutory standards set the maximum time employees may be on duty without relief, and the minimum time employees must be off duty between assignments.

I am interested in hearing from our witnesses what proactive plans industry has embarked on to improve rail safety. It has been my experience that proactive safety plans by industry with enforcement from FRA through oversight and inspections are an effective approach for encouraging a culture of safety and for identifying safety problems before they result in an accident. Further, I am interested in hearing from FRA to see what, if any, new requirements they are working on to improve human aspects in rail safety.

I look forward to the testimony of today's witnesses and learning more about these improvements and programs.

STATEMENT OF

EDWARD R. HAMBERGER

PRESIDENT & CHIEF EXECUTIVE OFFICER

ASSOCIATION OF AMERICAN RAILROADS

BEFORE THE

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

SUBCOMMITTEE ON RAILROADS

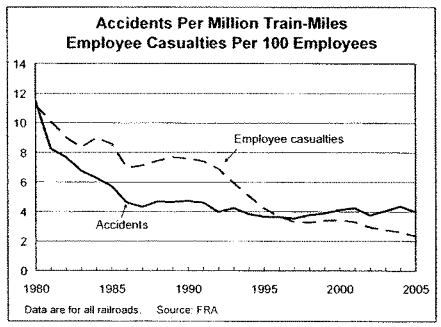
HEARING ON FATIGUE AND THE HOURS OF SERVICE ACT

JULY 25, 2006

Introduction

On behalf of the members of the Association of American Railroads (AAR), thank you for the opportunity to discuss issues surrounding rail safety, the Hours of Service Act, and fatigue in the rail industry. AAR members account for the vast majority of freight railroad mileage, employees, and traffic in Canada, Mexico, and the United States.

The overall railroad industry safety record is excellent, reflecting the extraordinary importance railroads place on safety. Since 1980, railroads reduced their overall train accident rate by 65 percent and their rate of employee casualties by 79 percent. In 2005, in fact, the employee casualty rate was the lowest in history. Railroads have lower employee injury rates than other modes of transportation and most other major industry groups, including agriculture, construction, manufacturing, and private industry as a whole. U.S. railroads also have employee injury rates well below those of most major European railroads. And when they do happen, railroad injuries are no more severe than injuries in U.S. industry as a whole.



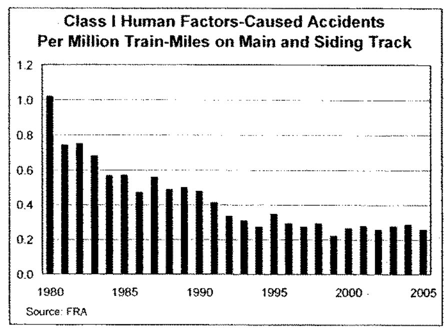
Railroads are also far safer than trucks. Rail freight transportation incurs less than one-fifth the fatalities that intercity motor carriers do per billion ton-miles of freight moved.

Background on Rail Accidents Caused by Human Factors

According to Federal Railroad Administration (FRA) data, human factors (*i.e.*, human errors) constitute the largest category of train accidents, accounting for 38 percent of all train accidents from 2001 to 2005.

Given the extent and complexity of rail operations — the railroad "factory floor" is outdoors and more than 140,000 miles long — the potential for rail accidents always exists. And while railroads respect and applaud the professionalism and attention to safety that rail employees bring every day to their jobs, people may sometimes make mistakes.

Over the past decade, the rate of rail accidents caused by human factors has stayed relatively constant, and in 2005 was 53 percent lower than it was in 1980. In addition, many human factor-caused accidents are low-speed yard accidents, which incur substantially lower damage and casualties. The rate of human factors-caused accidents involving freight trains on main and siding track in 2005 was 75 percent below its 1980 level and 46 percent below its level in 1990. Because of the more standardized work environment in yards and terminals, fatigue issues come into play most predominantly on mainline, long-distance trains. However, safety data indicate that the human factors-related accident rate (which include accidents caused by fatigue) on main lines has greatly improved.



Nevertheless, railroads agree that they, rail labor, and the FRA must continue to try to reduce the frequency of accidents caused by human factors.

Background on the Hours of Service Act

As members of this committee know, the on-duty time of rail employees involved in operating, dispatching, and signaling trains is governed by statute — specifically, the Hours of Service Act (HSA), now codified as 49 U.S.C. 21101-21108.

Under the HSA, rail employees that operate trains (*i.e.*, conductors and engineers) must go off duty after 12 consecutive hours on the job, and then must have at least 10 consecutive hours off duty. If they go off duty after less than 12 hours on the job, they must have at least 8 consecutive hours off duty. On-duty time starts the minute the employee reports for duty and includes any work that involves engaging in the movement of a train and deadhead transportation to a duty assignment. Off-duty time starts when the employee is released from duty, generally at a designated terminal or place of lodging. For dispatchers, a workday is limited to nine hours in a 24-hour period where two shifts are used, or 12 hours over the same period when there is only one shift. Finally, signal employees can work a maximum of 12 consecutive hours on duty, followed by at least 10 consecutive hours off duty.

Railroads must keep detailed records specifying when each covered employee is on duty or off duty. Violations of the HSA can result in fines of between $500 and $10,000 per violation, with each employee considered a separate violation.

To comply with the HSA and still operate as a highly-competitive 24-hours per day, 7-days per week industry, freight railroads try to schedule crew assignments with as much precision as possible. Unfortunately, the nature of rail operations makes precision extremely difficult to achieve.

Most people are familiar with passenger modes of transportation, and that familiarity at times slants our thinking about how freight railroads do and should operate. A single flight crew, for example, will typically fly a plane from, say, Los Angeles to Washington. Occasionally, weather or other problems might impact airline schedules, but by and large passenger airlines are able to offer predictable, regularly-scheduled service.

Generally speaking, freight railroads are quite different. Unlike airlines, freight railroading requires multiple crew changes to move commodities across the country. Railroads must use multiple local and yard assignments to gather freight at the beginning of its trip, then use multiple crews to move it across the country, and then use more local crews to deliver the freight to its final destination.

Where appropriate and practicable, train scheduling is being implemented and can have positive impacts on fatigue. However, because of the nature of some rail systems, trains in many cases cannot run on a precise schedule.

There are numerous reasons for this. For example, railroads are a derived demand industry: they move traffic that is tendered to them, and the volume of traffic tendered is influenced by a huge variety of factors — *e.g.*, the state of the general economy, customer operating and delivery cycles, conditions in specific industries, and the time of year. These factors mean that the volume of rail traffic on the U.S. rail network on one day of the year can vary by tens of thousands of carloads and intermodal units compared to another day.

These variances are driven by myriad external market forces over which railroads have no control, such as the arrival (and severity) of summer weather (and increased demand for coal to fuel power plants); the size and timing of grain and other agricultural harvests; the approach of Christmas season when retailers are stocking their inventories; factory ramp-ups and temporary shutdowns; ocean vessel arrivals and departures; the status of export markets for coal, grain, and other products; and even interest rates, which affect sales volumes of automobiles and home building material, among many other things.

These variances mean that a different number of trains must be operated from one time period to the next, which in turn impacts the number of crews needed.

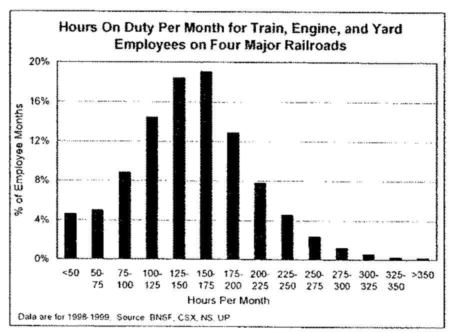
In addition to carload variances, weather conditions, track maintenance, accidents, track congestion, and dozens of other events or circumstances can delay a particular train's progress, thus impacting the time that crews down the line will be needed. For example, when a motor vehicle goes around crossing gates and is hit by a train, not only does that train stop for several hours, but all trains behind it are delayed as well. Crews at the next terminal are unexpectedly delayed in terms of when they go to work.

Thus, there is considerable volatility in railroad crew needs on a daily, weekly, and monthly basis. Indeed, there is probably no other industry with scheduling volatility as pronounced as freight railroading.

Additionally, the existing hours-of-service regime is embedded in many existing collective bargaining agreements, including provisions on crew calling and pay scales.

Crew calling is the procedure by which engineers and conductors are required to be available for duty and are called to report for duty. Railroads try to provide employees as much advance notification as is practical, but, again, the nature of rail operations and the fact that most rail operating employees bid into a seniority-based pool system from which they are drawn in a complex rotating order makes precise scheduling impossible to achieve. This pool system is part of the collective bargaining agreement between rail management and rail labor.

Some have pointed out that a rail employee could work 432 hours per month and still be in compliance with the HSA. Theoretically, that's true, but there is a huge difference between theory and practice, and in fact we know of no cases where this has occurred. As the chart on the right shows, the overwhelming majority of railroad train, engine, and yard employees are on duty each month for periods comparable to most other U.S. workers. Some 83 percent of these rail workers are on duty less than 200 hours per month, more than 95 percent are on duty



less than 250 hours per month, and more than 99 percent are on duty less than 300 hours per month.[1]

Of course, on duty time does not equate to time actually operating a train, which is typically much less. For example, under the statute and FRA interpretations, "on duty" time can include activities such as attending a safety briefing after leaving a train, being transported to and from trains, and making computer entries. Time spent on these activities is treated the same way as time spent running a train.

Railroads believe that a recent study of crews operating in the busy Western coal fields in 2004-2005 reveals what rail employees typically face in terms of hours worked. The study of more than 11,000 crew starts by 150 employees during a 10-month period found that the average time on duty was 9.5 hours with an average of 25 hours off duty between trips.

Fatigue in the Rail Industry

It is clearly not in the best interest of railroads to have employees who are too tired to perform their duties properly. That's why railroads have long partnered with their employees to gain a better understanding of fatigue-related issues and find effective, innovative solutions to fatigue-related problems. However, because factors that can result in fatigue are multiple, complex and frequently intertwined, there is no single solution.

Scientific research to date suggests that flexibility to tailor fatigue management efforts to address local circumstances is key to the success of these programs. Significant variations associated with local operations (*e.g.*, types of trains, traffic balance, and geography), local labor agreements, and other factors require customized measures. Consequently, a one-size-

[1] The data referenced in this paragraph cover 1998-1999. Recent analysis reveals that the average hours worked per year for train and engine employees have increased only slightly between 1998-1999 and 2005. Thus, the relationships noted above are believed to be valid today.

fits-all government approach is unlikely to succeed as well as cooperative efforts tailored to individual railroads.

Railroads recognize that combating fatigue is a shared responsibility. Employers need to provide an environment that allows the employee to obtain necessary rest during off-duty hours, and employees must set aside time when off duty to obtain the rest they need.

Since 1992, the AAR, the Brotherhood of Locomotive Engineers, and the United Transportation Union have addressed fatigue through the Work/Rest Task Force. The Task Force members share information about fatigue countermeasures. Periodically, the Task Force publishes a compendium of railroad initiatives. A revised compendium is currently being prepared.

Different railroads employ different fatigue countermeasures, or the same countermeasures in different ways, based on what they've found to be most effective. A list of countermeasures — at least some of which can be found on every major railroad — includes:

- Increasing the *minimum number of hours of rest* at both home and away from home terminals.
- Implementing a *morning return* to work time if off work over 72 hours.
- Evaluation of a system to *identify relative levels of fatigue* in different locations using a work schedule model.
- Evaluation and adoption of a sophisticated *fatigue modeling computer program* that allows users to vary shift lengths, duration of off-duty time, and the like to determine which set of variables is likely to induce the least amount of fatigue at a particular location. Employees and their labor representatives at several locations have been given a copy of the model and training in its use in order to test prospective countermeasures from the perspective of fatigue and lifestyle.
- Fatigue identification and avoidance *training information* for employees and families.
- Permitting *napping* by train crew members under limited circumstances (*e.g.*, when a train is expected to remain motionless for a minimum period of time)
- *Sleep disorder screening.* Recognizing that some employees with sleep disorders may be reluctant to come forward for treatment for fear of their livelihood, in 2005 railroads and labor produced and circulated a statement

saying that a sleep disorder will be addressed no differently than any other medical condition that might affect job performance — namely, individual evaluation by medical professionals for diagnosis and treatment.

- *Improved standards* for lodging at away-from-home facilities that provide black out curtains, white noise, and increased sound proofing.
- Railroads have devised a number of systems, including web sites and automated telephone systems, to *improve communication* between crew callers and employees. Union Pacific, for example, has developed a customized notification process allowing employees to specify how (cell phone, text message, e-mail) they want to be notified. They can also specify "when" to be notified — *i.e.*, when the number of employees "ahead" of them drops to a level that the employee specifies.

Railroads and unions have agreed in some cases to additional scheduling tools where such tools are feasible and will provide for an improved opportunity for rest. They include:

- Enhanced emphasis on *returning crews home* rather than lodging them away from home. Canadian National, for example, uses this practice for many of its road train crews.
- Providing more predictable *calling windows* and rest opportunities between shifts. For example, a significant number of Norfolk Southern crews know within a narrow window when their next assignment will begin.
- Providing for a *set number of days off* after being available for a given number of days. For example, at some 200 crew locations covering thousands of employees, BNSF has implemented a scheduling policy that provides three set days off after seven days of work. These provisions required local union agreements at the various locations and were implemented with union agreement and participation.
- Allowing employees to request an *extra rest period* when they report off duty.

In addition, all AAR member railroads offer fatigue education programs for employees and their families, including individualized coaching to assist employees in improving their sleep habits.

The importance of education in this area cannot be overstated, since the value of fatigue-related initiatives is highly dependent upon the actions of employees while off duty. The most important time frame that affects fatigue on the job are the hours prior to going on duty. Employees must make proper choices regarding how they utilize their off-duty time, and education of the entire family is important in encouraging sound decision making.

An educational web site designed solely for railroads and rail employees is under development by the Class I railroads in partnership with the American Short Line and Regional Railroad Association and the American Public Transportation Association. The site is scheduled to go on line later this year. The purpose of this tool is to provide general information to employees about alertness and to identify possible sleep disorders. The site will include a self-assessment tool and an explanatory letter about sleep disorders that employees can take to their physicians.

Another part of the web site will include existing educational programs (videos, pamphlets, etc.) that subscribers can exchange. An expert scientific panel has been formed to review content. The panel includes:

- Dr. Greg Belenky, Director of the Sleep and Performance Research Center at Washington State University Spokane.
- Dr. Simon Folkard, Emeritus Professor, Department of Psychology, University of Wales Swansea
- Dr. Stephen Popkin, Division Chief, Operator Performance and Human Safety Analysis, Volpe National Transportation Systems Center

The FRA also is addressing work/rest issues. For example, it is attempting to develop a fatigue model that could be used to improve crew scheduling. Railroads are cooperating in this project by supplying work-schedule data for their employees. If successful, the model might be used to improve scheduling practices based on aggregate data. The FRA is also investigating, with railroad cooperation, the use of wristwatch-like devices known as "actigraphs" to help measure the effect of schedules and educational efforts on sleep patterns.

It is important to remember that there is no single solution to the issue of fatigue. It must be, and is being, attacked on multiple fronts. Railroads agree with the NTSB that it is a

"...shared responsibility of the carrier to provide an employee the opportunity for adequate sleep and of the employee to acquire sleep sufficient to work at a safe level of alertness..."

What Should (and Should Not) Be Done

As detailed above, railroads are heavily involved in efforts to better understand and combat fatigue in the workplace, and have made many advances within the current framework of the HSA. They favor continued research on the subject and will continue to work with rail labor to find and implement new ways to combat fatigue. However, railroads urge extreme caution in amending the HSA.

New fatigue-related regulatory or statutory mandates are inappropriate because workplace fatigue issues are ill-suited to resolution in this way for a variety of reasons.

First, a single set of mandates cannot take into account the widely varying circumstances found on individual railroads. For example, operating characteristics vary widely between freight, intercity passenger, and commuter railroads, and within railroads in each of these categories.

Second, collectively-bargained labor agreements must be taken into account when addressing fatigue. Labor agreements commonly include provisions governing seniority, income, methods of calling crews to duty, and other matters that impact how often particular employees work. These agreements differ from one locale to another.

Moreover, rail operating crew pay scales typically reflect pay premiums for work beyond specified thresholds. This is why rail unions have traditionally resisted modifications to the HSA which would limit the freedom of their members, if they so choose, to maximize hours worked (within the limits of the HSA) and thereby maximize earnings.

The conflict between collectively-bargained agreements and government regulation is exemplified by the case of railroad signal employees, who install and maintain signal systems that direct the movement of trains. To enable signal employees to finish their work at far-away sites without having to commute multiple times, railroads and signal employees historically have agreed to work schedules of eight consecutive work days (ten hours each day, not including extended work days in emergency situations) followed by six consecutive days off. Although these work schedules are permitted under the HSA and would result in much less total off-duty travel time for employees working a substantial distance from home, they are not permitted by Federal Motor Carrier Safety Administration (FMCSA) hours-of-service regulations, which apply to the many railroad signal employees who drive commercial vehicles to perform their duties.

For several years, railroads and rail labor (through the Brotherhood of Railroad Signalmen) have petitioned FMCSA to allow the Congressionally-imposed requirements of the HSA to take precedence over FMCSA's hours of service requirements. To date, FMCSA has refused. Railroads respectively urge members of this committee to encourage FMCSA to accede to this reasonable request.[2]

Third, regulations could stifle needed innovation. Rail labor and management are constantly gaining knowledge in the area of fatigue, especially practical experience from projects they have begun. Flexibility is needed to facilitate new projects and changes in existing ones, but regulations could "lock in" procedures and preclude innovations.

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[2] I testified on this issue to this committee on June 22, 2000. On August 21, 2001, Chairman Don Young, Chairman Jack Quinn, and Ranking Democratic Member Bob Clement wrote to Secretary Mineta asking him to require that the FMCSA's hours of service requirements not apply to railroad signal employees.

Fourth, nonproductive work/rest rules could impair the railroads' ability to provide efficient, cost-effective service to their customers. Unproductive regulations could hinder rail service without improving safety.

Train Control Technology

Technology has long played a critical role in improving rail safety. Moving forward, railroads are looking to technological advances to reduce the incidence of human-factors caused accidents, including accidents caused by fatigue.

For example, several major railroads are now developing and testing train control systems that can prevent accidents by automatically stopping or slowing trains before they encounter a dangerous situation. Through predictive enforcement, train control technologies, in certain circumstances, could significantly reduce the incidence of train accidents caused by human error, especially train collisions and derailments due to excessive speed.

Train control systems are extremely complex. At a minimum, they must include reliable technology to inform dispatchers and operators of a train's precise location; a means to warn operators of actual or potential problems (*e.g.*, excessive speed); and a means to take action, if necessary, independent of the train operator (*e.g.*, stop a train before it reaches the physical limits of its operating authority). Some systems will also include additional features, such as expanding the ability to monitor the position of hand-operated switches. Perhaps the most critical element is sophisticated software capable of accommodating all of the variables associated with rail operations. When successfully implemented, these enhanced train control capabilities will enable trains to operate more safely than trains operate today.

Several major railroads are engaged in various projects to test elements of this new technology. For example, BNSF has done extensive and successful pilot testing in Illinois and has received approval from the FRA to expand its version of train control (Electronic Train

Management System – ETMS) on a second rail corridor between Texas and Kansas. The railroad is awaiting final approval from the FRA on the technology in order to implement it on lines throughout its system.

Additionally, there are train control projects in progress on other railroads which promise to provide similar or further enhanced functionality and safety benefits. These include CSX's Communications-Based Train Management (CBTM) system, Norfolk Southern's Optimized Train Control (OTC) system, and Union Pacific's Communications-Based Train Control (CBTC) system.

Implementing train control technology will require significant capital investments in wireless networks; sophisticated location determination systems; highly reliable software; and digital processors on board locomotives, in dispatching offices and, for some systems, along tracks. The major railroads that intend to install train control systems will use any related productivity gains to help offset their cost, thereby accelerating implementation.

Conclusion

Railroads' commitment to safety is absolute. Indeed, through massive investments in safety-enhancing infrastructure and technology; employee training; cooperative efforts with labor, suppliers, customers, communities, and the FRA; cutting-edge research and development; and steadfast commitment to applicable laws and regulations, railroads are at the forefront of advancing safety.

Combating fatigue is a shared responsibility. Railroads recognize that they must ensure that employees have sufficient opportunity to rest. For their part, employees are responsible for using a sufficient amount of the time made available to them for rest. No legislative, regulatory, or corporate measure can make employees devote their time to any particular activity.

Railroads and their employees are best able to design tailored fatigue countermeasures to match particular situations. Blanket statutory or regulatory requirements under the guise of fatigue management could undercut the cooperative efforts of rail labor and management by eliminating the flexibility necessary to test and implement custom-tailored, effective fatigue management programs.

August 25, 2006

CAWG Rebuttal

Dear Mr. Chairman:

At the July 25 rail safety hearing, FRA Administrator Joe Boardman announced the publication of a report on main track collisions by the Collision Analysis Working Group (CAWG). The report "analyzes" collisions and makes recommendations. AAR participated in CAWG discussions, but refused to endorse the report because it is fundamentally flawed. In numerous instances, it reaches conclusions or engages in speculation without having a factual basis for support. The CAWG report does the public a disservice by recommending or suggesting policy without having the evidence to support its assertions.

In making such observations, AAR has no intention of demeaning the work of the members of CAWG. Through no fault of the their own, the CAWG effort was doomed from the start because of the failure to include experts to undertake the analysis of the subjects studied and the selection of a very small number of accidents for analysis (and the exclusion of other accidents with apparently similar causes).

Last year, AAR informed FRA of its concerns over statements in the report unsupported by data and an incomplete discussion of relevant issues. While some changes were made as a result, there still are significant problems with the report. Since FRA referred to the report in its July 25 testimony, we want to ensure the hearing record reflects the industry's concerns. To illustrate, a few of the industry's concerns are set forth below.

One of the principal topics in the CAWG report concerns "crew composition and experience." The CAWG "final report" dated June 8, 2005, purported to show that Amtrak has a substantially higher collision rate than other railroads and speculated that crew size could be a factor in causing Amtrak to have a higher rate since Amtrak uses one-person engine crews on approximately three-quarters of its trains. After AAR, using a broader set of collisions than CAWG, showed that Amtrak's collision rate actually is slightly less than the Class I average, the CAWG report was revised to remove any statistical discussion relating to crew size. However, the revised report discusses Amtrak accidents and that Amtrak uses one-person crews on approximately ¾ of its trains, implying that one-person crews lead to collisions. The record does not support such a conclusion.

The "crew composition and experience" section of the CAWG report also concludes that "an inexperienced crew member should be paired with an experienced crew member." However, CAWG's statistical analysis of crew experience raises questions and does not state how the recommended pairing could be accomplished. Furthermore, while CAWG's analysis of crew experience purports to show that conductors with experience between 7 and 22 years are superior in terms of avoiding collisions, conductors with *more* experience, as well as less experience, had a greater frequency of involvement in the accidents studied by CAWG that involved violations of train authority.

The "alertness" section of the CAWG report is especially disappointing. The Class I railroads, in cooperation with labor, have focused on alertness issues for almost 15 years and we believe, along with much of the scientific community, that the railroad industry is one of the leaders in this area. Yet, no management experts in the area of fatigue were invited to participate in the CAWG effort. The result is a discussion of alertness that is incomplete and misleading. For example, the report defines "alertness" as "whether or not any action was taken" and then equates the failure to take action (impaired alertness) as fatigue, completely ignoring the possibility that an employee's failure to take action might be attributable to other factors such as depression, distraction, talking on a cell phone, sickness, or even engaging in a lively discussion. Having failed to consider that factors other than fatigue could cause impaired alertness, the report concludes that fatigue was a possible contributing factor in every accident in which impaired alertness was judged by CAWG to be a possible issue.

Another example of the simplistic nature of the alertness discussion is the analysis of acute sleep debt. CAWG states that "when a person has been awake more than sixteen hours since their last major sleep episode," the person has "acute sleep debt." We cannot find any contention in scientific literature that supports CAWG's contention of what constitutes "acute sleep debt." From our reading of the literature, we conclude that scientists generally believe that sleep debts result from 6 or less hours of sleep for multiple successive days.

AAR did submit an extensive rewrite of the alertness section to FRA. For reasons unknown, AAR's rewrite was not accepted.

The "operating methods" section of the CAWG report suggests that crews might be less alert in traffic control system territory than in train order territory. The June 8, 2005, report based this suggestion on the mistaken belief that train order territory necessarily involves written communication tasks that are not required in traffic control system territory. AAR pointed out that this belief is unsubstantiated, because on some railroads, the conductor in traffic control system territory is required to write down the signal aspect on a signal awareness form (also, signals are used in some train order territory). The July 2006 report omits the discussion of train order territory involving written communication tasks that are not required in traffic control system territory, but still leaves the suggestion in that alertness is more of an issue in train order territory.

Finally, CAWG did not use a statistically-sound methodology for selecting accidents for study. Even ignoring the other problems with the CAWG report, the problems with the CAWG database cast a pall on all the conclusions set forth in the report.

Once again, Mr. Chairman, I would like to thank you for the opportunity to provide AAR's views on rail safety matters.

STATEMENT OF

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BEFORE THE

U. S. HOUSE OF REPRESENTATIVES

COMMITTEE ON TRANSPORTATION & INFRASTRUCTURE

SUBCOMMITTEE ON RAILROADS

HEARING ON

HUMAN FACTOR ISSUES IN RAIL SAFETY

July 25, 2006

I appreciate your invitation to brief this Subcommittee on the current status of railroad Hours of Service regulations and the opportunities to further improve the management of employee fatigue and safety in US railroads. I have had the opportunity to witness the considerable improvements in railroad fatigue management and safety over the past 30 years, both as the Chairman and CEO of Circadian Technologies, Inc. ("CIRCADIAN"), www.circadian.com, a research and consultancy firm which has extensive experience in developing and implementing fatigue management programs for railroads and other round-the-clock industries, and as a professor of physiology at Harvard Medical School where I led the initial research programs which identified the biological clocks that control human cycles of alertness and sleep.

We all applaud the 50% reduction in human factor-caused accidents per million train miles since 1980, but also need to be sobered by the realization that this human error rate has remained essentially at a fixed plateau since 1985. Freight trains move more freight further and faster than ever before, and with ever increasing efficiency and automation. Since 1990 the number of trillion ton miles of freight moved on US railroads has increased by 56% while freight railroad employment has decreased by 25%. Each employee now moves more than double the ton miles of freight each year than they did in 1990, so the need for sustained employee attention and alertness while operating trains and maintaining track must be a paramount objective.

The freight railroads were early adopters of the science of fatigue management and have emphasized to a greater extent than perhaps any other industry the goal of assuring human alertness around-the-clock in their 24/7 operations. This is not a casual observation since CIRCADIAN has worked in virtually every 24/7 industry on all seven continents of the globe, and based on this experience, the US railroads stand out in their clearly stated commitment to fatigue management.

Specifically CIRCADIAN, and other fatigue management consultants and researchers, have collaborated with many of the major railroads including Amtrak, BNSF, Union Pacific, CSX, Conrail, Canadian National, and Canadian Pacific as well as the unions, including the Brotherhood of Locomotive Engineers and the United Transportation Union.

Together we have developed, implemented and scientifically evaluated a wide variety of fatigue countermeasure strategies.

So the question must be asked: Why have railroad human factor-caused accidents remained at a plateau despite the continued emphasis on fatigue management? Two possibilities can be quickly ruled out. Firstly, it is not because fatigue no longer exists. As any confidential survey of railroad employees will tell you, sleep disruption and fatigue continues to be a major concern of railroad employees. Secondly, it is not because fatigue no longer causes accidents. Despite advances in automation, fatigue-induced lapses in attention and cognitive behavior remain a significant cause of railroad accidents and injuries.

The answer instead, in my opinion, is that fatigue management to date has been more a process of measuring inputs rather than outputs. Fatigue education programs have been delivered, sleep disorder screening initiated, napping and other policies implemented, and various changes in work schedules proposed and tested. A large number of these efforts have been widely reported, and some research on their benefits has been published. However the relationship between these fatigue management initiatives (inputs) and bottom-line objective measures of effectiveness -- such as human factor-caused accidents per million train miles (outputs) has not yet been assessed or demonstrated.

At the core of the problem is the structure of the Hours of Service laws which date way back into fatigue management pre-history. As I will discuss, there is abundant evidence that the railroad Hours of Service laws which were put into place in 1908, almost 100 years ago, offer little hope for preventing fatigue, and furthermore they unduly restrict the business operations of the railroads and negatively impact the lives of rail employees. But most importantly the HoS emphasis on compliance with a set of prescriptive rules keeps the railroad industry in an outdated paradigm.

In contrast, I believe there is much more promise in a **Fatigue Risk-Informed Performance-Based Safety** management approach as a creative and effective tool for addressing this vital safety issue. The principle is that if railroads measure and monitor the specific risks, then government regulators can require the operators of the regulated industries to focus their attention and creative energy on ways to reduce those specific risks, without prescribing cumbersome rules on the exact interventions by which the safety goal should be met.

The evolution of Risk-Informed, Performance-Based safety management

Recent years have seen the evolution of a new regulatory paradigm which replaces deterministic rules, laws and regulations. This paradigm focuses on the measurement of risk, so that performance in meeting objective risk reduction goals can be measured and assessed. Managing by performance-based measure is a well-established method of obtaining tangible results in a business, as is removing some controls but enhancing accountability (see Hertzberg[1]). What is new is applying these concepts to government safety regulations, and allowing managers in the regulated industry the flexibility to find the solutions which achieve safety objectives within their own operations.

The Risk-Informed Performance-Based (RIPB) approach to safety management is probably most advanced in the nuclear power industry, although it has been applied to Fire Prevention[2], nuclear waste disposal[3] and the design of security and blast mitigation at Federal Buildings[4]. The Nuclear Regulatory Agency has made a significant effort to

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[1] Herzberg GF, Mausner B, Snydeman BB. The motivation to work. New York: Wiley; 1959.

[2] Federal Register. Vol. 69, No. 115, Wednesday, June 16, 2004/ Rules & Regulations "Voluntary Fire Protection Requirements for Light-Water Reactors: Adoption of NFA 805 as a Risk-Informed, Performance-Based Alternative" p. 33536.

[3] Mackin PC, Russell B, Turner DR, Ciocco, JA. Implementing risk-informed, performance-based regulations for high-level waste disposal. Paper presented at the Waste Management Symposium, Tucson, Arizona, February-March 2001. www.wmsym.org/Abstracts/2001/31B/31B-20.pdf

[4] National Research Council (U.S.) Committee to Review the Security Design Criteria of the Interagency Security Committee. ISC security design criteria for new federal office buildings and major modernization projects: a review and commentary. Washington, DC: The National Academies Press; 2003.

convert to this method of regulation and it now permeates every aspect of nuclear power safety regulation. As the Nuclear Energy Institute reports[5]:

> "In a risk-informed performance-based approach, the NRC establishes basic requirements and sets overall performance goals. The plant management then decides how to reach those goals. Risk-informed, performance based regulation is more sharply focused on safety than the current approach, because resources are applied to plant systems and equipment commensurate to their importance to safety"

For example, after working with the National Fire Protection Association (NFPA), the NRC published an NPRM and then a final rule on June 16, 2004 concerning a RIPB program for voluntary fire protection standards for nuclear power plants. This program allowed for fire protection measures that are based on a more realistic assessment of the actual fire hazard in various areas of a power plant than was assumed in the previous requirements[58].

This alternative results-driven process has now been systematically adopted by the Nuclear Regulatory Commission to regulate the myriad safety aspects of nuclear power plants, placing the responsibility on nuclear plant operators to find the most effective way to get the desired safety outcomes, rather than the NRC writing excessively complex and unmanageable prescriptive regulatory rules which are insensitive to local operating conditions or technology.

Application of Fatigue Risk-Informed Performance-Based Safety to other transportation modes

We have now five years of experience in applying the Fatigue Risk-Informed Performance-Based Safety (FRIPBS) paradigm to fatigue management in trucking

[5] Nuclear Energy Institute. Nuclear Power Plant Regulation. 2001. www.nei.org/documents/Status_Report_Regulation.pdf

operations. The results have been dramatic in reduced accident rates per million miles and reduced personal injuries per 200,000 hour worked.

The process started with the development and validation of a Circadian Alertness Simulator (CAS) model which predicts not only levels of fatigue risk (as a fatigue Risk Score) but also the rate of DOT recordable accidents.

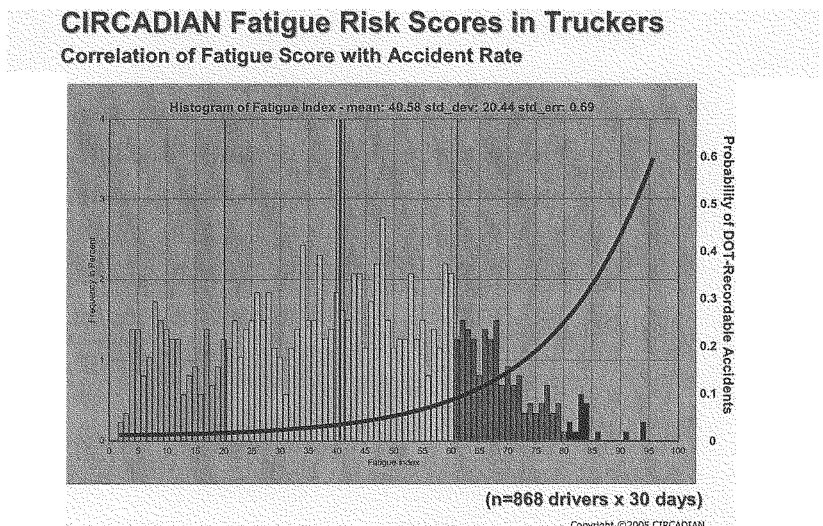

Fig 1. Each driver is assigned a fatigue-risk score between 1 (low risk) and 100 (high risk) which is calculated from his duty-rest pattern over the prior week. While the average fatigue risk score of US truck drivers is approximately 40 there is a wide frequency distribution of risk scores. The superimposed line is the probability of a DOT recordable accident per year with the risk rapidly rising as fatigue scores exceed 60-70. At a fatigue risk score of 90, for example, a driver has a 50% probability of having a DOT recordable accident in the next year.

The application of FRIPBS to truck driver fatigue management is illustrated in Figure 2. Information on the actual truck-driver Hours of Rest are continuously captured (from driver logs or in this case electronically using telematics) and entered into an Expert System for calculating Fatigue Risk in truck drivers. A "Fatigue Score" for each driver in the fleet is provided to the driver, his dispatcher and the operations and safety managers making them "Risk-Informed". Training programs are provided to these individuals to educate them in the principles of driver Flexible Sleep Management and the

"Performance-Based" standards of Fatigue score management. Based on the training and the repetitive feedback from the Fatigue Scores, the driver seeks to minimize his Fatigue Score by adopting flexible sleep management practices, and is monitored and is held accountable to these "Performance-Based" standards by his dispatchers and managers.

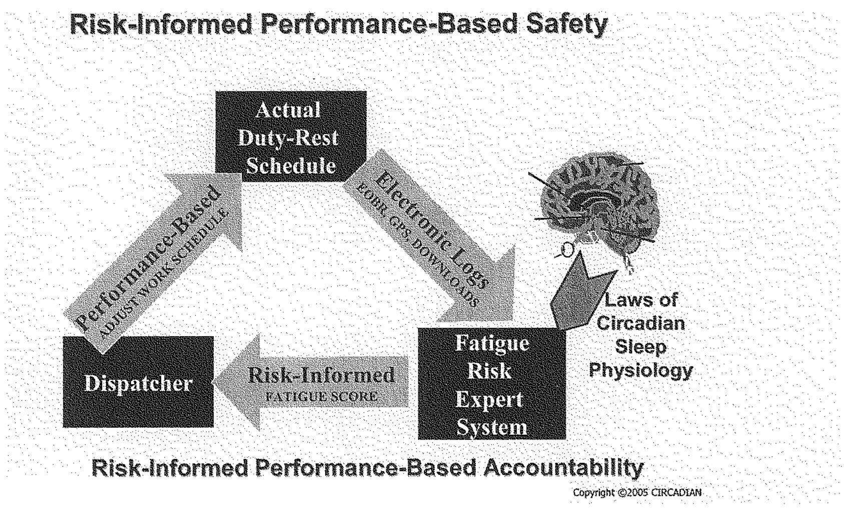

Fig 2: The feedback loop whereby the Fatigue Risk Score for each driver is calculated from his Hours of Rest pattern and provided to each driver (and his manager and dispatcher) so they are "Risk-Informed". The driver (and/or dispatcher in a scheduled operation) is then held accountable to meet a Performance-Based risk standard by adjusting his future Hours of Rest patterns which then are recalculated to track progress against meeting Fatigue Risk management objectives.

This Fatigue Risk-Informed Performance-Based Safety approach to duty-rest regulation and fatigue management enables drivers, dispatchers and managers to make safety conscious operational decisions while having sufficient flexibility to balance the specific business needs of their operation (e.g. optimization of customer service, minimization of operational costs) and therefore stay competitive in the marketplace. At the same time they have the incentive to address some of the most important causes of driver sleep deprivation, and therefore of fatigue-related highway accidents.

In addition because this FRIPBS process is automated and documented, it reduces the burden of compliance enforcement and log book inspections by the states. The focus of

FRIPBS compliance is shifted from input parameters (Hours of Service) to output parameters (Fatigue Risk Score & accident risk) which is where the true burden of safety management should lie.

Not only did the mean Fatigue Score (Fig 3) progressively decrease as the management trained the drivers and held them accountable for reducing their Fatigue Scores, but even more importantly there was a substantial left shift of the distribution of Fatigue Scores so very few drivers were operating in the highest CAS Fatigue Score zones where there is disproportionately greater risk of accidents and injuries occurring.

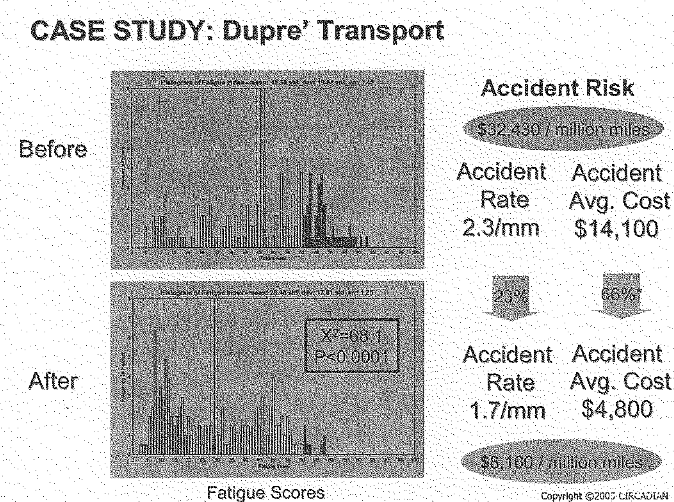

Fig. 3. Frequency distribution of CAS Fatigue Scores and accident rates and costs for drivers before (above) and after (below) the RIPB intervention where CAS Fatigue Scores were provided as feedback back to dispatchers and managers. Fatigue Score group averages are indicated by vertical lines. A significant reduction in both fatigue scores, and the frequency and severity of accidents was observed.

The reduction in CAS Fatigue scores as a result of the FRIPBS program correlated with a parallel decrease in accidents, personal injury and driver turnover in the truck drivers. Figure 4 shows the decrease in the "Big Four" accidents most likely to be associated with driver lapses of attention while on the road. These were Rollovers, Rear-End Collisions, Lane Change accidents and Intersection Accidents. The accident rate of 1.29 per million miles found in the base years (1998-2001) fell to 0.9 in 2001-2002, to 0.8 in 2002-2003 and to 0.5 in 2003 – 2004.

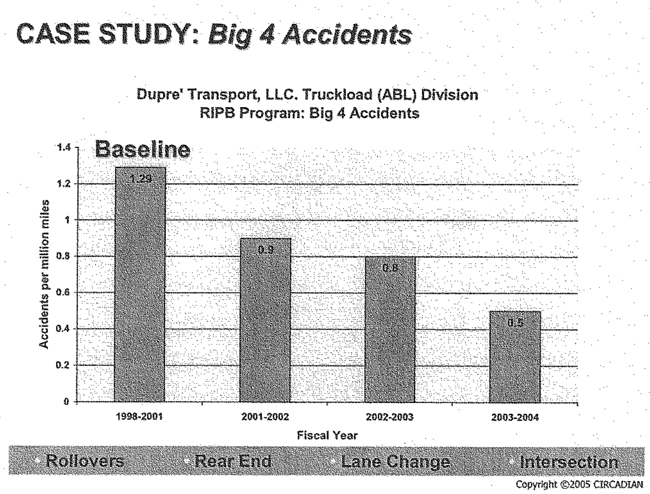

Fig 4. Comparison of the Big Four accident rate for truck drivers (Rollovers, Rear End, Lane Change, Intersection) before (three baseline years 1998-2001) and during three years of implementation (2001-2002, 2002-2003, and 2003-2004) of a FRIPBS Fatigue Management program with CAS Fatigue Score feedback to the drivers and dispatchers who were held accountable for minimizing the CAS scores.

I wish to propose that this Sub-Committee consider lending its full support and endorsement to a process which requires every railroad and their unions to jointly work towards developing, implementing and filing Fatigue Management Plans with the Federal Railroad Administration. These should demonstrate that each American rail operator is reducing fatigue risk through a process which is "Risk Informed" and "Performance Based." By "Risk Informed," I refer to the continuous objective assessment of fatigue risk across all operations; by "Performance-Based," I mean holding management and employees personally accountable for achieving measurable fatigue risk reduction.

Experience has taught us that excessive fatigue risk is manageable and preventable, but not by the traditional regulatory Hours of Service (HoS) approach. The issue of employee fatigue in transportation operations led in the early 1900's to the development of the HoS concept, which used a rudimentary "hour-glass" model of human fatigue: namely that after a certain number of consecutive hours on duty, or cumulative hours in a week, a person becomes fatigued. Over the past 30 years the science of human fatigue (sleep-wake, alertness & circadian physiology) has moved ahead rapidly, but regulatory reform has lagged behind. It is now broadly accepted that, while HoS can prevent some extreme abuses, under this "hour-glass" fatigue model of current HoS, an employee can be perfectly legal but unsafe, or illegal and perfectly safe. It is not enough to point to HoS compliance and claim that fatigue has been successfully managed.

First, HoS regulations fail to consider the well-established fact that nighttime work poses a higher risk than daytime work. Many studies have shown that the most consistent factor influencing operator alertness is time of day. Similarly, daytime sleep is not as restful as nighttime sleep so the efficiency with which off-duty time can be used for rest varies with the time of day.

Second, the total number of consecutive hours of work, or total accumulated hours of work in a week do not have a simple relationship with fatigue risk, except in extreme circumstances. For example while a person who works more than 60 hours a week may in certain circumstances become sleepy and risk falling asleep at the controls, at other times of the same day he would have very little likelihood of falling asleep. Similarly a person only working 10 or 20 hours a week, depending on what time of day he is at the controls, may be just as much as risk for fatigue as the person who worked more than 60 hours a week. Indeed one of the most common scenarios for fatigue-related accidents is the first few hours on night duty after a vacation or weekend off-duty, which should be a time of lowest risk according to the hour-glass HoS fatigue model. Yet, this time of enhanced risk is clearly predicted by fatigue risk models based on current science.

Third, the HoS does little to address the problem of unpredictable work. The flow of freight trains across a railroad system fluctuates from hour to hour, because of weather, mechanical failures, and track damage or repairs. Duty rest schedules are therefore hard to predict on a day-to-day basis, especially when labor agreements also allow other crewmembers to book off-duty, and hence accelerate the sequence of call to duty. The quality of sleep is significantly reduced during on-call situations where there is anticipation that sleep may be disrupted.

Finally, HoS regulations typically encourage operators to adopt work/rest schedules that are shorter than 24 hours. For train crews, for example, the most "productive" work/rest schedule is a duty–rest cycle consisting of successive periods of 11 ¾ hours running a train followed by the minimal 8 hours rest period, resulting in 20-hour work-rest cycles. This results in disruption of circadian rhythms, encourages employees to work when they are tired, and often obliges them to rest when they are not. Moreover, the direction of the rotation will be "backwards" since the cycle is shorter than the natural 24-hour day. There is extensive scientific data demonstrating that backward rotations are more fatiguing than forward rotations.

Building more complex prescriptive HoS regulations that take these physiological safety factors into account is not the answer. The regulations would have to be so complex as to be unmanageable due to the multiple factors that must be taken into account. It would severely impact the competitiveness and business operations of the railroad industry and potentially negatively influence the lives and earnings of the unionized crafts.

The method of choice to immediately and effectively address the issue of railroad employee fatigue, which I propose that this committee actively encourage and endorse, is a process of Risk-Informed Performance-Based Fatigue Management.

Significant advances have been made in the development and validation of effective fatigue countermeasures in railroad operations in the past 10 years. Railroads, more than any other transportation mode, have expended considerable resources to advance the science of fatigue management. These include the development of training programs, work-rest scheduling systems and crew scheduling software, napping policies and sleep disorder screening programs, each of which in scientific studies has been shown to reduce fatigue.

However, the full benefits from this fatigue research have not yet been obtained because the application of these fatigue countermeasures across the railroad industry has to date been limited and inconsistent. Furthermore adequate measures have not been implemented for documenting results and effectiveness on an ongoing basis, or for holding managers accountable.

There is now an opportunity to make substantial gains in transportation safety, but the achievement of this will not be without its challenges. 175 years of railroading tradition, and a complex thicket of regulations and collective bargaining agreements can sometimes make progress difficult. However, I know all parties view fatigue reduction and rail safety as important, so there is support for the overall goal.

This Subcommittee can do much to stimulate and motivate this process. I would propose that the House Railroad Subcommittee encourage railroad companies, and the railroad labor unions, to make the development of a formal process for Risk-Informed Performance–Based Fatigue Management a priority. An overall strategy should be developed that is sensitive to all stakeholders that could form a framework for future reform of rail safety legislation. A timetable for reporting back progress to this subcommittee might be helpful in ensuring that addressing this key railroad safety issue is maintained as a priority.

In summary, I have today discussed how sleep deprivation and fatigue significantly impairs train crew alertness and vigilance in our railroads, and that this loss of vigilance poses a safety threat. Moreover, FRA safety statistics suggest that the human factor-caused accident rate has plateaued over the past 20 years, and such a status quo is not acceptable. However, making the Hours of Service regulations more restrictive is clearly not the best answer to fixing the problem. Faced with today's challenges, a Fatigue Risk-Informed Performance-Based Safety management approach is best positioned to provide measurable benefits in a timely and efficient manner. I appreciate the opportunity today to share my thoughts and suggestions with this Sub-Committee, and I would be delighted to answer any questions.

STATEMENT OF
THE HONORABLE JAMES L. OBERSTAR
SUBCOMMITTEE ON RAILROADS
HEARING ON
"HUMAN FACTORS IN RAIL SAFETY"
JULY 25, 2006

Three weeks ago, the National Transportation Safety Board (NTSB) released an accident report of a collision involving a Union Pacific (UP) freight train and a Burlington Northern Santa Fe (BNSF) freight train in Macdona, Texas in June 2004. The collision derailed four locomotive units, the first 19 cars of the UP train and 17 cars of the BNSF train. As a result, a pressure tank car loaded with liquefied chlorine was punctured. The chlorine vaporized into a cloud of chlorine gas that engulfed the accident area to a radius of at least 700 feet. Three persons, including the conductor of the Union Pacific train and two local residents, died from chlorine gas inhalation.

The NTSB determined that the probable cause of the collision was fatigue that resulted in the failure of the Union Pacific train engineer and conductor to appropriately respond to wayside signals governing the movement of their train. Contributing to the crewmembers' fatigue was their failure to obtain sufficient restorative rest prior to reporting for duty because of their ineffective use of off-duty time and Union Pacific's train crew scheduling practices, which inverted the crewmembers' work/rest periods (Union Pacific changed the workers' previous work/rest schedule and this resulted in fatigue).

Fatigue is a serious issue. It is the silent killer that works its way into every action that an engineer or conductor takes. It weakens all your senses, all of your reaction times, and all of your ability to function at the highest level.

In 1999, the NTSB conducted an evaluation of the U.S. Department of Transportation's efforts to address operator fatigue. The NTSB found that while a commercial pilot may fly no more than 100 hours a month, a truck driver may be on duty no more than 260 hours a month, and certain licensed vessel operators may operate up to 360 hours a month when at sea, locomotive engineers and conductors may – and often do – work up to 432 hours a month.

The NTSB also found that although generally accepted as a factor in transportation accidents, the exact number of accidents due to fatigue is difficult to determine and likely to be underestimated. Fatigue never shows up in an autopsy. In most instances, one or more indirect or circumstantial pieces of evidence are used to make the case that fatigue was a factor in the accidents. This evidence includes witness statements, hours worked and slept in the previous few days, the time at which the accident occurred, and the regularity or irregularity of the operator's schedule.

I remember working the "graveyard shift" in the iron ore mines when I was in college. At 2:00 in the morning one night, I was sampling ore on top of a railroad car full of iron ore. It was raining, I was tired, and a chunk of ore slid out from under my foot, and I fell 15 feet from the top of the ore car, landed between two tracks, and missed a tie by inches. If I had been killed by hitting my head on that tie, nobody would have known that I was tired that night. Fatigue would have claimed another victim, and left no fingerprints.

Despite widespread agreement that the railroad hours-of-service law is antiquated and in need of updating, Congress has not reached agreement on Capitol Hill to change the hours-of-service statute. I ask this Subcommittee: How many more men and women will have to die before we take action?

The Railroad Hours of Service Act was enacted in 1907, and substantially amended in 1969 – almost 30 years ago. The law says that railroad workers can work 12 hours on and eight hours off, for a total of 20 hours. That means that an employee who begins a shift on Monday at 8:00 a.m. can be called for a shift on Tuesday at 4:00 a.m., and a shift on Wednesday at midnight. This kind of "backward-rotating shift" can wreak havoc on an employee's circadian rhythm.

A second key problem is that the eight hours of rest that are typically allotted to employees are simply not enough. By the time the employees drive home, shower, dress, and eat – not to mention actually talking to other members of their family – they typically have more like five or six hours of real rest rather than eight, and that's not enough for the demanding environment they will face when people's lives are dependent upon their alertness and the swiftness of their reactions.

I think the way to move railroad employees more in the direction of a regular 24-hour schedule is to give them more rest, so that the sum of their on-duty and off-duty time is closer to 24 hours. If employees were guaranteed enough adequate rest, they might even be able to work an on-duty shift that was a little bit longer.

We also need to make sure that the hours-of-service law is being enforced, that workers are not being intimidated into submitting false time sheets to conceal hours-of-service violations, that workers and their supervisors are being trained on how to recognize fatigue and how to mitigate it, and that workers understand what the hours-of-service law provides. That was an issue in the Graniteville, South Carolina investigation, where the NTSB found that on 10 of the 30 days prior to the accident, train crewmembers had spent time on paperwork after having been on duty for 12 hours. Any work, including paperwork, done on behalf of the railroad beyond the allotted 12 hours is considered a violation of the Hours of Service Act. The train crewmembers weren't aware of that; neither were Norfolk Southern's managers. I wonder whether train crewmembers and supervisors at other railroads are unaware of what the law provides.

Finally, I want to briefly mention how disappointed I am with the railroad industry. I recently received a letter from the carriers, stating that the negotiations between management and labor have reached an impasse. The letter went on about the terrific compensation and benefit package that management offered, and labor's unwillingness to accept it. Absent from the letter were details of the work rule and legislative changes industry wants labor to agree to; changes which could, if implemented, have an adverse impact on safety. For example, the railroads have asked labor to agree to reducing train crew sizes from two persons to one person, so the industry can save money and invest in new train control technologies, which are intended to take control of the train when a worker makes an error. I support implementation of that technology, but not at the expense of safety. Positive train control was meant to be a safety overlay – to be an additional measure of safety to the current system. It was never meant to be a substitute for a train crewmember, and should this impasse between management and labor come before this Congress, I will not support any measure that does not guarantee a high-level of safety for the workers and for the communities through which railroads operate.

Thank you, Mr. Chairman, and I yield back the balance of my time.

July 25, 2006

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON TRANSPORTATION and INFRASTRUCTURE
SUBCOMMITTEE ON RAILROADS

HEARING ON HUMAN FACTORS IN RAIL SAFETY

TESTIMONY OF W. DAN PICKETT
INTERNATIONAL PRESIDENT
BROTHERHOOD OF RAILROAD SIGNALMEN

Good Morning. Mr. Chairman and members of the Committee. It is an honor for me to testify today on human factors in rail safety, a subject of great concern to this country and to all employees of the nation's railroads.

My name is Dan Pickett, and I am the International President for the Brotherhood of Railroad Signalmen. The Brotherhood of Railroad Signalmen (BRS), a labor organization with headquarters at 917 Shenandoah Shores Road, Front Royal, Virginia, 22630-6418, submits the following comments on human factors in rail safety.

The BRS, founded in 1901, represents approximately 9,000 members working for railroads across the United States and Canada. Signalmen install, maintain and repair the signal systems that railroads utilize to direct train movements. Signalmen also install and maintain the grade crossing signal systems used at highway-railroad intersections, which play a vital role in ensuring the safety of highway travelers. Throughout our entire existence, the BRS has dedicated itself to making the railroad workplace safer, not just for rail workers, but also for the public at large.

Before beginning any discussion of the role human factors play in rail safety, it should be noted that the Brotherhood of Railroad Signalmen believes that many of the accidents and fatalities that are attributed to human factors are actually due to other factors. Approximately one-third of all accidents are attributed to human factors; one-third are attributed to track causes; and one-third fall into other categories. In their never-ending zeal to find the simplest answer available, railroads often list the cause of an accident to "human factors." However, when one looks closely at what really happened, the catch-all basket of human factors often shows that it was not human factors after all.

For example, signalmen currently work under an Hours of Service law that was first implemented in 1976. It was written as a 12-hour maximum service law during a 24-hour period, and an exception was made that in the case of an "emergency," a signal employee could work up to four additional hours in a 24-hour period. The law worked well, and for years the railroads limited signal workers to 12 hours of work in a 24-hour period. Now however, signal employees have seen the law mutate into a 16-hour law. Many railroads have policies that state that any signal problem is an "emergency" and workers are not to contact their supervisors for an interpretation. All problems are emergencies and therefore, all signal employees can work up to 16 hours in a 24-hour period.

What is the net result of this policy? Signal workers are working longer hours than ever before and many "human factor" accidents and incidents are not caused by human factors, but are actually due to fatigue from working longer hours.

This becomes an even bigger problem as you look further in-depth at the events that lead up to accidents. The inability to perform adequate testing and the failure to comply with minimum federal regulations have contributed, if not caused, many recent railroad accidents. Railroads tend to focus on the financial bottom line. As such, the railroads have allowed staffing levels to fall below the minimum necessary to perform basic safety functions. Additionally, the railroads are not through with their desire to further reduce manpower levels. BRS manpower levels have shrunk over the last decade. Railroads are not keeping up with basic attrition, let alone preparing for the barrage of retirements that are going to occur over the next 10 years. This is not the boy crying wolf - this is a reality that is going to happen, and the railroads are not adequately prepared for the enormous loss of institutional knowledge. They are making a bet which cannot be won. They are hoping to continue to reduce staffing levels, and the few new hires they make will have no knowledge of the work they will be performing.

Quite frankly, the railroads are insidious in what they are attempting to do. While they are reducing manpower levels, they are also trying to increase the use of contractors to perform signal work. Railroads reduce staffing levels to a point where the remaining signal employees cannot perform all of the required work, and then the railroads come out crying that they need to contract out more signal work. Some people may argue, incorrectly I might add, that contracting out is the solution for railroads. In reality, however, it will only cause more accidents, collisions and deaths. What the railroads do not mention when they plead that they need more contracting out is that contractors are *not* covered by the Hours of Service Act. The railroads would like nothing better than to employ less educated, less skilled employees to perform signal work because they are not covered by the Hours of Service Act, and they would be able to work unlimited hours with absolutely no restrictions. This mode of action is reprehensible at best, and borders on criminal at worst. The answer to reducing or eliminating "human factors" caused signal accidents is not to hire contractors, but to prepare for the future by hiring and properly training signal employees to ensure the safety of the traveling public.

Training and Education

Training and education is another key preventive measure that needs to be considered. Rail labor considers it equally important to provide Advanced Training to improve the skills of the professional men and women that install and maintain safety systems for the rail industry. This is an area that will improve safety. Rail labor continues to work to implement training provisions, which were agreed to by the industry – but to date have not been implemented on many of our nation's railroads.

In addition to craft-specific training, security training must be mandated. While some rail carriers might claim progress in this area, I have spoken with too many workers who are not receiving any training or might be allowed to watch a one-size-fits-all video. This is woefully inadequate. Workers need to know how to identify a security risk and what to do in that situation. When should passengers be evacuated? Who is the contact person to report a potential risk? What actions, if any, should a worker take in a given situation? How should trains, stations or tunnels be evacuated and handled in different situations? What are the appropriate and necessary communication protocols crewmembers should follow in the event of a security breach or incident? These are just a few of the many questions we know workers are asking but not receiving sufficient answers to. In addition to formal training, technology must be provided to allow train operators to alert dispatchers and management of security developments that may arise during operations.

As you know, railroads transport the most toxic and dangerous materials in the country, such as poisons, explosives, and flammable gases. The train crews are usually aware of which trains carry hazardous commodities, but that is little protection in preventing a catastrophe. Most freight trains in the United States transport some hazardous materials, yet the train crews are given very limited training in understanding what to do in case of a hazardous material leak or explosion. Basically, the instructions are to leave the scene and allow local emergency personnel to deal with the matter. However, that kind of action is totally insufficient when a terrorist attack occurs. It is too late to save lives after the train has been targeted. The risk to the public and the train crews are too extraordinary not to have knowledgeable, well trained crews to deal with safety and security.

After 9/11 each railroad was required to develop and implement security plans. The Transportation Security Administration (TSA) has apparently approved the plans of most railroads. The problem is that the plan is a secret between the railroads, the Department of Transportation (DOT) and the TSA. The employees have not been included in the loop. The bottom line is that the TSA and the railroads must promptly begin an intense training program to educate and prepare railroad employees to recognize potential terrorists and safety/security risks in the vicinity of railroad facilities, and instruct the workers on the appropriate action to take in case of an attempt to target a train. If it is not done voluntarily then Congress should mandate the necessary training.

FRA Efforts to Reduce Human Factor Accident/Incidents

Under an FRA initiative, the Brotherhood of Railroad Signalmen recently participated in a study entitled "Work Schedules and Sleep Patterns of Railroad Signalmen." The study collected two weeks of data from a random sample of actively working U.S. railroad signalmen. Two survey instruments were used in the study, a background survey and a daily log. The background survey gathered demographic information while the daily log was used to record sleep and work periods, commute times, and self-assessments of alertness. The daily log also included two separate spaces for participants to record any comments regarding their sleep and work periods each day. The study illustrated how travel to a distant work site can lead to fatigue in addition to compromising personal and sleep time. Most of the fatigue comments related to fatigue resulting from travel, unscheduled work and poor sleep. Also mentioned during the study were the difficulties of achieving meaningful sleep when sleeping away from home. A major disrupter of sleep was the unscheduled or emergency work situations that arise during the course of the night. Finally, when you add weather to the above-mentioned issues, it was apparent that survey participants frequently felt weather affected their perceived level of fatigue and the overall quality of the workday experience.

While the study was a good first effort by the FRA to identify problems that railroad signalmen face, it should not be considered the final word on this issue. The time period that was selected was the last two weeks of October. This is one of the most benign periods of the year in which weather seldom plays a factor. This time period is also one when work/production gangs have shut down and many of the problems that signal employees routinely face are not encountered. While the study produced good information showing that fatigue routinely plays a role in the work schedules and sleep patterns of railroad signalmen, the study was not a true snapshot of what railroad signalmen normally face.

Conclusion

There is little question that more must be done to reduce human factor accidents/incidents in the rail industry. It is the position of the Brotherhood of Railroad Signalmen that the rail industry, the FRA and labor must continue to explore the true root causes of accidents and stop taking the easy route of blaming the individual. Humans do make mistakes; that is indeed the essence of being human. However, when a signal employee makes a "mistake" while working at a railroad crossing, it is not always his fault. When you examine the events leading up to the "mistake," we often find that there were contributing factors that were ignored and not addressed. For example, the individual may have worked 30 or more 12-hour work days without a day off prior to the "mistake." The signal employee on the adjacent territory may have been on vacation and the employee was instructed to cover twice the amount of work prior to his "mistake." It is these type of issues that need to be examined every time the railroad designates an accident as caused by "human factors." When conditions are such, it is just a matter of time when a signal employee will fail. To blame the individual for the "mistake" does not get to the real reasons why an accident happens, and it definitely will not get to the root cause which is necessary to prevent the "mistake" from happening again.

There is much to accomplish to make the nation's railroads safer for communities across the country and for the employees. Experience teaches us that it is Congress that must provide the leadership to make safety a reality. I hope we can work together to see that improved safety practices become a reality.

On behalf of rail labor I appreciate this opportunity to testify before the Committee. At this time I would be more than pleased to answer any questions.

Respectfully submitted,

W. Dan Pickett

W. Dan Pickett
International President

STATEMENT of Rep. JON PORTER (R-NV)
House Transportation and Infrastructure Committee
Subcommittee on Railroads
July 25, 2006

Mr. Chairman, I thank you for holding this hearing today on Human Factors and Issues in Rail Safety.

As we continue to study safety, I am happy to see that the Chairman has decided to address the human factors that impact overall performance. The success of an industry can be traced back to its workforce and as we review the factors that help or impede overall safety we must consider the structure and legal framework that governs the nation's railroads.

The statutory regulations governing certain classes of railroad employees date back to 1907 when Congress passed the Hours of Service Act. Today's rail system and its safety record is a result of decades of negotiations and regulations by the industry and the federal government. In the 100 years since the passage of the Hours of Service Act we have made tremendous advances in medicine and our understanding of the human body. We have also developed new technologies such as cell phones, which present new challenges when considering rail safety.

As we discuss issues such as fatigue, alertness, physical stamina, and the overall health of rail employees, we should consider the environmental factors that impact these areas. Railroad employees are exposed to natural hazards like extreme weather which contribute to fatigue and impact physical stamina. While discussing these factors I am interested in learning how advances in medicine will address these issues.

As a Representative from Nevada, I am concerned about the transportation of nuclear waste from other states to our nation's nuclear waste repository at Yucca Mountain which is 90 miles from Las Vegas. Today's hearing will be helpful in determining how human factors in rail safety impact the transporting of hazardous materials.

Our nation's rail industry has helped us conquer the west, win Word War II, and transport billions of tons of freight from cost to cost. As we review the human factors of rail safety, I look forward to ensuring that rail transport continues to serve our great nation in the decades ahead.

I am extremely interested in hearing the comments from my fellow subcommittee members as well as the testimony from the witnesses. I yield back.

House Transportation and Infrastructure Committee

Railroads Subcommittee

Testimony of

United Transportation Union

James Stem

July 25, 2006

Chairman LaTourette, Ranking Member Ms. Brown, and Members of the Committee: On behalf of the men and women that are operating the trains moving on our nation's railroads today, I want to thank you for giving us the opportunity to testify on our priorities for rail safety.

My name is James Stem and I serve in the position of Alternate National Legislative Director with the United Transportation Union (UTU). I devote more than a majority of my time every day working on rail safety issues. I also have the assignment of coordinating our participation with the Federal Railroad Administration (FRA) Rail Safety Advisory Committee (RSAC) at the direction of UTU International President Paul Thompson.

Today I am going to focus my remarks on training and the significant effect that inadequate training has on safety. I am also going to discuss the effects of acute and cumulative fatigue on situational awareness of safety critical employees. Also in our testimony today, we will discuss the responsibility of both employees and railroad supervisors to comply with Federal law, Federal regulations and operating rules dealing with safety issues.

I want to make the following major points in my testimony:

(1) Training of new employees working in safety sensitive positions is inadequate and not focused on safe operations. New employees should not be allowed to work unsupervised until they accumulate at least one years experience.

(2) Fatigue of safety sensitive employees is not addressed in any rail operational safety plan. We are asking Congress to take appropriate action to amend the Hours of Service Act to resolve this issue:
- To restrict each tour of duty to 10 Hours and no more.
- To also establish a cumulative total for covered service each 7 days

(3) Federal Laws and Federal Regulations apply to all railroad employees, including railroad supervisors.

We are pleased to report to you that UTU is the FRA partner working together to improve safety in our rail industry. We appreciate the positive relationship Administrator Joe Boardman, Associate Administrator of Safety Jo Strang and their staff have developed with labor and management. We believe that FRA is on the right track and fully comprehends the complex safety issues confronting our industry today.

We also have a strong opinion that Congressional intervention is now warranted to give FRA more resources and more authority to have a more immediate impact on the increasing numbers of train collisions and major accidents that continue to occur.

Accidents caused by human factors account for about 38% of total train accidents; this category of accidents is increasing. Inadequate training programs for new employees, their lack of practical on-the-job experience, an absence of familiarity with the workplace physical environment, substandard recurrent training requirements for existing employees, and the unacceptable prevalence of fatigue throughout the rail industry are the causes of these accidents.

The insufficiency of existing training programs together with fatigue and the resulting loss of situational awareness are contributing causes in the majority of accidents attributed to human factor failures. Cumulative fatigue is the major contributing factor in the loss of situational awareness; however, training deficiencies and other demands on the employee's time disrupt the ability to focus, prioritize, and process the critical information streams that require constant attention.

Training

We believe it is appropriate that we express our enthusiasm to the Committee this morning for the process that Administrator Boardman and FRA have established to address training issues. A Working Group consisting of representatives from Brotherhood of Locomotive Engineers and Trainmen (BLET), UTU, FRA, the railroads, and recognized training experts has been formed and will meet, for the first time, later today. We are very optimistic that this proactive working group can move quickly to find and implement solutions that will have an immediate positive effect on the training and qualifications of operating crew members. We salute both FRA and American Association of Railroads (AAR) for their willingness to contribute their resources in this effort to make training in the rail industry a safety advantage instead of the most significant safety issue.

The rail industry will have more than 80,000 new employees in the next five years. The rail industry is also experiencing an unprecedented retention problem involving new employees. Based on reports from the field, new employees are resigning and leaving the industry because they are dissatisfied with the quality of their training, they are uncertain of their skills and understanding of the work processes, and they are understandably uncomfortable with their level of responsibility. Exit interviews conducted with former new employees indicate that their training did not prepare them for service in what they believe is a dangerous work environment, and they did not receive the opportunity to become accustomed to the realities of working a self supervised position with irregular shift scheduling and uncertain rest day opportunities.

The lack of appropriate training is the number one safety issue facing the rail industry today – and training failures should be of significant and urgent concern to the Congress. These training deficiencies are not limited to operating employees, but also include train dispatchers, signal employees, maintenance of way employees, locomotive repair and servicing employees, and track inspectors.

It is obvious to us this trend towards declining rail safety, increased train collisions, and human factor accidents has a direct relationship with the failure of training programs and the rampant fatigue problems throughout the industry.

Training experts advise that appropriate and focused initial training instills discipline, an understanding of the job responsibilities including the limitations on the employee's decisions, and the role of the employee in the overall operation. It is training rather than intelligence that produces the proper and safe reaction to different circumstances, especially, in cases when something unusual occurs.

Well trained employees understands their roles and limitations, while an employee that knows he lacks the knowledge and skills to safely perform his or her duties will perform unsafe acts more frequently out of fear of being sanctioned by his employer for being unqualified. A well trained employee knows when to stop and ask questions. Experience and familiarity with the physical characteristics of the work place instills confidence. New employees should receive the opportunity to gain experience, become familiar, and develop competency. They should not be expected to work unsupervised and perform their duties under the assumption that they will react to work place situations as if they were seasoned veterans.

Neither of the two crew members on the train involved in the accident at Graniteville, S.C. in January 2005 had received training on hazardous material emergency response from the railroad involved. The young engineer ran out of the chlorine cloud (after the derailment and breach of the tank car). He was overcome by the gas and died. The conductor, on the other hand, a bit older and with Army chemical training, walked slowly and deliberatively out of the cloud and survived.

Training in every industry except the railroad is delivered in incremental segments. With incremental training, an employee receives basic levels of knowledge and learns the approved techniques and procedures that must be followed to insure that each task is performed safely and correctly. This segment involves a traditional classroom setting. The employees then receive an opportunity to practice and perfect what they have studied in a classroom working on-the-job in a directly supervised environment in the work place. This hands-on experience prepares the employee for the next level of class room training, which again will be followed by intervals of supervised on-the-job experience gathering.

The railroads training philosophy has evolved into a "single injection" process where a new recruit is given a single dose of training, in lieu of incremental training. This one shot approach to training attempts to transform inexperienced individuals into proficient Conductors and/or Remote Control Operators before the employee earns a day's pay working as a trainman or yardman on a train crew. There may be a few unusually adept people who will manage to survive their entry to this industry without contributing to an accident or injury, but the overwhelming majority of new employees require much remedial training and exposure to the hazards of railroading before they are capable of applying their classroom lessons to actual situations in the work place.

The UTU is of the strong opinion that newly hired trainmen should not be required to work unsupervised or operate locomotives until they are truly experienced in the trainman craft. This ensures they have become proficient in their train service job functions and have gained needed on-the-job experience before assuming additional demanding duties and responsibilities.

A one year minimum in train service prior to becoming a conductor would improve the quality and competency of railroad operating employees, which equates to safer and more efficient operations.

It also ensures that newly hired employees will have approximately two years of practical railroad experience before they can be expected to operate locomotives without direct supervision.

Unless we can quickly eliminate training as the major safety issue, we can only expect this negative trend in safety to accelerate.

Fatigue

Everyone involved with Rail Safety understands the inescapable truth that cumulative fatigue has significant adverse safety consequences for safety sensitive positions. Unfortunately, FRA is not empowered to deal with anything beyond Acute Fatigue. The railroads have refused to address the problem in a meaningful manner and many employees are now told "Either come to work or you are fired" when they have not been able to sleep before reporting for duty.

The railroad companies are operating at, or attempting to exceed, maximum capacity and today they are booking record profits. However, the absence of sufficient manpower and the continuing reliance on an understaffed, overworked, and often fatigued worked force has created a ticking time-bomb.

The NTSB has for more than a decade identified fatigue as the most serious safety concerns affecting the railroad industry. Fatigue has remained near the top of the Board's listing of the "most wanted" safety issues that need to be addressed. The NTSB notes that safety sensitive rail employees can be required to work in excess of 400 hours in a 30 day period, compared with about 250 hours for operators of highway vehicles.[1]

Unless a human being knows well in advance what time they must report to work, they can not arrange to be rested and fit for duty. The railroad industry functions on a 24/7 schedule with continuous operations from coast to coast. This is not an excuse for the current position of the railroads, holding that their employees do not require advance knowledge of the time they must appear for their next assignment in order to manage their lives and obtain sufficient sleep before reporting for work. Every railroad terminal has an information delivery system commonly referred to as a "lineup" that is used to advise crews who are subject to call 24/7 regarding their status. Every railroad has "problems" with the accuracy of these "lineups". To insure the safe operation of trains, it is absolutely essential that the employees have early and reliable information indicating the date and time when they will be required to report for duty.

The incidence of fatigue for railroad operating crews and its significant detrimental effect on situational awareness for safety sensitive employees

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[1] Safety Report NTSB/SR-99/01, Figure 1-1. Maximum work hours in a 30-day period.

covered by the Hours of Service, is directly associated with the so called "limbo time" ruling.

"Limbo time" is nomenclature created when the judicial system interpreted the hours of service statute to permit operating crews to work their entire 12 hour tour of duty moving trains. All time consumed between completion of the maximum allowable twelve hour shift and the time when an employee is completely released from service is classified as time awaiting deadhead transportation or "limbo time". The railroads have now subverted this court decision and regularly compel crews to remain at the work place to guard the stationary trains until a relief crew is available for service. The crews are eventually transported from the train and relieved from service at the convenience of the railroad.

The railroads do not dispute the fact that management is responsible for the prevalence of "limbo time" by forcing crews to remain on duty in a "Relieved but Not Released" status for hours and hours after completing a 12 hour shift.

Reports indicate that the number of employees who are obligated to remain at the work place for lengthy periods of time following the expiration of 12 hours on duty is large and the situation occurs many times each day. The expenditure of 18 consecutive hours between the time when an employee reports for duty and the time when this individual is finally released from service is not unusual. In such circumstances, crews are then only entitled to be off duty 10 hours before they can be required to report for another 18 to 20 hour shift.

The only human beings that do not accept the horrendous safety consequences of this Limbo Time fiasco are the railroad executives that stand to make a tremendous amount of personal bonus income by perpetuating an unsafe practice that exploits their coworkers. Their bonuses are based, in part, on keeping head counts down and train velocity up.

Limbo time increases the prevalence of fatigue, at the expense of safety, as evidenced by the increasing number of train collisions and major accidents allegedly caused by human error.

Before this limbo time fiasco became reality, the railroads relieved their crews in a timely manner with very rare exceptions, and their operations were not gridlocked as a result. Their crew management system operated much more efficiently and they did not have a high percentage of their crews sitting on idle trains because management was forced to organize and dispatch relief crews in time to prevent hours of service violations.

Immediate Congressional intervention is warranted to correct the Limbo time fiasco and the occurrence of fatigue caused by the practice. In the railroad industry today, 12 hours on duty normally means 12 hours working on the train and then several additional hours while you wait for someone to pick you up and transport you to a terminal for rest and nourishment.

UTU welcomes public debate and Congressional scrutiny on these important matters. It is obvious to us that if the fatigue issue is going to be resolved in the rail industry, Congress must be involved. FRA does not currently have the authority to take the significant actions required to solve this problem.

The only surprise in all of this debate is the fact that human factor accidents and train collisions are not increasing at an even faster rate. The professionalism of our veteran operating crews is the only reason we do not have a daily high profile collision somewhere in this country. The Hours of Service Act was intended to improve safety in our industry by managing the amount of time a safety sensitive employee could work. Congress never intended for this legal subversion to move the allowable service time to anything the railroads find to be convenient.

UTU has entered into many 'work-rest' agreements with the railroads in the past several years to address human fatigue and operational safety issues. An overwhelming majority of those projects were canceled by the railroads in a short period of time because guaranteed time off reduces the number of hours an employee must be available for duty each week, month, and year. The railroads recognized that they need additional employees to cover assignments if the employees have regular and predicable time off each week.

To credit FRA, a Collision Analysis Working Group (CAWG) was created to analyze 65 main track train collisions, identify commonalities, and recommend changes to prevent future collisions. Rail management, the UTU, the Brotherhood of Locomotive Engineers and Trainmen (BLET), and the FRA were all equal partners in this exercise. This analysis obviously showed a direct link to fatigue as a contributing factor in many of these collisions and the corresponding loss of situational awareness by the crews. The industry participated in the analysis as an equal partner.

The industry also participated in drafting and approved the final language contained in the report as an equal partner, and afterwards demanded that their officers' names be stricken from the final report when senior management learned the involvement of fatigue was mentioned in connection with these collisions. I am thankful that FRA had the courage to publish this significant work after removing the railroad officers' names.

UTU referred to this CAWG group in earlier testimony and realized that a copy of this report has not been furnished to this committee or your staff. We are furnishing the committee with copies of this report today for your ready reference. UTU thinks this document forms a foundation for necessary Congressional action to resolve fatigue as a major safety issue. We are making printed copies of this document available today for your staff and the committee.

We are also submitting as an appendix to our testimony NTSB Safety Report NTSB/SR-99/01 entitled Evaluation of U. S. Department of Transportation Efforts in the 1990's to Address Operator Fatigue. We think this report also has a significant contribution on fatigue for your consideration. This is one of many NTSB recommendations in the past 18 years on operator fatigue.

UTU has now testified on multiple occasions that we know that Congressional intervention is required to resolve fatigue in the rail industry.

Our <u>recommendations</u> to the Transportation and Infrastructure Committee are:

- Amend the Hours of Service Act to permit only 10 Hours of Service for each tour of duty for covered employees
    - This means that the time an employee reports for service and is then released at the final terminal will not exceed 10 hours.
- Establish a reasonable cumulative total for permitted service each 7 days.
- Require a minimum of 12 hours notice for employees reporting for service on call that do not have a regular starting time.
- Provide FRA additional resources to enforce these safety parameters.
- Provide FRA the authority to further restrict the total time on duty when sensitive operations are involved and the safety of the operation requires.

Good Faith Challenge and Employee Responsibility

The railroad companies formal stated position in more than one FRA sponsored working group is that a railroad supervisor has the legal authority to instruct employees under his supervision to violate Federal Law, Federal Regulations, and even the company's own operating rules. Obviously many times these confrontations result in charges of insubordination and dismissal for the employees involved with these safety discussions when they do not follow the instructions out of concern for their own safety.

The railroad also stated that the only recourse an employee should have when instructions are received that will endanger the life of the employee is to file a grievance under 49 U.S.C. 20109. More troubling than that ridiculous position is the AAR position that 20109 also prohibits FRA from taking any action to establish a Good Faith Challenge provision in other sections of the Federal Regulations.

One section of the Federal Regulations (CFR Part 214.313(d) and 214.311(b)) contains a Good Faith challenge provision that outlines the procedure to be followed when an employee expresses a concern that instructions received from his supervisor will endanger his safety and violate company rules and Federal Regulations. This provision in Part 214 has proven to be very effective in making safety the top priority under this section of operations for roadway workers.

Strict compliance and proper application of operating rules, special instructions, and Federal regulations are key components of any rail safety program. Rules and regulations apply to all railroad employees, including the mid level managers and all railroad supervisors.

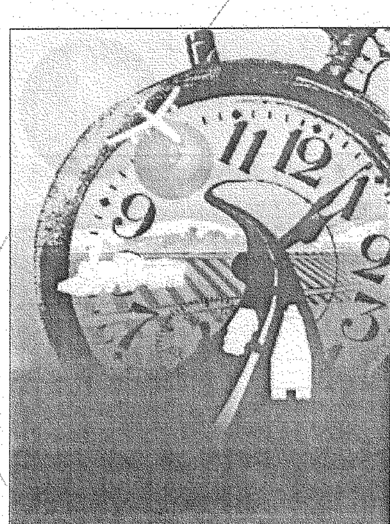
Our lawyers support the FRA position on the Good Faith Challenge. We hope this issue will be resolved in the near future by consensus with all parties participating. If there is further legal challenge based on 20109 and an employees right to comply with rules and federal regulations, we will be back to ask this Committee to clarify FRA's authority on this issue.

We will try to offer an informed response to any questions. We appreciate the opportunity to appear before the Committee today.

Attachments:
FRA Collision Analysis Working Group (CAWG) February 21, 2006 Final Report

NTSB Safety Report NTSB/SR-99/01 entitled Evaluation of U. S. Department of Transportation Efforts in the 1990's to Address Operator Fatigue

Evaluation of U.S. Department of Transportation Efforts in the 1990s to Address Operator Fatigue



Safety Report
NTSB/SR-99/01

May 1999
PB99-917002
Notation 7155

National Transportation Safety Board
Washington, D.C.

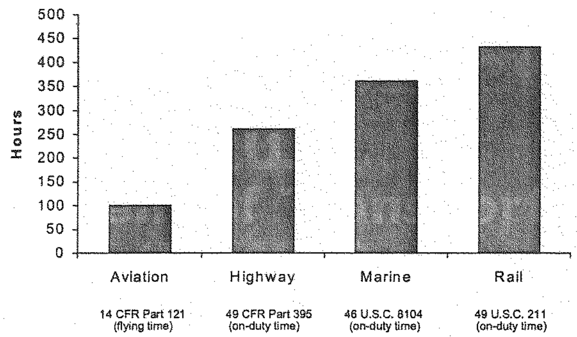


Figure 1–1. Maximum work hours in a 30-day period. For marine, the on-duty and off-duty times are for a licensed individual on an oceangoing vessel or coastwise vessel of not more than 100 gross tons at sea. (CFR = *Code of Federal Regulations;* U.S.C. = *United States Code*)

What is Fatigue?

Traditionally, fatigue was viewed as a simple condition related to the amount of time spent working on a given task.[5] Scientific research, however, has shown that fatigue is related to much more than just the time on a task.[6] Researchers have studied factors that affect fatigue, such as duration and quality of sleep,[7] shiftwork and work schedules,[8] circadian rhythms,[9] and time of day.[10] Others have examined the influence of drugs and alcohol on fatigue and compared performance impaired by alcohol to performance

[5] McDonald, Nicholas. 1984. *Fatigue, Safety and the Truck Driver.* London and Philadelphia: Taylor & Francis. pp. 104-115.

[6] Kryger, M.H.; Roth, T.; Dement; W.C., eds. 1994. *Principles and Practice of Sleep Medicine*. 2nd edition. Philadelphia: W.B. Saunders Company.

[7] (a) Johnson, L.C.; Naitoh, P. 1974. *The Operational Consequences of Sleep Deprivation and Sleep Deficit.* AGARD-AG-193, NATO. London: Technical Editing and Reproduction. (b) Rosekind, M.R.; Gander, P.H.; Connel, L.J.; Co, E.L. 1994. *Crew Factors in Flight Operations. X: Alertness Management in Flight Operations.* NASA/FAA Technical Memorandum DOT/FAA/RD-93/18. Washington, DC: National Aeronautics and Space Administration. (c) National Transportation Safety Board. 1995. *Factors That Affect Fatigue in Heavy Truck Accidents.* Safety Study NTSB/SS-95/01 and NTSB/SS-95/02. Washington, DC.

[8] (a) Folkard, S.; Monk, T.H.; Lobban, M.C. 1979. "Towards a Predictive Test of Adjustment to Shiftwork." *Ergonomics* 21: 785-799. (b) Thomas, G.R.; Raslear, T.G.; Kuehn, G.I. 1997. *The Effects of Work Schedules on Train Handling Performance and Sleep of Locomotive Engineers: A Simulator Study.* DOT/FRA/ORD-97-09. Washington, DC: Federal Railroad Administration.

[9] Kryger, M.H.; Roth, T.; Carskadon, M. 1994. "Circadian Rhythms in Humans: An Overview." In: Kryger, M.H.; Roth, T.; Dement, W.C., eds. *Principles and Practice of Sleep Medicine.* 2nd edition. Philadelphia: W.B. Saunders Company. pp. 301-308.

[10] Wylie, C.D.; Shultz, T.; Miller, J.C.; and others. 1996. *Commercial Motor Vehicle Driver Fatigue and Alertness Study: Project Report.* FHWA-MC-97-002. Washington, DC: Federal Highway Administration.

impaired by fatigue.[11] Sleep disorders and the characteristics of sleep patterns at different ages have also been studied.[12] Cumulative sleep loss and circadian disruption can lead to a physiological state characterized by impaired performance and diminished alertness.[13] Fatigue can impair information processing and reaction time, increasing the probability of errors and ultimately leading to transportation accidents.[14] A summary of sleep and circadian rhythms was originally completed for the Safety Board's investigation of the 1993 American International Airways accident in Guantanamo Bay, Cuba.[15] An update of that summary is provided in appendix C.

Scope of the Fatigue Problem

Fatigue has remained a significant factor in transportation accidents since the Safety Board's 1989 recommendations were issued. Although generally accepted as a factor in transportation accidents, the exact number of accidents due to fatigue is difficult to determine and likely to be underestimated. The difficulty in determining the incidence of fatigue-related accidents is due, at least in part, to the difficulty in identifying fatigue as a causal or contributing factor in accidents. There is no comparable chemical test for identifying the presence of fatigue as there is for identifying the presence of drugs or alcohol; hence, it is often difficult to conclude unequivocally that fatigue was a causal or contributing factor in an accident. In most instances, one or more indirect or circumstantial pieces of evidence are used to make the case that fatigue was a factor in the accidents. This evidence includes witness statements, hours worked and slept in the previous few days, the time at which the accident occurred, the regularity or irregularity of the operator's schedule, or the operator's admission that he fell asleep or was impaired by fatigue.[16]

Despite the difficulty in identifying fatigue as a causal factor, estimates of the number of accidents involving fatigue have been made for the different modes of transportation; the estimates vary from very little involvement to as high as about one-third of all accidents.

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[11] (a) Roehrs, T.; Beare, D.; Zorick, F.; Roth, T. 1994. "Sleepiness and Ethanol Effects on Simulated Driving." *Alcoholism: Clinical and Experimental Research* 18(1): 154-158. (b) Dawson, D.; Reid, K. [In preparation]. "Equating the Performance Impairment Associated With Sustained Wakefulness and Alcohol Intoxication." Woodville, South Australia: Centre for Sleep Research.

[12] (a) Aldrich, M.S. 1994. "Cardinal Manifestations of Sleep Disorders." In: Kryger, M.H.; Roth, T.; Dement, W.C., eds. *Principles and Practice of Sleep Medicine.* 2nd edition. Philadelphia: W.B. Saunders Company. pp. 413-425. (b) Bliwise, D.L. 1994. "Normal Aging." In: Kryger, M.H.; Roth, T.; Dement, W.C., eds. *Principles and Practice of Sleep Medicine.* 2nd edition. Philadelphia: W.B. Saunders Company. pp. 26-39.

[13] Rosekind, M.R.; Graeber, R.C.; Dinges D.F.; and others. 1993. *Crew Factors in Flight Operations. IX: Effects of Planned Cockpit Rest on Crew Performance and Alertness in Long-Haul Operations.* NASA Technical Memorandum 108839; DOT/FAA/92/94. Washington, DC: National Aeronautics and Space Administration.

[14] (a) Dinges, D.F. 1989. "The Nature of Sleepiness: Causes, Context, and Consequences." In: Stunkard, A.; Baum, A., eds. *Perspectives in Behavioral Medicine: Eating, Sleeping, and Sex.* Hillsdale, NJ: Lawrence Erlbaum. pp. 147-179. Chapter 9. (b) Dinges, D.F. 1992. "Probing the Limits of Functional Capability: The Effects of Sleep Loss on Short-Duration Tasks." In: Broughton, R.J.; Oglivie, R., eds. *Sleep, Arousal, and Performance.* Boston: Birkhauser-Boston. pp. 176-188. Chapter 12.

Aviation

The Federal Aviation Administration (FAA) reported that 21 percent of the reports in the Aviation Safety Reporting System (ASRS) were related to general issues of fatigue. This includes reports that mentioned fatigue directly or indirectly. When only reports that directly mention fatigue are included, the percentage drops to 3.8 percent.[17]

Highway

The National Highway Traffic Safety Administration (NHTSA) estimates that each year 100,000 crashes, which result in more than 1,500 fatalities and 71,000 injuries, are caused by drowsy drivers.[18] This amounts to about 1.6 percent of all crashes and about 3.6 percent of fatal crashes. In 1998, the Federal Highway Administration (FHWA) derived estimates of the percentages of large truck crashes involving fatigue: all police-reported crashes (0.53 percent to 1.3 percent); all fatal crashes (2.8 percent to 6.5 percent); crashes fatal to the truck occupant only (12 percent to 29 percent); and crashes fatal to nontruck occupants (1.2 percent to 2.8 percent). The FHWA also concluded that more in-depth investigations yield higher percentages of fatigue-related crashes than indicated in comparable samples of police accident reports.[19] The Safety Board's 1990 study of 182 heavy truck accidents that were fatal to the driver showed that 31 percent of the accidents in this sample involved fatigue.[20] This number is frequently cited as an estimate of the incidence of fatigue in truck accidents that were fatal to the truckdriver. The Safety Board's numbers regarding fatigue-involved accidents are more revealing because the Board's in-depth investigations included such surrogate measures as a 72-hour history of rest and duty times, the amount of sleep in the last 24 hours, and the regularity of the work schedule, to name just a few.

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[15] Rosekind, Mark R. [NASA Ames Research Center]; Gregory, Kevin B. [Sterling Software]; Miller, Donna L. [Sterling Software]; and others. 1994. "Analysis of Crew Fatigue Factors in ATA Guantanamo Bay Aviation Accident." In: *Uncontrolled Collision With Terrain, American International Airways Flight 808, Douglas DC-8-61, N814CK, U.S. Naval Air Station in Guantanamo Bay, Cuba, August 18, 1993.* Aircraft Accident Report NTSB/AAR-94/04. Washington, DC: National Transportation Safety Board. pp. 133-144.

[16] The Safety Board recognizes that people have a limited ability to predict the onset of sleep and to determine their level of sleepiness. (Itoi, A.; Cilveti, R.; Voth, M.; and others. 1993. *Can Drivers Avoid Falling Asleep at the Wheel? Relationship Between Awareness of Sleepiness and Ability To Predict Sleep Onset.* Washington, DC: AAA Foundation for Traffic Safety. p. 25.)

[17] (a) *Federal Register*, Vol. 60, No. 244, dated December 20, 1995. (b) Batelle Memorial Institute. March 1998. *A Review of Issues Concerning Duty Period Limitations, Flight Time Limitations, and Rest Requirements as Stated in the FAA's Notice of Proposed Rulemaking 95-18.* Washington, DC: Federal Aviation Administration.

[18] Knippling, R.R.; Wang, J.S. October 1995. "Revised Estimates of the U.S. Drowsy Driver Crash Problem Size Based on General Estimates System Case Reviews." In: 39th Annual Proceedings, AAAM; October 16–18, 1995; Chicago, IL. Des Plaines, IL: Association for the Advancement of Automotive Medicine.

[19] Federal Highway Administration, Office of Motor Carriers. September 1998. *Crash Problem Size Assessment: Large Truck Crashes Related Primarily to Driver Fatigue.* Washington, DC.

[20] National Transportation Safety Board. 1990. *Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes.* Safety Study NTSB/SS-90/01 and NTSB/SS-90/02. Washington, DC.

Marine

A 1996 United States Coast Guard (USCG) analysis of 279 incidents showed that fatigue contributed to 16 percent of critical vessel casualties and 33 percent of personal injuries.[21]

Railroad

According to a Safety Board analysis of Federal Railroad Administration (FRA) data from January 1990 to February 1999, only 18 cases were coded "operator fell asleep" as a causal or contributing factor. The Board believes that 18 cases in more than 9 years underestimates the actual number of cases in which fatigue might have been involved. For example, two Safety Board investigations—Sugar Valley, Georgia (August 9, 1990), and Corona, California (November 7, 1990)—in which fatigue was cited by the Safety Board as a causal factor were not coded in the FRA database as fatigue-related but rather as a failure to comply with signals.

In testimony before the Senate Subcommittee on Surface Transportation and Merchant Marine[22] on September 16, 1998, the Administrator of the FRA stated that "about one-third of train accidents and employee injuries and deaths are caused by human factors. We know fatigue underlies many of them."

In summary, although the data are not available to statistically determine the incidence of fatigue, the transportation industry has recognized that fatigue is a major factor in accidents, as was clearly demonstrated at the Safety Board's 1995 symposium on fatigue.[23] Further, the Safety Board's in-depth investigations have clearly demonstrated that fatigue is a major factor in transportation accidents.

[21] McCallum, Marvin C.; Raby, Mireille; Rothblum, Anita M. 1996. *Procedures for Investigating and Reporting Human Factors and Fatigue Contributions to Marine Casualties*. CG-D-09-97. Washington, DC: U.S. Department of Transportation, U.S. Coast Guard, Marine Safety and Environmental Protection.

[22] The subcommittee is an entity of the Senate Committee on Commerce, Science, and Transportation.

[23] The symposium is discussed in further detail in part 2 of this report.

Fatigue in Transportation: Physiological, Performance, and Safety Issues[1]

Mark R. Rosekind
Alertness Solutions
April 1999

Introduction

Maintaining safe transportation operations is a complex task. The undertaking must address a range of issues from the functioning of large systems to the individual human operator. For the foreseeable future, the human operator (pilot, driver, maintenance person, etc.), remains central to safe, efficient, and reliable transportation activities. Therefore, the importance of addressing human-related error, which accounts for at least 70% of transportation accidents, remains critical to maintaining and improving safety (Ref 1).

Fatigue, sleep loss, and circadian disruption created by transportation operations can degrade performance, alertness and safety. An extensive scientific literature exists that provides important physiological information about the human operator, which can be used to guide operations and policy. For example, there are human physiological requirements for sleep, predictable effects of sleep loss on performance and alertness, and patterns for recovery from sleep loss. Additionally, the circadian clock is a powerful modulator of human performance and alertness, and in transportation operations, it can be disrupted by night work, time zone changes, and day/night duty shifts. Scientific examination of these physiological considerations has documented a direct relationship to errors, accidents, and safety. This scientific information can provide important input to policy and regulatory considerations.

Managing fatigue in the complex and diverse transportation environment requires an integrated and multi-component approach. The complexity and diversity of operational requirements preclude a simple solution, and managing fatigue will benefit from addressing education, hours of service, strategies, technology, design, and research. The transportation industry has established a strong safety record by identifying and proactively addressing both substantiated and potential risks. Effectively managing fatigue in transportation operations offers the opportunity to further reduce risks and improve safety.

[1]Adapted from the following references: (a) Rosekind MR, Gregory KB, Miller DL, Co EL, and Lebacqz JV. "Analysis of crew fatigue factors in AIA Guantanamo Bay Aviation Accident." *Uncontrolled Collision With Terrain, American International Airways Flight 808, Douglas DC-8-61, N814CK, U.S. Naval Air Station in Guantanamo Bay, Cuba, August 18, 1993.* Aircraft Accident Report NTSB/AAR-94/04. Washington, DC: National Transportation Safety Board, 1994. (b) Rosekind, MR, Neri, DF, and Dinges, DF. (1997). "From laboratory to flightdeck: Promoting operational alertness." *Fatigue and Duty Time Limitations—An International Review: Proceedings of the Royal Aeronautical Society, London, UK, 16 September 1997.*

This overview provides an introduction to the scientific foundation that exists regarding the physiology of and performance related to fatigue in transportation. It also examines the human physiological requirement for sleep and the functioning of the circadian clock.

The Biological Imperative: Human Sleep Need and the Circadian Clock

Human Sleep Requirements

Sleep is a vital physiological function. Historically, sleep has been viewed as a state when the human organism is turned off. However, scientific findings have clearly established that sleep is a complex, active physiological state that comprises different stages. On average, most people physiologically require about 8 hrs of sleep per night. When provided adequate time to sleep, humans can average about 8.25 to 8.5 hrs of physiological sleep (Refs 2,3). Laboratory studies use physiological measures (i.e., brain, eye, and muscle activity) of sleep quantity and quality and daytime sleepiness to determine the number of hours of sleep that provide an optimal level of waking alertness (Refs 4–6). It is important to distinguish this physiologically determined sleep requirement from both habitual and reported sleep amounts. Some studies have examined the reported amount of habitual sleep over time and other studies have collected one-time surveys inquiring about average sleep amounts. Overall, most adults report an average of about 7–7.5 hrs sleep per night (Ref 7). However, data obtained in controlled laboratory settings challenge whether this "reported" amount of sleep is sufficient for optimal levels of waking alertness. Studies have demonstrated that extending sleep beyond the reported 7–7.5 hrs of "usual" sleep significantly increases daytime alertness (Refs 3,8). The National Sleep Foundation commissioned a Gallop survey examining the report of daytime sleepiness in a random sample of 1,001 individuals. The findings demonstrated that 75% reported daytime sleepiness, with 32% of these reporting severe levels. Thirty-two percent reported that their sleepiness interfered with activities and 82% of the respondents believe that daytime sleepiness has a negative effect on their productivity (Ref 9).

These amounts are averages and there are individuals at both extremes of short and long sleep requirements. These sleep requirements change significantly with age (Ref 10). Younger individuals require more total sleep and this amount decreases to that needed by adults (although it is not the case that older people need less sleep than other adults). Sleep structure also changes with age (e.g., less deep sleep, more awakenings in older adults). In summary, humans physiologically require about 8 hrs of sleep, though they report usual sleep amounts of about 7–7.5 hrs. A majority of the adult population report daytime sleepiness, and when sleep is extended, there is a significant increase in alertness.

Effects of Sleep Loss

Sleep loss is common and can be acute or cumulative. In an acute situation, sleep loss can occur either totally or as a partial loss. Total sleep loss involves a completely missed sleep opportunity and continuous wakefulness for about 24 hrs or longer. Partial sleep loss occurs when sleep is obtained within a 24-hr period but in an amount that is reduced from the physiologically required amount or habitual total. Sleep loss also can accumulate over time into a "sleep debt." For example, an individual who requires 8 hours of sleep and obtains only 6 hours is essentially sleep deprived by 2 hours. If the individual sleeps only 6 hours over 4 consecutive nights, then the 2-hour-per-night sleep loss would accumulate into an 8 hour sleep debt. Sleep loss, whether total or partial acute or cumulative, results in significantly degraded performance, alertness, and mood (Refs 7, 11–21).

The reduced human performance capability that results from total sleep loss is well documented (Refs 11–18). However, perhaps the most common occurrences in transportation operations are acute partial sleep loss and accumulation of a sleep debt. A review of the relevant scientific literature indicates that as little as two hours of sleep loss on just one occurrence can result in "impairment of performance and levels of alertness" (Ref 7). Therefore, an average individual with a physiological requirement of 8 hours sleep who obtains only 6 hrs of sleep may demonstrate significantly degraded waking performance and alertness. Cumulative sleep debt also significantly reduces alertness and performance (Refs 19–21). Studies have demonstrated that not only does the sleep loss accumulate but that the negative effects on waking performance and alertness also are cumulative and increase over time (Ref 20).

Performance decrements due to sleep loss can occur across diverse functions. For example, studies have demonstrated slowed reaction time, reduced vigilance, cognitive slowing, memory problems, time-on-task decrements, and optimum response decrements (e.g., Refs 13,14,16,18). Performance variability also increases with sleep loss. Therefore, overall performance can be significantly reduced with an increased variability or unevenness in responding (Ref 16). Consider that these findings occur in some of the simplest performance challenges, such as reaction time to a single stimulus or minimal choice memory task. These basic psychomotor and cognitive functions are the foundation for any task requiring complex, higher-order performance.

An important phenomenon, highly relevant to operational environments, is that there is a discrepancy between the subjective report of sleepiness/alertness and physiological measures. In general, individuals will report higher levels of alertness than indicated by physiological measures (Refs 22–24). Data from an international study of flight crews had an example where the highest subjective rating of alertness occurred at a time when physiologically the individual was falling asleep within 6 minutes (an indicator of severe sleepiness) (Ref 22). Likewise, subjective and physiological self-assessment of performance can differ significantly. The operational relevance of this phenomenon is clear. For example, an individual might report a low level of sleepiness or fatigue but could be carrying an accumulated sleep debt with a high level of associated physiological sleepiness. This individual, in an environment stripped of factors that conceal the underlying physiological sleepiness, would be susceptible to the occurrence of spontaneous, uncontrolled sleep episodes and to the performance decrements associated with sleep loss.

Recovery from Sleep Loss

When determining requirements for providing a recovery opportunity from sleep loss, two factors should be considered. First, when does the internal sleep architecture return to usual levels? Second, when do waking performance and alertness levels return to their baseline? After sleep loss, recovery is not accomplished through an hour-for-hour restitution. Even after extremely prolonged wakefulness, initial recovery sleep may last only 12–15 hrs (Ref 25). Rather, recovery is accomplished through an increase in deep sleep (Non-Rapid-Eye-Movement or NREM slow wave sleep) observed starting on the first night of regular sleep (Refs 26–28). Generally, two nights of recovery sleep (slightly longer than an average night's sleep) are needed to resume a normal baseline sleep pattern (Refs 26,29), though this can be dependent on the duration of the continuous wakefulness. Also, typically, two nights of recovery sleep are needed to return to a normal baseline of waking performance and alertness (Refs 20,30), though this too can be dependent on the length of prior wakefulness (e.g., Ref 3).

The Circadian Clock

Besides sleep, the other major physiologic determinant of waking performance and alertness is the internal circadian clock (Refs 31–33). Circadian (*circa* = around, *dies* = day) rhythms fluctuate on a 24-hr cycle with peaks and troughs occurring in a regular pattern. These patterns are controlled by a circadian pacemaker located in the suprachiasmatic nucleus (SCN) in the brain. The SCN is the circadian timekeeper for a wide range of human functions. One of the most prominent is the 24-hr sleep/wake cycle programmed for a daytime period of consolidated wakefulness and a nighttime period of consolidated sleep. There are circadian patterns for cognitive and psychomotor performance, physiological activity (e.g., digestion, immune function, thermoregulation, DNA synthesis), alertness, and mood (Refs 34–38). Even birth and death have circadian patterns that peak during the night (see Ref 31).

Body temperature is often used as a marker of the internal circadian clock (sometimes referred to as the "hands of the clock"). The trough or low point of the clock is around 3 am to 5 am, with many functions demonstrating reduced levels from 12 am to 6 am. The lowest level of function (e.g., alertness, performance, subjective mood, temperature) occur within the 3 am to 5 am trough. Sleepiness has bimodal distribution (i.e., two peaks and two troughs each day), being most severe at 3 am to 5 am with a less marked but significant expression between roughly 3 pm to 5 pm. This afternoon increase in sleepiness occurs whether or not a meal has been consumed, though the meal may exacerbate the underlying sleepiness (Ref 39).

Zeitgebers ("time givers") are cues that synchronize circadian rhythms to their 24-hr pattern. To date, light has been demonstrated to be among the most powerful zeitgebers to synchronize the circadian pacemaker. Bright light can dramatically shift the phase of the human circadian clock when applied at responsive times in the 24-hr cycle (Refs 40–42). Without cues, the intrinsic rhythm of the clock is longer than 24 hrs. Generally, data have demonstrated a free-running pattern approximating 24.9 hrs, though recent findings suggest this may be closer to 24.2 hrs (Refs 31–33,43). An intrinsic period longer than 24 hrs provides an inherent tendency to support circadian delays (e.g., staying awake longer) and to oppose advances (e.g., trying to go to sleep earlier).

Moving to a new light/dark schedule, such as a shift to nightwork or a time zone change, can create internal and external desynchronization. These involve an internal desynchrony among circadian rhythms and a discrepancy between internal circadian timing and external/environmental cues, respectively. The internal clock can take from several days to weeks for adjustment or, in some circumstances, not fully resynchronize at all. Scientific studies have demonstrated these findings in the laboratory and in field studies conducted during actual transportation operations (e.g., Refs 31–33, 44–54).

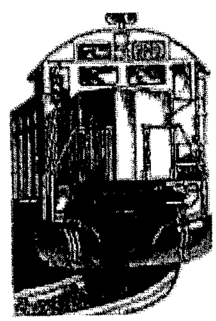
[Additional discussion is not included in this appendix.]

Collision Analysis

Working Group (CAWG)

65 Main-Track Train Collisions, 1997 through 2002:

Review, Analysis, Findings, and Recommendations



February 21, 2006

CAWG Final Report

Federal Railroad Administration

NOTICE

Although the Collision Analysis Working Group (CAWG) developed the findings, discussions, and recommendations contained is this report, the Federal Railroad Administration (FRA) takes sole responsibility for the final content. This report is issued under the auspices of the FRA.

CAWG representatives included many, but not all, of the Switching Operations Fatality Analysis (SOFA) Working Group. CAWG representatives:

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United Transportation Union (UTU)

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Dedication

The Collision Analysis Working Group (CAWG) dedicates this report to the memory of those railroad employees who died on duty. Recognition should never be lost that the real cost of main-track train collisions too often is human life. CAWG expresses its condolences to the families. The families should be aware that each collision review was handled with the utmost dignity and respect.

CAWG spent many hours studying the events of these collisions in developing its consensus findings and recommendations aimed solely at eliminating future tragedies. The study of operating conditions, environmental factors, and behavior leading up to these tragedies offered a unique opportunity to further improve safety and save the lives of men and women working in the railroad industry. The families who have experienced loss are assured that the lessons learned, presented herein, will save others their agonizing sorrow.

Acknowledgments

The Collision Analysis Working Group (CAWG) expresses its sincere appreciation to Allan Rutter, past Administrator of the Federal Railroad Administration, for proposing this important safety initiative: the review and analysis of main-track train collisions involving human-factor issues. The findings and recommendations made, based on the commonality of facts among collisions, will reduce and prevent the loss of life and injuries to railroad employees and passengers as well as damage to track, signal, lading, and equipment.

CAWG thanks Dr. E. Donald Sussman, past Chief of the Operator Performance and Safety Analysis Division of the John A. Volpe National Transportation Systems Center, USDOT/RSPA, for his dedicated support of CAWG from its inception; and for many other human-factor, railroad safety contributions during his career at the Volpe Center.

CAWG recognizes that without the support of those listed below, and their organizations, this safety effort could not have occurred:

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Richard F. Timmons
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United Transportation Union (UTU)

Acknowledgments (cont.)

CAWG thanks those listed below, and their organizations, for committing their energies and expertise to CAWG's effort:

James Brunkenhoeler
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Table of Contents

D: CAWG Meeting Schedule

E: Collision Analysis Working Group (CAWG)

F: George Last's Crashworthiness Letter

G: Locomotive Crashworthiness

List of Figures

List of Tables

Data Appendix

EXECUTIVE SUMMARY

General

- Federal Railroad Administrator Allan Rutter proposed a Collision Analysis Working Group (CAWG) on June 4, 2002, to review and analyze main-track train collisions involving human-factor issues, and to make safety findings and recommendations should the facts warrant.

- Holding its first meeting on July 17-18, 2002, CAWG agreed to review main-track train collisions where human factor causes contributed to trains exceeding their authority by (1) passing a stop signal; (2) failing to comply with a signal requiring restricted speed; or (3) entering territory without a train order, track warrant, or direct traffic control authority. CAWG eventually selected 65 collision cases it believes contain enough information to find meaningful commonalities upon which to base collision-avoiding findings and recommendations.[1]

- Reviewing additional cases, CAWG believes, would unduly delay this collision-avoiding information from reaching the railroad industry. Many collisions were associated with human casualty both to railroad employees and passengers, a fact re-emphasizing the importance of timely prevention efforts.

- CAWG's review and analysis provides the railroad industry with an opportunity to re-examine its safety policies and practices based on the commonality of facts found in the 65 collisions. Taking note of the findings and recommendations will ensure reasonable precautions are being taken to prevent future such collisions.

- While working on this study, CAWG members, all serving as Switching Operations Fatality Analysis Group (SOFA) representatives, wrote and issued the report *Findings and Recommendations of the SOFA Working Group: August 2004 Update*, as well as releasing other switching operations safety information. CAWG members believed the recent number of switching fatalities required this effort.

Methods

CAWG's review and analytical methods consisted of:

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[1] Findings and recommendations in this study are based on commonalities of main track train collisions and not yard, highway-rail, or switching-operation collisions. Information contained in this report – including the Findings, Discussions, and Recommendations – is based solely on the review and analyses of 65 main-track train collisions occurring from 1997 through 2002. CAWG did not consider results of other investigations, reviews, and analyses of main track, or other types of collisions. CAWG results are specific to its data.

- Including all cases meeting CAWG's selection criteria.
- Reviewing and discussing the operating practice and conditions involved in each case, and recording the information in the CAWG Database.
- Discovering meaningful and factual commonalities among cases.
- Making findings and recommendations based on these commonalities.

Collision 'Causality'

- CAWG developed an approach to collision 'causality' based on consideration of an often complex combination of rail system operating characteristics, conditions, and events. In determining causality, CAWG does not attempt to rank these factors, usually expressed as Possible Contributing Factors (PCFs). CAWG views causality as a web of interrelated factors. CAWG found that collisions do not result from chance, randomness, or bad luck; but from identifiable human-factor issues having remedies in operating practices.

  CAWG used the FRA's "Train Accident Cause Codes"[2] and its own defined codes as the basis for PCFs. As mentioned above, CAWG does not attempt to rank PCFs. Each collision was assigned as many PCFs as CAWG believed applied; however, the number of PCFs applied to a collision case did not go beyond the number necessary to capture the essence of the identified factors. CAWG avoided redundancies. Causal information not appropriately captured by a PCF was described in narrative form.

- Rarely are main-track train collisions the result of a single factor or cause. Review of the 65 collisions clearly establishes that most collision events are a combination of unrelated factors and deviations occurring at the same time, at the same location, and on the same train. Sometimes, these factors and deviations do not rise to the level of identifiable violations of operating rules, federal regulations, and/or industry standards; the greater the number of factors and deviations present, the greater the potential for a collision.

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[2] Contained in Appendix C, pages 1-11, of the *FRA Guide for Preparing Accident/Incident Report.* Federal Railroad Administration. 1997.

Harm

- Eliminating main-track train collisions will prevent enormous harm. CAWG wants to emphasize that although the 65 collision cases are 'accidents' in the sense physical damage exceeded the Federal Railroad Administration defining monetary threshold, main-track train collisions often are associated with human casualties. The 65 main-track train collisions resulted in 16 fatalities and 531 injuries. There were 14 employee fatalities and 128 employee injuries; 2 passenger fatalities and 403 passenger injuries. (One passenger collision in Placentia, CA, No. 53 [3], accounted for all the passenger fatalities and 163 passenger injuries.) There was $83,108,072 in track, signal, lading, and equipment damage. The most damage in one collision (Pacific, MO, No. 49) was $7,855,920, average damage being $1,278,586. There were 42 hazardous material cars derailed with four hazmat releases. Numerous other costs – direct, indirect, and opportunity – are associated with collisions, some calculable, some not.

Crashworthiness

- In its review, it was not the intent of CAWG to determine the crashworthiness of various locomotives; or relatedly the advisability of crews staying in, or jumping from, their locomotives given collision certainty. CAWG's review and analysis did, however, create data of potential interest to those involved in locomotive crashworthiness.

- CAWG went as far as it could in evaluating the locomotive crashworthiness issue. While having enough collision cases, CAWG needed more specific knowledge on the crashworthy features of different versions of the S-580 standard locomotives. CAWG hopes its effort establishes a baseline useful to other groups assessing crashworthiness. (Refer to Federal Railroad Administration's (FRA's) Website.[4]

- Additionally, CAWG believes its data and results should not influence a crew member's jump-or-stay decision. Such decisions are based on many variables, not the least of which is speed.

Findings and Recommendations

Note: CAWG Findings and Recommendations are based solely on its analyses of information contained in the 65 main-track train collisions occurring from 1997 through 2002.

CREW COMPOSITION AND EXPERIENCE

Findings and Discussion: Crew Composition and Experience

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[3] A CAWG No. is used to reference each collision case. A narrative summary of each case is included in this report, referenced by its CAWG No.

[4] On Federal Railroad Administration's (FRA's) Website: Click on 'Research and Development', then 'Research Reports'. Studies include DOT/FRA/ORD-02/03, DOT/FRA/ORD-01/23, DOT/FRA/ORD-95/08, and DOT/FRA/ORD-95/08I through 95/08V.

For freight trains, the conductor and engineer work as a team. One member points out situations that may have escaped the other's attention. In theory, this team concept should prevent collisions, but on occasion, collisions do occur. It is interesting to note of the six Amtrak collisions in this study, four involved one person in the locomotive cab. Two of four cases (CAWG Nos. 2 and 44) may have been avoided if a second crew member was present in the cab. A third collision (CAWG No. 3) possibly could have been avoided with an additional member. In all three cases (CAWG Nos. 2, 3, and 44) the engineer was not asleep. CAWG found, in fact, extraneous circumstances played a role in these three cases.

Based on a small sample of 33 trains, an estimate of the percentage of conductors who have experience between 7 and 22 years is 21.2 percent. CAWG has surveyed other industry sources that suggest the percentage of conductors (road and yard) in this experience range could be as high as 42 percent. Conductors with 7 to 22 years experience were not crew members of any violating trains. This suggests conductors in this experience range fulfill their role as additional safeguards in preventing collisions of the CAWG's criteria type.

Recommendation: Crew Composition and Experience
CAWG cannot conclude conductors with fewer than seven years experience are at a higher risk. However, when possible, an inexperienced crew member should be paired with an experienced crew member. Such pairing reduces the risk for the inexperienced crew member; but does not, as CAWG collision cases show in Table 5-4, increase the risk for the experienced crew member.

ALERTNESS

Findings and Discussion: Alertness
The methodology employed by CAWG in studying alertness includes: (1) defining alertness, for purposes of railroad operations, as to whether or not any action was taken; (2) examining available information concerning each crew member's sleep history, sleep period, work period, and time of event; and (3) consulting a sleep expert to independently evaluate CAWG's assessment of cases involving alertness.

After completing its review of each collision case, CAWG found that 19 of 65 cases – nearly 30 percent – involved alertness as a PCF.

Findings and Discussion: Alertness
Research indicates that degradation of employee alertness can lead to lapses in attention, slowed reactions, and impaired reasoning and decision-making that have been shown to contribute to accidents, incidents and errors in a host of industrial and military settings. Collectively, these effects have been described as 'fatigue' or 'impaired alertness'. CAWG adopted a data driven approach that focuses on observable behaviors of alertness, i.e., attention to and appropriate responses to one's surroundings rather than the less exact term fatigue that has various meanings for different people. Some collisions appear to

reflect impaired alertness since appropriate actions were not taken. Impaired alertness may be traced to a number of variables. Here the focus is on two main causes:

- Amount of sleep a person has had in the recent past
- Time of day

Many sleep experts believe the average person should obtain about eight hours of sleep per day to maintain peak alertness. Sleep induced impairments in alertness fall into two main categories. The first kind of problem occurs when a person does not get sufficient amounts of sleep each day, extending over a series of days. This produces what is called a sleep debt, a difference between the average amount of sleep actually obtained and the amount of sleep the person needs to maintain alertness. This may be caused by a number of factors including, but not limited to, problems obtaining sleep during off duty time (trying to sleep during the day or in an unfavorable environment), excessive work and associated work demands, such as commuting. Such chronic sleep debt factors may limit the amount of time to get sleep, compromise the quality of sleep or involved sleep disorder, such as sleep apnea. All of these factors can cause an accumulated sleep debt that can impair alertness.

The second kind of sleep problem occurs when a person has been awake more than sixteen hours since their last major sleep episode, called acute sleep debt. Ideally, people sleep eight hours a day and are awake for sixteen hours. Once the awake period exceeds sixteen hours, there is increasing pressure to go to sleep, which is reflected as a gradual loss of alertness and an increased potential for lapses. Problems from acute sleep debt can occur even when a person has been generally getting eight hours of sleep per day. A classic example of acute sleep debt can occur when a person awakens in the morning at 6 am after sleeping regularly from 10 pm to 6 am and does not take any naps prior to going to work in the evening. If work starts twelve hours after awakening and the work period is eight hours long, the person will have been awake for twenty hours at the end of the shift and may experience an acute impairment of alertness during the last half of the work period.

The time of day can induce problems with alertness because the human body has a biological rhythm that modulates alertness. People who are adjusted to day-time work are generally most alert during the hours from 8 am to 8 pm and experience impaired alertness between midnight and 6 am. This is called the circadian rhythm and is a property of many biological systems, including the brain. The exact timing of the rhythm can be changed by environmental factors. For example, when traveling to a new time zone, it can take many days for the rhythm to realign to the new time for sleep and wakefulness. If a person shifts from a day job to a night job, requiring sleep during the day, it may take many days or weeks for that person to adjust to that new routine. During the period of adjustment, the person will experience impaired alertness.

The two causes of impairments to alertness – sleep debt and time of day – are additive. A person working at four in the morning will be more impaired if also sleep deprived compared to a person at that same time who has been getting plenty of sleep and has been awake for only a few hours.

In summary, there are a number of variables that can impair alertness: chronic sleep debt, hours since awakening, and time of day. To determine the level of alertness impairment a crew member might experience, CAWG gathered evidence from numerous sources, including witness statements and interviews, event recorder data, and available work/rest histories of the crews. CAWG reviewed and analyzed each crew member's sleep history, sleep periods, work periods, and time of event.

After completing its review of each collision case, CAWG found that 19 of 65 cases – nearly 30 percent – involved alertness as a PCF. Realizing the importance of the alertness issue, CAWG asked Dr. Stephen Hursh, a sleep expert already working for FRA, to independently review CAWG's findings concerning each of the 19 cases. The expert corroborated CAWG's independent alertness evaluations. Material reviewed by Dr. Hursh originated from Federal Railroad Administration investigations, and in some cases National Transportation Safety Board investigations. CAWG then compared his alertness assessment with that of its independent findings, the result being that CAWG's methodology was determined sound.

Recommendation: Alertness
CAWG makes several general observations suggesting avenues for improvements in railroad industry habits and procedures to reduce the incidence of impaired alertness. First, working between midnight and 8 am is an operational necessity that entails an operational risk. This risk needs to be further recognized and countered by the railroad industry. The circadian impairment in alertness that occurs at this time of day is a biological fact. No amount of training, conditioning, or motivation can eliminate the risk of lapses in attention that can occur at these hours. Procedural innovations should be devised to create redundancy and error checking to counter this natural phenomenon.

CAWG believes adequate sleep leading up to night work and napping immediately prior to a night shift are important countermeasures for minimizing the effects of the circadian reduction in alertness occurring between midnight and 8 am. Getting this sleep is a shared responsibility of employees and management. The employees must be trained and encouraged to:

- Understand the importance of adequate sleep and good sleep hygiene.
- Make personal decisions to incorporate evening naps into their daily routines.
- Plan activities so sleep is properly timed to minimize both chronic and acute sleep debt.

Management has a major role in enabling these behaviors. Unexpected or unplanned calls to work in the evening make it difficult for employees to take naps in anticipation of an evening call. It is unrealistic to expect employees to take naps in the evening when the family is at home unless there is a reasonable expectation they will be called to work. In short, evening calls for night work should be as predictable as possible. An unexpected call in the morning for a day shift is almost never a problem for alertness because it usually follows a night of sleep and coincides with the up-swing in normal circadian alertness. Unexpected calls in the evening are precisely the opposite; the person has already been awake for ten to twelve hours and will experience acute sleep debt. The work shift will coincide with the down-swing in circadian alertness. Operational procedures that increase the predictability of evening and night calls make it possible for employees to take necessary naps that minimize impairments to night-time alertness.

INTRA-CREW COMMUNICATION

Findings and Discussion: Intra-crew Communication
CAWG examined the interviews conducted and data reported for the crews, attempting to document each individual's performance of assigned duties during the time previous to the collision when track authority was exceeded and up to the actual impact, noting whether the crew member stayed aboard or jumped.

Recommendation: Intra-crew Communication
When there are two or more train and engine service employees in the cab of a locomotive, there should be an established process to ensure that every wayside signal, directive, instruction, and order is clearly and completely understood and properly executed by every crew member. Other activities must not interfere with the safe operation of the train. Particular attention to movement authority is needed when trains meet, one train overtakes another train, or when train operations occur in the vicinity of yards or industries where other train movements take place. There are ongoing crew resource management efforts.[5]

HIGH-RISK HOLIDAY PERIODS

Findings and Discussion: High-Risk Holiday Periods

[5] The FRA's Human Factors Research Program and the Office of Safety have jointly sponsored an extensive program of research and development on crew resource management (CRM) training in the railroad industry. The CRM program has four components: 1) a review of CRM training methods, the types of teams found in the railroad industry, and the matching of team types with the most appropriate CRM training methods; 2) the development of curricula appropriate for CRM training for crews in transportation crafts (locomotive engineers, conductors, dispatchers, switchmen, brakemen), engineering crafts (MOW, signal maintainers, electrical catenary crews), and mechanical crafts (machinists, electricians, pipe fitters, carmen); 3) the implementation and evaluation of a pilot training program at a Class I railroad; and 4) the development of a business case for CRM training in the railroad industry.

Reports on the components of the CRM program are under review and will be posted on the FRA website when approved for publication. In addition to these reports, training course materials for the transportation, engineering and mechanical crafts will also be available.

While main-track train collisions have occurred at any time of year, based on the 65 collisions reviewed by CAWG, there are two high-risk periods for main-track train collisions:

- One week period bracketing Independence Day (July 4th.).
- Three-week period bracketing Christmas (December 25th) and New Year's Day (January 1).

In the six-year period 1997 through 2002, there were 10 collisions during the four-week (per year) holiday period. This exposure over the six-year period equals 24 weeks (6 x 4). Ten collisions over 24 weeks is an incidence risk of 0.42 collisions per week (10 / 24 = 0.42). The remaining 55 collisions occurring over the complementary six-year, 288-week period (6 x [52 – 4]) corresponds to an incidence risk of 0.19 (55 / 288 = 0.19). The relative risk (RR) for the four-week holiday period is 2.21 (RR = 0.42 / 0.19). A statistical test applied to the differences in incidence risk indicated significance at the 95 percent level.

Reasons for the increased risk are not apparent from the review of the 65 main-track train collisions. If train traffic is reduced during the two holiday periods above, then the increase in risk during these four-weeks is more dramatic. Three other holiday periods – Memorial Day, Labor Day, and Thanksgiving – were not found to be at higher risk.

Recommendation: High-Risk Holiday Periods
The potential exists for the industry to better understand the reasons for the high-risk periods for main-track train collisions. Identifying the reasons could bring opportunities for prevention. Studies directed towards understanding should be undertaken. These studies need not be specific to main-track train collisions. Studies could include all human-factor related undesirable outcomes including collisions and employee casualties. These findings may identify and reduce risk during holiday periods.

The industry should alert employees to the increased risk during these periods.

END OF TRAIN DEVICES (EOT),
49 CFR Part 232, Subpart E

Findings and Discussion: End of Train Devices (EOT)
CAWG could find little evidence of testing and data collection on the effects of EOT activation in emergency train brake applications. How much stopping distance was actually saved by simultaneous application of the EOT? Obviously, train speed effects distance in feet. CAWG wonders whether it is proportional for speed, or if the percent benefit in stopping distance saved is greater for higher train speeds. CAWG conducted a literary search for industry data on any available research and testing on this issue. CAWG was unable to establish any definitive research or studies.

CAWG canvassed the railroad industry with little success. A few railroads responded with experience, mostly anecdotal that with the existing train brake system, "The automated feature for the 2-way valve on the rear of the train has minimal affect on stopping distance. If the emergency application actually occurred simultaneously at both ends of the train (as simulations we performed were done to evaluate this issue) stopping distance is improved approximately 10%."

Recommendation: End of Train Devices (EOT)
Training programs should be created, conducted, and documented on a continuing regular basis to ensure engineers are able to instinctively activate the EOT when the train brakes are put into emergency. CAWG suspects that junior engineers are probably made aware and qualified during their training. More senior engineers are of greater concern to CAWG, since instruction and review of the practice must overcome years of experience without a two way EOT to activate. This shortcoming potential for more senior engineers may manifest itself under time-critical performance of operational duties. EOT training should be included in locomotive engineer evaluations and, when possible, in rule efficiency checks. Training should also include train crew awareness of whether or not the locomotive in the lead that they are operating will activate the EOT automatically; or whether it requires manual activation. This question becomes critical as more of the new locomotives come on-line.

All locomotives ordered on or after August 1, 2001, or placed in service for the first time on or after August 1, 2003, shall be designed to automatically activate the two-way, end-of-train device to effectuate an emergency brake application whenever it becomes necessary for the locomotive engineer to place the train's air brakes in emergency. [from 49CFR Part 232.405(f)][6]

Data driven simulation and actual research should be conducted and published for the railroad industry, and train crews in particular, to clearly understand the impact and importance of this issue; and the effects of EOT activation when the train brake is placed in emergency from the lead locomotive.

CRASHWORTHINESS

Findings and Discussion: Crashworthiness
Locomotive crashworthiness is important to the survivability of locomotive crews given that a collision has occurred. The intent of CAWG was not to determine the crashworthiness of various locomotives, or the advisability of crews staying in, or jumping from, the locomotive given collision certainty. However, from the review and analysis of the 65 collision cases, information was generated of likely interest to those engaged in locomotive crashworthiness. CAWG wants to make those interests aware of this information now contained in the CAWG Database.

[6] During the 1990s, prior to this requirement, several railroads had initiated this practice.

Some analysis, however, was performed. Logistic regression was used to analyze the risk of injury and fatality in collisions from the decision to jump from, or stay in, the locomotive. This multivariate technique controls for confounding variables while testing the effect of interest – whether the employee's decisions to exit or stay, given collision certainty, changed the risk of injury or fatality. Factors controlled for affecting the risk were: train speed, collision type, whether the locomotive was built to S-580 standards. The current S-580 standards are contained in the Appendix. CAWG again stresses that crashworthiness was not a study purpose, and its review and analytical methods did not include a study design to best capture crashworthiness information.

The analysis produced the following results:

- The probability of injury was greatly affected by the decision to exit or stay with the locomotive. Eighty-seven percent of employees who exited the locomotive were injured compared to 51 percent who stayed with the locomotive.

- There was no significant indication in the data that the decision to exit or stay with the locomotive changed the likelihood of fatality. The probability of a fatality was greatly affected by train speed.

Recommendation: Crashworthiness
CAWG suggests that future groups studying crashworthiness may find our efforts of some use as a baseline point as enhanced safety equipment and changes brought on by the continued development of S-580 standards. (Refer to Federal Railroad Administration's (FRA's) Website.[7])

OPERATING METHODS

Findings and Discussion: Operating Methods
CAWG compared collisions occurring in Traffic Control System (TCS) territory to those occurring in train order territory[8] (e.g. track warrant territory). The purpose of the comparison was to determine whether the number of collisions per million train miles is different in one type of territory versus another. The comparison was difficult to conduct because the current accident reporting form does not have a consistent process of reporting methods of operations. (See the finding on accident reporting below.)

After considerable review and discussion, CAWG was able to determine the method of operation for all collisions. Table 5-14 shows 45 CAWG collisions in TCS territory and

[7] On Federal Railroad Administration's (FRA's) Website: Click on 'Research and Development', then 'Research Reports'. Studies include DOT/FRA/ORD-02/03, DOT/FRA/ORD-01/23, DOT/FRA/ORD-95/08, and DOT/FRA/ORD-95/08I through 95/08V.
[8] *Train order territory* is defined herein as territory within which written authority is required for train movements.

12 collisions for train order territory.[9] The remaining 8 collisions occurred in other situations.

Table 5-14. Collisions by Territory Type

Territories from Volpe Center Study	Train Miles from Volpe Center Study	CAWG Collisions	Collisions per million Train Miles
Auto	44,220,891	6	
CTC	300,580,358	39	
Total for TCS	**344,801,249**	**45**	0.131
ABS	80,773,696	8	
Dark	58,600,600	4	
Total for Train Orders	**139,374,296**	**12**	0.086
Interlockings, Yard Limits, Form Bs	-----	8	-----

Using estimated train miles by territory from a Volpe Center study,[10] CAWG was able to form an estimated collisions per million train miles for each type of territory. The collision rate for train order territory, 0.086, is not higher than the collision rate, 0.131, for TCS territory. CAWG expected the number of collisions per million train miles for train order territory[11] to be significantly higher than TCS territory, so this is a surprising result. Most expected the additional computer assisted data and information developed with TCS to reduce exposure unique to train order territory, where additional manipulation and oversight by crew members is required; and thus, train order territory would be expected to be subject to additional human failure.

Two study limitations may account for this unexpected result:

[9] As mentioned, *Train order territory* is defined herein as territory within which written authority is required for train movements.
[10] *Base Case Risk Assessment: Data Analysis & Tests.* Study done by the John Volpe National Transportation Systems Center for the Office of Safety, Federal Railroad Administration. RSAC/PTC Working Group Risk 2 Team. Updated April 19, 2003.
[11] As mentioned, *Train order territory* is herein defined as territory within which written authority is required for train movements.

- CAWG collisions do not represent all collisions.[12] For example, CAWG selected only those collisions having an FRA HQ investigation number; and from those, collisions where trains exceeded authority. Situations where crews improperly gave up authority, such as misaligning a manual switch, are not covered by CAWG.

- Collisions for 2003 and 2004 are not covered in this report. Adding CAWG collisions for these years could change the estimated collision rates in a significant way.

A PCF profile of the two types of territories sheds light on the different collision rates associated with the two territories (Table 5-16).

In train order territory, Table 5-16 identifies problems with intra-crew communication in 4 of the 12 cases; this is a significantly higher ratio than the corresponding ratio for TCS of 5 out of 45 cases.

Table 5-16 also shows all collisions where at least one employee was asleep occurred in TCS territory. Table 5-16 indicates alertness is more of a risk factor in this type of territory. The 12 cases in train order territory did not identify any employee being asleep. This risk factor may partially explain why TCS territory does not exhibit a lower CAWG collision rate than train order territory.

Recommendation: Operating Methods
CAWG suggests a potential finding of differences in crew alertness between TCS and train order territory, but does not make a recommendation.

COLLISION INVESTIGATION AND REPORTING

Findings and Discussion: Collision Investigating and Reporting
Collect Human Factor Data
After reviewing the first 14 collision cases, CAWG decided to rate the quality of the Federal Railroad Administration's investigation. Seven cases (14 percent) were rated 'very good'; 26 (50 percent), 'good'; 17 (34 percent), 'fair'; and 1 (2.0 percent), 'marginal.'

Those cases rated as either very good or good contained detailed information concerning each employee's work history, experience, training, the level of management oversight, and work/rest histories going back at least 10 days. Those cases rated fair or marginal by CAWG did not contain many of the items listed for various reasons. These findings led CAWG to discuss how FRA conducts a collision investigation, what is required, and why FRA does not, as a rule, investigate and document an employee fatality as the result of a

[12] The Volpe Center study formed rates by territory from approximately 800 collisions. These collisions were selected based on being preventable by a Level 3 PTC system and having total damages exceeding the FRA's monetary reporting threshold.

human factors collision with the same level of thoroughness as an employee on duty fatality (FE).

Where human factor issues were not fully developed in cases, CAWG felt that "root cause analysis," with accurate conclusions and beneficial recommendations, could not always be clearly established. However, since the end of the CAWG study period (2002) additional training has been provided for FRA Inspector forces; and regional management has been re-trained on Accident/Incident Investigation Review. This effort, along with personnel changes at FRA's Accident Analysis Branch have led, in many cases, to a more comprehensive and standardized final report, particularly over the last four years. Additionally, the FRA and some railroads are in the process of developing new human factor tools that have the potential to be useful when applied to accident/incident investigation.

Recommendation: Collision Investigating and Reporting
Collect Human Factor Data
FRA should identify and document all relevant human factor data. This data includes crew members' experience on the territory where the collision occurred, their age, experience in craft, and railroad seniority of each of the crew members in the collision (striking and struck crews). A work/rest history that clearly indicates off and on-duty times for both train crews and accompanying paperwork on how off duty time was spent, if possible, should go back a minimum of 10 days. CAWG recommends a review of management oversight for all of the violating train crew-members. The oversight should include training results and a review of the number of efficiency tests performed on each crew member during the last 6 months, the number directly related to the incident and the number of tests passed and failed.

Findings and Discussion: Collision Investigating and Reporting
Update CAWG Database
The experience gained by the Switching Operations Fatality Analysis (SOFA) Working Group (SWG) development and analysis of a data matrix was valuable to the CAWG's work and endeavors. The SWG entered detailed information on the 76 switching fatalities upon which its October 1999 [13] study was based, into a Microsoft® Excel spreadsheet. By continuing to review and add switching fatalities to its 'SOFA Matrix', the SWG created retrievable, electronic records of 124 fatalities. Integrating the information on the additional 48 switching fatalities with that of the original 76 fatalities allowed the SWG to further identify additional operational exposures to fatalities, in the form of Special Switching Hazards, to employees engaged in switching operations. CAWG would benefit from additional case analysis.

Recommendation: Collision Investigating and Reporting
Update CAWG Database
The CAWG Database allows for quick retrieval and querying of information on the 65 main-track train collisions occurring from 1997 through 2002. CAWG recommends that its Database be updated for 2003 and 2004 collisions meeting the established criteria.

[13] *Findings and Recommendations of the SOFA Working Group*. October 1999.

Additional years of information will allow for up-to-date querying to determine present risk factors and commonalities with past collision events.

Findings and Discussion: Collision Investigating and Reporting
Reporting Signal Information
CAWG notes that some collisions occurred in territory where the transiting train encountered the sequence GREEN, YELLOW, RED. CAWG considered the benefit of a fourth signal: FLASHING YELLOW, or two consecutive YELLOWs, giving a greater advanced warning time to an absolute stop signal. Changes in the configuration of existing signals may have provided beneficial results to safe operations in some of the collisions reviewed. However, the data files, which CAWG had available and reviewed, did not contain sufficient data and information on signal systems to establish and/or evaluate. Therefore, CAWG could not make a determination about the collision-prevention value, if any, of a four- signal sequence as opposed to a three.

Many cases contain information about crew members' perceptions of signal aspects prior to a collision. This information was derived from testimonies taken from those affected during post-collision interviews. Given that Distant Signals (the signal preceding a Home Signal) are not routinely equipped with recording devices and therefore cannot create a record of what aspect the Distant Signal was displaying, the investigation regarding specific signal aspects preceding the collision is based upon the testimonies of carrier officials, affected train crew members, signal tests that have been performed on the signals in question and information gleaned from data and event recorders at the Control Point or Interlocking where the collision took place. When these tests and signal reports contradict the crew member's testimony, it is assumed that the crew member did not correctly remember the signal indication. It appears that at times, detailed information on signal issues is not identified, collected, documented, and reported. Until this information is systematically collected, a system wide database cannot be developed capable of being queried regarding the number of collisions occurring in three signal-sequence territory, as opposed to the number occurring in territory equipped with a four sequence-system. Without this level of relevant information and data, CAWG believes that future working groups will be unable to establish specific conclusions and effect meaningful safety improvements.

Recommendation: Collision Investigating and Reporting
Reporting Signal Information
In an effort to build a reliable data base, CAWG recommends that reporting of post incident testing involving signal systems include information on the type of signal system, model number of signal apparatus, and aspects from each signal. Aspect information should be gathered from an adequate number of signals to clearly identify all those relevant to the incident. Signal apparatus information should include the type and number of heads located on each signal mast.

Finding and Discussion: Collision Investigating and Reporting
Reporting Method of Operations

CAWG found inconsistencies regarding the entries made to field number 30 (Methods of Operation) on form *FRA F6180.39* used by FRA Investigators to record objective data about the accident they are investigating. Often, commingling signal authority with safety overlays. For instance, a train operating in Traffic Control System (TCS) territory will also be governed by automatic block signals; therefore, it is redundant to use both the "e" and the "g" codes. Further, the practical difference between "I"-Timetable/train order, "j"-Track warrant, and "k"-Direct traffic control is negligible when annotating a block used to indicate a "method of operation" and could certainly be spelled out later on in the report if necessary to clarify why the accident occurred as the result of one of these methods of operation and may not have happened using another. [Deleted paragraph beginning with:" Additionally,..."

CAWG invested considerable effort to convert the reported codes into a framework that was useful for analysis.

Recommendation: Collision Investigating and Reporting
Reporting Method of Operations
FRA should review block 30 on the most recent form *FRA F6180.39* (Revised July 2003) and determine which methods of operation belong in the block, which methods of operation should be combined, and which methods should be removed. CAWG believes FRA would create a more standardized and efficient way of sorting on the method of operation in effect at the time of the incident.

OVERVIEW

In June 2002, Allan Rutter, then Administrator for the Federal Railroad Administration, proposed creation of the Collision Analysis Working Group (CAWG) for the purpose of reviewing main-track train collisions with the intent of making preventive findings and recommendations should the facts warrant.

CAWG held its first meeting on July 17-18, 2002; and its final meeting on February 9-11, 2005. During the intervening period, CAWG met twenty-six times to review and analyze 65 main-track train collisions and to develop findings and recommendations based on the commonality of facts. Often these collisions resulted in personal injuries or fatalities. This study discusses the review and analysis of the 65 main-track train collisions, the principles upon which this process was based, and the findings and recommendations thought helpful in preventing similar occurrences.

Because of continuing fatalities to employees engaged in switching operations, CAWG members, all who serve as Switching Operations Fatality Analysis Group representatives, suspended their CAWG work and researched, analyzed, and wrote the report *Findings and Recommendations of the SOFA Working Group: August 2004 Update*, as well as releasing other switching operations safety information.

1. INTRODUCTION

1.1 CAWG Scope

CAWG reviewed and analyzed 65 main-track train collisions occurring from January 1997 through December 2002. These collisions, of both freight and passenger trains, involved human-factor issues. In this study, the review and analysis process is described and findings and recommendations, based on commonalities, are given to prevent future main-track train collisions.

1.2 Background of CAWG

Federal Railroad Administrator Allan Rutter proposed on June 4, 2002, that a Collision Analysis Working Group (CAWG) be established to review and analyze main-track train collisions and make safety findings and recommendations based on commonalities – should the facts warrant. This proposal provided the railroad industry with an unique opportunity to re-examine relevant safety policies and practices. Administrator Rutter encouraged participation from representatives of the railroad industry.

Holding its first meeting on July 17-18, 2002, in Alexandria, VA, CAWG initially agreed to review 49 collisions where human factors contributed to trains exceeding their authority by (1) passing a stop signal; (2) failing to comply with a signal requiring restricted speed; (3) entering territory without a train order, track warrant, or direct traffic control authority. These 49 main-track train collisions occurred during a five-year period from January 1, 1997 through December 31, 2001.

Subsequently, at its August 2003 meeting, CAWG expanded the number of collisions it would review, by adding the 16 qualifying main-track train collisions occurring in 2002. The decision was based on two factors. First, to increase the number of collisions being reviewed so any commonalities would become more apparent; and second, to make the findings and recommendations contained in this study as current as possible. CAWG believes these 65 collision cases are enough to find meaningful commonality while not unduly delaying collision-avoiding information from reaching the railroad industry.

The first collision case reviewed by CAWG occurred on July 2, 1997 at Kenefick, KS, No. 1. (*CAWG No.s*, indicating the review order, are used to uniquely reference each case.) The most recent collision reviewed occurred on November 5, 2002 at Valley Pass, NV, No. 65. Cases were not necessarily reviewed in chronological sequence of occurrence. A narrative summary of each collision case is included in the next section of this study, referenced by its CAWG No.

Each of the six years, 1997 through 2002, contains all the main-track train collision cases that met CAWG's selection criteria described below. However, all of the 2003 investigations were not completed when the review of these 65 cases was finished. CAWG felt extending the publication date of this study would unduly delay this collision-avoiding information from reaching the railroad industry. CAWG stresses that many collisions were associated with human casualty both to railroad employees and passengers, a fact re-emphasizing the importance of timely dissemination of prevention information.

Because of continuing fatalities to employees engaged in switching operations, CAWG members, all who serve as Switching Operations Fatality Analysis Group representatives, wrote and issued the report *Findings and Recommendations of the SOFA Working Group: August 2004 Update*, as well as releasing other switching operations safety information.

1.3 Objectives

CAWG's main collision review and analysis provides the railroad industry with an opportunity to re-examine its safety policies and practices based on commonality of facts found among the 65 collisions.[14] Taking note of the findings and recommendations will ensure reasonable precautions are taken to prevent future collisions.

1.4 Methods

Selection criteria

CAWG's review and analytical methods consisted of case selection based on a series of main-track train collisions occurring, 1997 through 2002, involving human factor issues:

- Collisions must have been assigned a FRA HQ investigation number. All Amtrak collisions are assigned a FRA HQ investigation number. Note, not all freight collisions receive a FRA HQ investigation number. Thus, the 65 selected main-track train collisions consist of all Amtrak collisions plus the major freight collisions assigned a FRA HQ investigation number, occurring during the study period.

- Each collision must occur during main-track train operations. Thus, yard collisions are eliminated. Yard collisions may result from different factors than main-track train collisions.

- Except for passenger trains[15], each collision must involve a train having at least two crew members on the locomotive consist. Collisions occurring during switching operations and miscellaneous one-person train crews are eliminated.

- Each collision must involve a train exceeding its authority by (1) passing a stop signal; (2) failing to comply with restricted speed; and/or (3) entering territory

[14] Contemporary accident investigation goes beyond the simplistic approach of blaming the accident on the operator(s) and moves toward a comprehensive analysis where human error is seen as a symptom of deeper trouble. In this procedure, an accident event is an opportunity to recognize that human error is the starting point for an investigation. The investigation ought to reveal how human error is systematically connected to the tools, tasks, operations, and organizational environment.

[15] Qualifying passenger train collisions are included even though many passenger trains are operated with a lone engineer. The criteria concerning "at least two crew members on the locomotive consist," to eliminate switching operations, does not apply to these types of movements.

without train order, track warrant, or direct traffic control authority. Thus collisions resulting from vandalism and adjacent track events are eliminated.

Review process

After selecting 65 cases meeting its criteria, CAWG reviewed and discussed each case. CAWG members were assigned cases as 'homework' to become familiar with, and present a case description at the next CAWG meeting. Case information was derived from Federal Railroad Administration investigations and, in some instances, National Transportation Safety Board investigations.

During the presentation, quantitative and narrative case information was entered into a Microsoft® Access database that came to be known as the 'CAWG Database'. Descriptive information entered included:

- Collision location, time, weather;
- Operating conditions noting any special restrictions;
- Consist characteristics noting any defects; and
- Crew description and location during the time previous to the collision when authority was exceeded and up to the actual impact, noting whether crew stayed onboard or jumped.

Appendix H provides a full listing of data elements used. After entering the detailed description information for each of the 65 collision cases, CAWG began its discussion of commonalities and causality, the latter often being expressed as Possible Contributing Factors (PCFs). CAWG's approach to causality, based on PCFs, is discussed below along with coding conventions to capture, in retrievable form, key aspects of causality.

Analysis – searching for commonalities

As mentioned, once review of the 65 cases was completed, and a quality check made of the information contained in the CAWG Database, the process of discovering commonalities began. The CAWG Database, with its Boolean[16] search and retrievable characteristics, allowed quick calculation and display of commonalities among the 65 collision cases without interrupting CAWG's flow of discussion and analysis. CAWG, based on the consensus of its members, developed findings and recommendations from the commonality of information contained in the CAWG Database. CAWG findings and recommendations in general involve human factor issues: alertness including work/rest and shared crew responsibility issues, crew experience and optimal makeup based on that experience, and operation procedures and methods.

[16] Boolean searches allow the joining of simple searches or queries by the words *and*, *or* and *not*. For instance, the CAWG Database can retrieve information on collisions occurring between 4 and 6 am, *and* involving crews with less than five-years experience *or* more than thirty-years experience, but *not* the result of extreme environmental conditions.

1.5 CAWG's Approach to Causality

CAWG developed an approach to collision 'causality' based on consideration of an often complex combination of rail-system operating characteristics, conditions, and events.[17] CAWG in determining causality does not attempt to rank these factors, usually expressed as Possible Contributing Factors (PCFs).

CAWG used the FRA's "Train Accident Cause Codes"[18] and its own defined codes as the basis for PCFs. Each collision was assigned as many PCFs as CAWG believed applied; however, the number of PCFs applied to a collision case did not go beyond the number necessary to capture the essence of the identified factors. CAWG avoided redundancies. As mentioned above, CAWG does not attempt to rank PCFs. Causal information not appropriately captured by a PCF was described in narrative form.

1.6 Study Limitations

CAWG recognizes its review of 65 main-track train collisions contain limitations to the type and depth to which safety-related issues were explored. Such limitations apply to crashworthiness, alertness, crew resource management, and other subject areas affecting safe operations. Safety studies, in general, make advances to existing knowledge and with additional information and thought undergo modification. As such, this study offers opportunity for subsequent safety groups, and subject-matter experts, to improve operating practices by exploring in depth the issues raised in, and related to, this study.

1.7 Results

Findings and recommendations made in this study apply to main-track train collisions and not yard, highway-rail, or switching operation collisions. Rarely are main-track train collisions the result of a single factor or cause. Review of the 65 collisions clearly establishes that most collision events are a combination of unrelated factors and deviations occurring at the same time, at the same location, and on the same train. Sometimes, these factors and deviations do not rise to the level of identifiable violations of operating rules, federal regulations, and/or industry standards; the greater the number of factors and deviations present, the more likely a collision.

1.8 Importance of Collision Prevention

Eliminating main-track train collisions will prevent enormous harm. CAWG wants to emphasize that although the 65 collision cases are 'accidents' in the sense physical damage exceeded the Federal Railroad Administration defining monetary threshold, main-track train collisions often are associated with human casualties. The 65 main-track train collisions resulted in 16 fatalities and 531 injuries. There were 14 employee fatalities and 128 employee injuries; 2 passenger fatalities and 403 passenger injuries.

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[18] Contained in Appendix C, pages 1-11, of the *FRA Guide for Preparing Accident/Incident Report*. Federal Railroad Administration. 1997.

(One passenger collision in Placentia, CA, No. 53, accounted for all the passenger fatalities and 163 passenger injuries.) There was $83,108,072 in track, signal, lading, and equipment damage. The most damage in one collision (Pacific, MO, No. 49) was $7,855,920, average damage being $1,278,586. There were 42 hazardous material cars derailed, and four hazmat releases. Numerous other costs – direct, indirect, and opportunity – are associated with collisions, some calculable, some not.

2. SIXTY-FIVE MAIN-TRACK TRAIN COLLISIONS

2.1 Overview

This study is based on the Collision Analysis Working Group (CAWG) review of 65 collisions occurring from January 1997 through December 2002. The selection criteria for those collision cases are described below. Information from the review and analysis was entered into the CAWG Database, allowing for quick retrieval and querying of information as an aid in establishing commonalities. CAWG's intent is to ensure that subsequent main-track train collisions will be added to the CAWG Database, thereby allowing for up-to-date analysis. A narrative summary of each of the 65 cases is presented at the end of this section.

2.2 Selection Criteria

CAWG's selection criteria for the 65 main-track train collisions was presented in the Introduction and is repeated here for reference:

- Collisions must have been assigned a FRA HQ investigation number. All Amtrak collisions are assigned a FRA HQ investigation number. Note, not all freight collisions receive a FRA HQ investigation number. Thus, the 65 selected main-track train collisions consist of all Amtrak collisions plus the major freight collisions assigned a FRA HQ investigation number, occurring during the study period.

- Each collision must occur during main-track train operations. Thus, yard collisions are eliminated. Yard collisions may result from different factors than main-track train collisions.

- Except for passenger trains[19], each collision must involve a train having at least two crew members on the locomotive consist. Collisions occurring during switching operations and miscellaneous one-person train crews are eliminated.

- Each collision must involve a train exceeding its authority by (1) passing a stop signal; (2) failing to comply with restricted speed; and/or (3) entering territory without train order, track warrant, or direct traffic control authority. Thus collisions resulting from vandalism and adjacent track events are eliminated.

2.3 Collision Case Summaries

The 65 main-track train collision cases are listed in Table 2-1 in chronological order. Each case was assigned a CAWG reference number. These numbers were assigned in the

[19] Qualifying passenger train collisions are included even though many passenger trains are operated with a lone engineer. The criteria concerning "at least two crew members on the locomotive consist," to eliminate switching operations, does not apply to these types of movements.

order the cases were reviewed, which is slightly different from the chronological occurrence of the collisions.

Table 2-1. Sixty-Five Main-Track Train Collisions, 1997 through 2002

#	Location	Date	CAWG No.	#	Location	Date	CAWG No.
1	Lagro, IN	05/31/97	6	34	Kenner, LA	12/21/00	29
2	St. Albans, WV	06/07/97	7	35	Malden, TX	12/21/00	30
3	Kenefick, KS	07/02/97	1	36	Woodburn, IA	12/27/00	31
4	Hummelstown, PA	09/29/97	5	37	Racine, MO	01/14/01	38
5	North Bay, CA	10/16/97	8	38	Syracuse, NY	02/05/01	3
6	Borderland, WV	10/23/97	9	39	Carlisle, OH	02/17/01	39
7	Houston, TX	10/25/97	10	40	Richmondville, NY	04/09/01	40
8	Navasota, TX	10/29/97	12	41	Glenwood, IA	08/18/01	41
9	Welka, AL	11/02/97	13	42	Ransom, IL	08/20/01	42
10	Alvord, TX	11/03/97	4	43	Jacksonville, TX	09/07/01	43
11	W. Memphis, AR	12/14/97	11	44	Hallsville, TX	09/11/01	44
12	Herington, KS	03/23/98	14	45	Wendover, UT	09/13/01	45
13	Butler, IN	03/23/98	15	46	Andersonville, MI	11/15/01	46
14	Creston, IA	03/28/98	16	47	Mayfield, OH	11/28/01	47
15	Orin, WY	09/12/98	17	48	Pacific, MO	12/13/01	49
16	Stryker, OH	01/17/99	18	49	Kenner, LA	12/15/01	50
17	Momence, IL	03/23/99	19	50	Bradford, IL	01/01/02	51
18	Mt. Pleasant, TX	04/15/99	20	51	La Porte, IN	02/03/02	52
19	Jacksonville, FL	07/01/99	2	52	Placentia, CA	04/23/02	53
20	Palm Springs, CA	07/05/99	21	53	Douglas, WY	05/11/02	54
21	Perkins, WY	07/22/99	32	54	Clarendon, TX	05/28/02	55
22	Clinton, IA	08/11/99	33	55	Aurora, IL	06/12/02	56
23	Wickes, AR	09/13/99	34	56	Leesburg, TX	06/16/02	57
24	Cumberland, MD	09/20/99	35	57	Baltimore, MD	06/17/02	58
25	Waldeck, KS	11/13/99	36	58	North Platte, NE	06/19/02	59
26	Fullerton, CA	11/18/99	37	59	Jamaica, NY	06/22/02	60
27	Tyrone, OK	06/01/00	22	60	San Bernardino, CA	06/30/02	61
28	Cincinnati, OH	09/04/00	23	61	Vader, WA	09/15/02	62
29	Kingman, AZ	09/16/00	24	62	Reddick, IL	10/10/02	63
30	Bellemont, AZ	10/31/00	25	63	Des Plaines, IL	10/21/02	64
31	Yarmony, CO	11/04/00	26	64	Valley Pass, NV	11/05/02	65
32	Laredo, MO	11/20/00	27	65	Swenney, TX	12/06/02	48
33	Murray, NE	12/18/00	28				

Narrative summaries, written by CAWG, for each of the 65 collision cases are presented below. Summaries of 2003 and 2004 collision cases, qualifying for CAWG review, are also given. As mentioned, the 2003 cases for which some investigations had been completed, and the 2004 cases, were not reviewed to allow for timely release of the study's findings and recommendations.

CAWG No. 1 Kenefick, KS **02-Jul-97**
At about 0215, in CTC territory, a westbound freight train moving at 1-2 mph struck the side of a 70 mph eastbound freight train six cars behind the engine at the west end of the controlled siding at Kenefick, near Delia, KS. A serious diesel fire engulfed hazmat cars that were derailed. 1500 people were evacuated. The engineer on the westbound train died in the collision.

CAWG No. 2 Jacksonville, FL **01-Jul-99**
At 0309, a southbound passenger train attempting to pass through a three-mile long temporary DTC block, where a signal suspension was in effect, ended up striking the side of a northbound passenger train which was taking the siding at 13 mph through a hand-throw switch. The lone engineer on the southbound train attempted to communicate with switch tenders inside the signal suspension territory via radio to comply with the requirement in a General Bulletin while maintaining the 59 mph track speed and failed to stop at the first operational controlled signal at the south end of the suspension where the northbound train was diverging.

CAWG No. 3 Syracuse, NY **05-Feb-01**
At 1140, a passenger train that had just made a crew change, accelerated to 59 mph before passing a signal that required restricted speed. The passenger train collided with the rear end of a freight train that was standing on a right hand curve. The lone engineer had distracted himself while running by turning and reaching down into his grip. One of two locomotives and four of the five passenger cars were derailed.

CAWG No. 4 Alvord, TX **03-Nov-97**
At about 1210, a relatively inexperienced engineer and a conductor with less than one year of experience operated a loaded coal train in TWC/ABS territory. Due to an obstructed brake pipe, the air brakes on the striking train failed to stop the train at the end of its authority. The rear-end collision with an empty coal train occurred at a speed of approximately 15 mph. Both crew members jumped prior to impact and received only minor injuries.

CAWG No. 5 Hummelstown, PA **29-Sep-97**
At 1745, a 13,000-ton freight train collided with a standing light engine. Before the collision, the engineer on the striking train put his train in emergency and followed the conductor out the rear door of the locomotive. The conductor was killed in the ensuing collision. The lens of the previous signal was later discovered to be discolored by water in the signal head and reenactments of the incident showed that the signal was displaying a "phantom" aspect.

CAWG No. 6 Lagro, IN **31-May-97**
At about 740, a westbound train with a crew which had been on duty for over 11 hours passed a stop signal at the west end of a controlled siding and struck the side of an eastbound train at a speed of about 9 mph. The conductor sustained minor injuries.

CAWG No. 7 St. Albans, WV **07-Jun-97**

At 2205, an 8100-ton eastbound mixed freight train being operated by an experienced engineer and a qualified conductor (with a student conductor on board), struck the rear end of an eastbound coal train standing just beyond an intermediate signal. An Approach Signal was displayed 1.4 miles from this Restricted Proceed grade signal. The speed at the time the striking train went into emergency was 39 mph. Speed at impact was approximately 30 mph. The rear car of the standing train climbed the nose of the striking locomotive and the engineer was killed. Hazmat was released from a punctured tank car and a fire ensued.

CAWG No. 8 North Bay, CA **16-Oct-97**

At about 1500 on October 16, 1997, after waiting five minutes, a local switcher with two locomotives and 15 cars entered the main on TWC authority in ABS territory at a hand-throw switch. The crew exceeded restricted speed and was unable to stop short of a standing cut of cars set out on the main without authority at the next station east of them. Speed at impact was 22 mph. Two platforms of a five-car articulated set were derailed.

CAWG No. 9 Borderland, WV **23-Oct-97**

At 1305 hours, a westbound train being operated by a student engineer (under the guidance of a qualified engineer) failed to stop at a crossover in Traffic Control territory and ran out into the path of a 12,000-ton eastbound coal train approaching the crossovers on a diverging-clear signal. The westbound train was stopped when the collision occurred. All crew members jumped and several received serious injuries.

CAWG No. 10 Houston, TX **25-Oct-97**

At 1450 hours, a westbound train collided head-on with a standing eastbound train in CTC territory. The westbound train crew passed an Approach Signal and was attempting to slow the train but an obstruction in the brake pipe of the fourth locomotive on the striking train prevented the proper operation of the air brakes.

CAWG No. 11 West Memphis, AR **14-Dec-97**

At 0455 hours, a westbound freight train struck the side of a southbound freight train at an automatic interlocking in CTC territory (CTC for both railroads). The westbound, very experienced engineer had made several small brake pipe reductions while in idle, but failed to put the train into emergency soon enough to stop short of the absolute stop signal. He did induce an emergency application with the EOT device just before impact at 13 mph.

CAWG No. 12 Navasota, TX **29-Oct-97**

At 0420 hours, a southbound freight train collided with the rear end of a southbound freight train that had stopped in CTC territory to do work. The striking train hit the standing train at a speed of 25 mph derailing the rear car of the standing train, the two striking locomotives, and ten cars of the striking train. No one was seriously hurt on either train.

CAWG No. 13 Welka, AL **02-Nov-97**

At 1013 hours, an engineer operating a two locomotive light consist from the trailing end collided with the rear end of a train which was standing on a curve. The striking train had come out of a passing track after having been run around. The crew of the striking train had not changed ends when reversing direction after a switching move and poor communication contributed to this collision.

CAWG No. 14 Herington, KS **23-Mar-98**

At 1055 hours, a westbound manifest freight train struck the rear end of a westbound intermodal train. A crimped air hose on the seventh car was found to have restricted airflow when the engineer attempted to slow down for the yellow and flashing red signals. The restricted brake pipe interfered with the train's braking power; and the rear end device was not activated from the head end.

CAWG No. 15 Butler, IN **25-Mar-98**

At 0448 hours, a southbound freight train struck the side of an eastbound freight train where the two railroads intersected. The speed at impact was 30 mph. A student engineer was running from the controlling locomotive that had its long nose forward. The conductor on the striking train was killed after jumping from the rear catwalk just before the collision.

CAWG No. 16 Creston, IA **28-Mar-98**

At 1035 hours, an empty westbound coal train struck the rear of a preceding standing empty westbound coal train at a speed of 30 mph while operating through yard limits on the main. The engineer placed the train into emergency approximately 20 seconds prior to impact, at a speed of 50 mph, but did not activate the EOT from the head end.

CAWG No. 17 Orin, WY **12-Sep-98**

At 2035 hours, an eastbound loaded coal train (16,000 tons) collided with the rear end of a standing loaded coal train at a speed of 35 mph. Inexperience and territorial unfamiliarity induced the engineer of the striking train to operate without regard for the for the grade, the signals, and his ability to stop the train in accordance with signal indications. The conductor did not sufficiently monitor the engineer's performance.

CAWG No. 18 Stryker, OH **17-Jan-99**

At 0158 hours, while operating in dense fog, a westbound freight train moving at 56 mph struck the rear end of a freight train moving at a speed of less than 10 mph. Event recorder data showed no braking activity prior to impact. The engineer and conductor on the striking train were killed.

CAWG No. 19 Momence, IL **23-Mar-99**

At 0703 hours, an eastbound freight train struck a southbound freight train from another railroad at a railroad crossing at grade at a speed of 2 mph. The engineer had been qualified for approximately two years. The conductor was a 32-year veteran working his assigned pool.

CAWG No. 20 Mt. Pleasant, TX **15-Apr-99**

At 1230 hours, a crew with very little time left to work failed to stop their freight train short of the rear end of a standing train near the place where they were supposed to get their 12-hour relief. After the engineer put the train into emergency, the conductor, the engineer, and the student engineer on the striking train jumped prior to impact and sustained minor injuries.

CAWG No. 21 Palm Springs, CA **05-Jul-99**
At 0140 hours, westbound intermodal train ran by a stop signal at the west end of a controlled siding and into the path of an eastbound manifest freight train. The westbound came to a stop before the eastbound collided with the violating train. All four crew members were able to jump prior to impact. The engineer on the eastbound train received severe injuries during his fall.

CAWG No. 22 Tyrone, TX **01-Jun-00**
At 1805 hours, an eastbound road switcher left a siding in DTC single-track, ABS territory ahead of a following intermodal train. The following train crew was attempting to get block authority ahead as they were approaching the west end of the siding. The struck train crew did not wait 5 minutes after lining the east switch and it was designated as the violating train.

CAWG No. 23 Cincinnati, OH **04-Sep-00**
At 0815 hours, a two-person freight-train crew collided on main number two of three main within traffic control territory, with the rear of a stopped freight train. The striking freight train crew miss-interpreted a restricting signal as an approach indication, striking the stopped train. In addition to the damage of the striking and struck train, wreckage impacted and damaged two moving trains on the other two main tracks which both were moving in the same direction. No injuries where reported.

CAWG No. 24 Kingman, AZ **16-Sep-00**
At 2245 hours, a freight train, with a two person crew, struck the rear of a stopped light engine consist while operating on double main in traffic control territory while an opposing train passed the site. The light power was stopped short of a signal, allowing the following striking train to believe the block was clear when they identified the next block as clear while not seeing the stopped locomotives in front of the clear signal. Three minor injuries were reported.

CAWG No. 25 Bellemont, AZ **31-Oct-00**
At 1815 hours, a freight train, with a two-person crew, collided with the rear of a stopped freight train while operating on double track in traffic control territory. The engineer of the striking train reported the last signal he went by as being a grade signal with a clear indication. The conductor suffered fatal injuries and the engineer suffered serious injuries involving second and third degree burns, smoke and heat inhalation, along with shoulder, back and ankle injuries.

CAWG No. 26 Yarmony, CO **04-Nov-00**
At 1410 hours, within traffic control territory, a coal train and an opposing light power consist were to meet at a siding. The light power consist, with a two person crew, entered the siding at 30 mph, reduced speed to 25 mph, then failed to stop for the signal displaying stop on the opposite end of the siding. After initiating an emergency application of the air brakes, the light engines impacted with the side of train passing on main track, derailing two locomotives and three coal cars. Two minor injuries were reported.

CAWG No. 27 Laredo, MO **20-Nov-00**
At 0755 hours, a freight train with a two person crew, while operating on single main, traffic control territory, struck an opposing freight train as the opposing train was about to clear into a siding. Minor injuries were reported to the assistant engineer after he jumped from the train before impact.

CAWG No. 28 Murray, NE **18-Dec-00**
At 1035 hours, a two-person freight-train crew collided with the rear of a stopped freight train while operating within TWC/ABS territory on single main track in extreme blizzard weather conditions. No injuries were reported.

CAWG No. 29 Kenner, LA **21-Dec-00**
At 0415 hours, a two-person freight-train crew struck the side of an opposing freight train within a manual interlocking operated remotely by a dispatcher. Striking crew reported that the head light on the struck train temporarily blinded them, causing them to 'overshoot' the interlocking home signal. Two minor injuries were reported.

CAWG No. 30 Malden, TX **21-Dec-00**
At 1555 hours, a three-person freight-train crew (engineer, conductor and student engineer), while operating in TWC/ABS territory collided head-on with a stopped train that was waiting in the siding for the striking train to pass. Siding switch was protected by a signal system and had not lined its self for main track movement before the arrival of striking train. Five minor injuries were reported.

CAWG No. 31 Woodburn, IA **27-Dec-00**
At 1420 hours, a two-person crew, while operating on double main track within TWC/ABS territory, collided with the rear of a stopped freight train, while operating down a 0.6 percent descending grade. Two minor injuries were reported.

CAWG No. 32 Perkins, WY **22-Jul-99**
At 0515 hours, a two-person coal train, operating in traffic control territory with cab signals traveling at 15 mph, struck a stopped coal train while ascending a .82 percent grade. No injuries were reported.

CAWG No. 33 Clinton, IA **11-Aug-99**
At 1612 hours, a two person freight train crew, collided with the rear of a stopped freight while operating in yard limits and TWC territory killing the engineer and the assistant engineer of the striking train.

CAWG No. 34 Wickes, AR **13-Sep-99**
At 0435 hours, a two person coal train, while operating in traffic control territory collided with the rear of a stopped coal train at 25 mph. Crew of the striking jumped from the locomotive shortly before the collision, resulting in the death of the conductor and minor injuries to the engineer.

CAWG No. 35 Cumberland, MD **20-Sep-99**
At 1150 hours, a two person locomotive crew of a passenger train, struck the rear of a slowly moving freight train while operating in traffic control territory at 42 mph., in a curve with an obstructive view while descending a .22 percent hill. 32 passengers sustained minor injuries.

CAWG No. 36 Waldeck, KS **13-Nov-99**
At 0001 hours, a two-person freight train crew collided head-on with another freight train that was stopped on the main track to meet the striking train. Both trains were operating in DTC/ABS territory. The switch at the meeting point was a hand-operated switch. Striking train passed over the meeting point switch and struck the standing train. The conductor of the striking train sustained minor injuries while exiting the locomotive before the collision.

CAWG No. 37 Fullerton, CA **18-Nov-99**
At 0800 hours, a passenger train crew consisting of an engineer in the control cab and a conductor attending to duties with the passengers, collided with the side of an opposing freight train that was crossing over in triple main-traffic control territory. The collision resulted in 19 minor passenger injuries and one minor injury to the engineer of the striking train.

CAWG No. 38 Racine, MO **14-Jan-01**
At 2320 hours, a two-person freight-train crew, operating in traffic control territory, struck the side of an opposing freight train that was entering a siding to meet the striking train. No injuries were reported. The conductor of the striking train tested positive on the required drug toxicology test.

CAWG No. 39 Carlisle, OH **17-Feb-01**
At 0140 hours, a three-person freight-train crew (engineer, engineer pilot (operator) and conductor) while operating in single main-traffic control territory collided with the rear of a stopped freight train. The struck train's EOT was not functioning. Resulting collision led to the death of the engineer pilot and severe injuries to the conductor and engineer.

CAWG No. 40 Richmondville, NY **09-Apr-01**
At 0645 hours, a two-person freight train, while operating in single main-traffic control territory, was struck by an opposing freight train (operating on the main track) after passing the absolute signal at the end of the siding. The struck train was to meet the striking train at this siding. All crew members jumped from the locomotives prior to the collision, resulting in one crew member suffering minor injuries.

CAWG No. 41 Glenwood, IA **18-Aug-01**
At 1255 hours, a two-person freight-train crew struck the rear of a stopped freight train while operating in double main-traffic control territory. The grade was a descending .62 percent. Two minor injuries were reported.

CAWG No. 42 Ransom, IL **20-Aug-01**
At 0848 hours, a two-person, freight-train crew struck the rear of a stopped freight train while operating in double main-track traffic control/ABS territory. The collision resulted in two minor injuries.

CAWG No. 43 Jacksonville, TX **07-Sep-01**
At 1220 hours, a two-person freight-train crew collided with the rear of a stopped freight train. Both trains were operating in single main-traffic control territory. The resulting collision contributed to a release and explosion of a damaged car of phthalic anhydride. The conductor reported minor injuries.

CAWG No. 44 Hallsville, TX **11-Sep-01**
At 0950 hours, a passenger train crew of three people (engineer was the only crew member on lead locomotive) collided with the side of a moving freight train at the end of a controlled siding in single main-traffic control territory while operating on the siding. Collision resulted in 12 injuries.

CAWG No. 45 Wendover, UT **13-Sep-01**
At 0508 hours, a four-person passenger train crew, collided with an opposing two-person freight train on the main track. The freight train was pulling into the clear on the siding. The passenger train failed to comply with restrictive signals and hit the side of the freight train. Two employees and forty-one passengers were injured.

CAWG No. 46 Andersonville, MI **15-Nov-01**
At 0553 hours, a two-person freight-train crew taking siding to meet an opposing two-person freight train, which was to hold the main track, failed to take any action to stop in the clear at the end of the siding and reoccupied the main track. It was struck head-on by the opposing train, killing both its crew members.

CAWG No. 47 Mayfield, OH **08-Dec-01**
At 2350 hours, a two-person freight train failed to comply with restrictive signals and struck the rear end of a two-person standing freight train ahead of them on the same main track. All three locomotives of the striking train derailed, but remained upright. There were no injuries sustained in this rear end collision.

CAWG No. 48 Swenney, TX **06-Dec-02**
At 0645 hours, a two person freight train crew holding the main track at a meet failed to comply with restricting signals and then passed a stop signal at the far end of the siding and struck the opposing two man freight train which was taking siding. All four employees sustained injuries.

CAWG No. 49 Pacific, MO **12-Dec-01**
At 0545 hours, a two-person freight train failed to comply with restrictive signals and struck the rear end of a stopped two-person freight train ahead. The resulting derailed cars and engines fouling the adjacent track then derailed an opposing two-person freight train on that track. One employee was injured.

CAWG No. 50 Kenner, LA **15-Dec-01**
At 0415 hours, a two-person freight train failed to comply with a stop signal displayed at an interlocking associated with a drawbridge and collided with the side of an opposing two-person freight train transiting the interlocking. One employee was injured.

CAWG No. 51 Bradford, IL **01-Jan-02**
At 2346 hours, a southbound two person freight train failed to stop on the main track in the clear at the end of authority in track warrant territory and struck the side of an opposing two person freight train that was taking siding. One employee on the southbound train sustained injuries.

CAWG No. 52 La Porte, IN **03-Feb-02**
At 0335 hours, an eastbound two-person freight train running on an Approach signal failed to stop in the clear of the home signal at a crossover and collided with an opposing two-person freight train entering the crossover to pass on the second main track. All four crew members on the two colliding trains sustained non-fatal injuries.

CAWG No. 53 Placentia, CA **23-Apr-02**
At 0816 hours, an eastbound two-person freight failed to comply with Approach and Stop signals and struck an opposing two-person-crew passenger train head-on that was entering the interlocking for a diverging route. All four crew members of the two trains sustained injuries. Two passengers were killed and 163 passengers were injured.

CAWG No. 54 Douglas, WY **11-May-02**
At 0753 hours, a two person westbound freight train collided with an opposing two-person freight train on the same track in two main territory after the former failed to comply with the stop indication given to them at the interlocking signal. All four crew members of the two freight trains sustained injuries.

CAWG No. 55 Clarendon, TX **28-May-02**
At 0856 hours, eastbound two person freight train failed to comply with track warrant and collided head on with a two person opposing intermodal freight train, killing one employee and injuring the remaining three.

CAWG No. 56 Aurora, IL **12-Jun-02**
At 1521 hours, an eastbound four employee commuter train failed to comply with a stop signal, trailed through an opposing power switch, and collided head-on with a westbound four employee passenger train. Five employees and forty-three passengers sustained injuries.

CAWG No. 57 Leesburg, TX **16-Jun-02**
At 0440 hours, a two person freight train failed to comply with signal indications, including stop signal, and struck the rear-end of a two person freight train that was stopped ahead of them. One crew member of the striking train sustained non-fatal injuries.

CAWG No. 58 Baltimore, MD **17-Jun-02**
At 0541 hours, a three employee passenger train passed a stop signal at an interlocking and collided with the side of a four employee passenger train in the interlocking that was going in the same direction. Five employees and three passengers on the two passenger trains sustained injuries.

CAWG No. 59 North Platte, NE **19-Jun-02**
At 0415 hours, a two-person freight train failed to comply with a stop signal and collided with the rear end of a two-person freight train stopped ahead on the same track. An opposing two-person freight train on the adjacent main track collided with the derailed equipment, resulting in an additional derailment. One employee on the striking train and one employee on the opposing train that struck the derailed equipment sustained injuries.

CAWG No. 60 Jamaica, NY **22-Jun-02**
At 1157 hours, a four-employee passenger train operating on a "restricting" signal failed to stop before colliding with a six-employee passenger train had stopped on the same track. Three employees and sixty-seven passengers were injured as a result of this rear end collision.

CAWG No. 61 San Bernardino, CA **30-Jun-02**
At 1310 hours, a two-person freight train following another two-person freight train on the same track under a restricting signal failed to realize that the train ahead had stopped. The striking train could not stop before colliding with the rear of the stopped freight train ahead. There were no injuries. Four cars of the struck train derailed.

CAWG No. 62 Vader, WA **15-Sep-02**
At 0120 hours, eastbound two-person freight train failed to comply with a stop signal and struck the rear of a two person eastbound freight train that was stopped ahead on the same track. One employees sustained injuries.

CAWG No. 63 Reddick, IL
10-Oct-02
At 0830 hours, an eastbound two person freight train operating in track warrant territory struck a stopped two person opposing freight train waiting in the clear at the west end of the siding when the crew member of the train in the siding failed to correctly line the switch for the main track. Three employees were injured in the head-on collision.

CAWG No. 64 Des Plaines, IL **21-Oct-02**
At 2238 hours, a northbound two-person freight train failed to comply with a stop signal at an interlocking and collided with the side of a southbound two-person freight train that was transiting the interlocking. The two employees on the striking train sustained injuries.

CAWG No. 65 Valley Pass, NV **05-Nov-02**
At 0145 hours, a two person intermodal freight on the main track failed to comply with a stop signal at the end of the siding and collided with the side of a two person freight unit train that was pulling out of the siding onto the main track to go in the same direction as the striking train. There were no injuries.

2.4 Qualifying Collisions in 2003 and 2004

There are 13 collisions in 2003 and 18 in 2004 resulting in 8 fatalities (6 employees and 2 non-trespassers) meeting CAWG's review criteria. The 2003 investigations were not complete when the review of these 65 cases was finished. Extending the publication date of this study would unduly delay this collision-avoiding information from reaching the railroad industry. CAWG's intent is to ensure subsequent main-track train collisions will be added to the CAWG Database, thereby allowing for continuous, up-to-date analysis. CAWG views collision prevention efforts, using the methods of this study, as ongoing.

Preliminary case descriptions of the 31 qualifying collisions occurring in 2003 and 2004, pending review, are listed below:

2003 Main-Track Train Collisions

1. Philadelphia, PA **25-Jan-03**
A northward freight train, operating at 24 mph, struck the rear end of a standing freight train.

2. Brush, CO **02-Mar-03**
A westward coal train, operating at 16 mph, struck the rear end of a standing coal train.

3. Seattle, WA **10-Mar-03**
A freight train, operating at 18 mph, struck the side of an opposing train.

4. Ashtabula, OH **11-Mar-03**
A freight train, operating at 7 mph, collided head-on with a standing train.

5. Seattle, WA **02-May-03**
A freight train, operating at 5 mph, struck the rear-end of another train.

6. Flomaton, AL **04-May-03**
A freight train, operating at 20 mph, struck the rear-end of another train.

7. Matfield Green, KS **17-May-03**
An eastbound freight train, struck the side of a westbound freight train.

8. Cumberland, MD **19-Jun-03**
A westbound container train, operating at 28 mph, collided head-on with a freight train operating at 11 mph.

9. Bisbee, TX **28-Jul-03**
A freight train, operating at 20 mph, collided head-on with a standing train.

10. Chriesman, TX **17-Sep-03**
A freight train, operating at 13 mph, struck the rear-end of another train.

11. Baltimore, MD **18-Sep-03**
A freight train, operating at 7 mph, collided head-on into a standing train.

12. Longview, WA **15-Nov-03**
An intermodal train, operating at 50 mph, struck the side of an intermodal train.

13. Pauls Valley, OK **29-Dec-03**
A westbound train, traveling at 4 mph, struck the side of an eastbound train traveling at 14 mph.

2004 Main-Track Train Collisions

1. Carrizozo, New Mexico **21-Feb-04**
A freight train, operating at 36 mph, struck the side of a loaded grain train as the grain train entered the siding to clear the main track. Both crew members of the striking train were killed.

2. Hesperia, CA **28-Apr-04**
A freight train, operating at 18 mph, struck the side of a freight train operating at 8 mph, resulting in derailed cars and closed highways.

3. San Antonio, TX **03-May-04**
A westbound freight train operating at 40 mph struck the side of the last car of an eastbound freight train, as the eastbound train was crossing over from one main track to another.

4. North Dexter, MO **07-May-04**

A northward freight train, operating at an estimated 16 mph, struck the rear of a standing northward intermodal train.

5. Surgoinsville, TN **14-May-04**
An eastward loaded coal train, operating at an estimated 40 mph, struck the rear of a standing eastward freight train.

6. Gunter, TX **19-May-04**
A southward freight train, operating at an estimated 40 mph, collided, head-on, with a northward freight train. One employee was killed and four were injured.

7. Gurdon, AR **24-May-04**
A northward freight train, operating at an estimated 30 mph, struck the rear of a standing northward intermodal train.

8. Front Royal, VA **27-May-04**
A westward intermodal train, operating at an estimated 19 mph, struck the rear of a standing westward freight train.

9. Morton, MS **07-Jun-04**
A westward freight train, operating at an estimated 24 mph, failed to stop and struck the side of an eastward freight train.

10. Bloom, UT **19-Jun-04**
An eastward freight train, operating at an estimated 7 mph, struck the side of a westward freight train as it was entering the siding.

11. Saugerties, NY **27-Jun-04**
A northward freight train, operating into a siding at an estimated 11 mph, struck the rear of a standing northward freight train that was waiting for an opposing train to arrive.

12. MacDona, TX **28-Jun-04**
A westward freight train, operating at an estimated 45 mph, failed to stop and struck the side of an eastward freight train while it was entering the siding. A chlorine leak ensued, an evacuation was ordered. The conductor and two citizens were found dead at the scene.

13. Baltimore, MD **10-Oct-04**
An eastward freight train, operating at 18 mph, struck the side of another freight train that was crossing over from one main track to another.

14. Zita, TX **02-Nov-04**
A freight train, operating at 6 mph, struck the rear of a standing intermodal train.

15. Vitis, FL **29-Nov-04**
A southward freight train collided head-on with a northward freight train. As a result, two employees were hurt and one was killed.

16. Niland, CA **10-Dec-04**
An eastward freight train, operating at 30 mph, collided head-on with a westward freight train operating at 10 mph. As a result of the collision, 1 crew member was killed and 4 were injured.

17. Drury, TX **20-Dec-04**
A northward freight train, operating at 24 mph, passed a "stop and proceed at restricted speed" signal and struck the rear car of a standing northward train.

18. Greencastle, PA **20-Dec-04**
A southward freight train, operating at restricted speed and pulling into a siding, was struck in the side by a northward train operating at 21 mph.

3. DESCRIPTIVE OVERVIEW

3.1 Understanding Causes of Main-Track Train Collisions

This section contains descriptions and tables of selected attributes of the 65 main-track train collisions. Data description is the sole purpose of this section. These attributes include: collision type, year, month, weekday, daylight condition, visibility, weather, casualty counts, damage, speed, hazmat release, and track density. Displaying these attributes begins the process of understanding the causes of these collisions – both what is, and is not, involved. Many of the collision attributes presented tend to rule out at the general level – as opposed to confirm – possible causes.

Collision type

The collision type for 31 of the 65 collisions was rear-end – 48 percent – as shown in Table 3-1. There were 18 side collisions: 13 head-on; and 3 at railroad crossings. [Note to FRA: include in NTSB response.]

Table 3-1. Type of Collision, 1997 through 2002

Collision Type	Count	Percent
rear end	31	47.7
side	18	27.7
head on	13	20.0
railroad grade crossing	3	4.6
total	65	100.0%

Year

On average 10.8 main-track train collisions occurred per year over the six-years, 1997 to 2002. The number of main-track train collisions fluctuated yearly from a low of 4 in 1998 to a high of 16 [20] in 2002, as shown in Table 3-2. CAWG draws no conclusion as to whether the number of main-track train collisions are increasing over the six-year period, or just fluctuating randomly about the average of 10.8 collisions, with the 1998 count of 4 being an unusually low value (outlier). However, by arranging main-track train collisions on a time-series basis, and noting the average and the average variation (about 4.0 collisions), a structure is created to help evaluate whether *absolute* changes in the number of collisions are occurring over time – and to what extent the findings and recommendations made in this study, along with government and industry safety efforts, have affected such change.

[20] The standard deviation, a measure of the average variation about the mean, is 3.97 collisions. The medium is 11 collisions, almost identical to the average (10.8), indicating the distribution in the number of collisions per year is slightly skewed to the left, but essentially normal.

Table 3-2. Collisions by Year, 1997 through 2004

Year	Yearly Count	Rear End	Side	Head On	Railroad Grade Crossing
1997	11	6	2	2	1
1998	4	3	0	0	1
1999	11	6	2	2	1
2000	10	5	4	1	0
2001	13	7	4	2	0
2002	16	4	6	6	0
*2003	13	5	4	4	0
*2004	18	7	8	3	0
total	96	43	30	20	3

* 2003 and 2004 collision cases were not reviewed, but are included here with the 1997 through 2002 cases for trend-comparison purposes. All years were selected by the same main-track, human-factor criteria.

Month

During the six-year period of CAWG's review, 1997 through 2002, monthly collisions ranged from 3 in five of the months to a high of 10 in September followed by 9 in November and 8 each in December and June as shown in Table 3-3.. The average monthly number of collisions is 5.4; the medium, 4.0.

Note: In the Findings, Discussion, and Recommendation section, two periods of heightened risk during the year are identified. While there is always risk, employees should be aware of these periods.

Table 3-3. Collisions by Month, 1997 through 2002

Month	Count	Percent
JAN	3	4.6
FEB	3	4.6
MAR	4	6.2
APR	3	4.6
MAY	3	4.6
JUN	8	12.3
JUL	4	6.2
AUG	3	4.6
SEP	10	15.4
OCT	7	10.8
NOV	9	13.9

DEC	8	12.3
total	65	100.0%

Weekday

As shown in Table 3-4, there was one main-track train collision on Fridays, compared to 15, 13, and 13 respectively on Mondays, Thursdays, and Saturdays. CAWG did not establish why variation existed among days of the week, and particularly why the count on Friday was relatively low.

Table 3-4. Collisions by Day of Week, 1997 through 2002

Month	Count	Percent
Sunday	8	12.3
Monday	15	23.1
Tuesday	8	12.3
Wednesday	7	10.8
Thursday	13	20.0
Friday	1	1.5
Saturday	13	20.0
total	65	100.0%

Time

Table 3-5 shows the frequency of collisions by hour of day. The highest number of collisions (8) occurred between 4:00 am and 5:00 am. The second highest number of collisions (6) occurred between 8:00 am and 9:00 am. The fewest collisions (0) occurred between 7:00 pm and 8:00 pm. One collision occurred between 2:00 am and 3:00 am; 9:00 am and 10:00 am; 4:00 pm and 5:00 pm; 8:00 pm and 9:00 pm; and 9:00 pm and 10:00 pm.

Table 3-5. Collisions by Hour of Day, 1997 through 2002

	Hour of Day	Count	Percent of 65 Collisions		Hour of Day	Count	Percent of 65 Collisions
AM	**1**	3	4.6	**PM**	**1**	2	3.1
	2	5	7.7		**2**	2	3.1
	3	1	1.5		**3**	3	4.6
	4	2	3.1		**4**	3	4.6
	5	8	12.3		**5**	1	1.5
	6	4	6.2		**6**	3	4.6
	7	2	3.1		**7**	2	3.1
	8	3	4.6		**8**	0	0.0

9	6	9.2	**9**	1	1.5
10	1	1.5	**10**	1	1.5
11	4	6.2	**11**	2	3.1
12	3	4.6	**12**	3	4.6
totals	42	64.6%		23	35.4%

Daylight condition

Collisions occurred nearly equally between day and dark, 33 v. 28 collisions (51 v. 43 percent), as shown in Table 3-6. There were 3 collisions at dawn and 1 at dusk.

Table 3-6. Collisions by Daylight Conditions, 1997 through 2002

Daylight Condition	Count	Percent
Day	33	50.8
Dark	28	43.1
Dawn	3	4.6
Dusk	1	1.5
	65	100.0%

Weather

Stormy weather was not generally a Possible Contributing Factor (PCF), as shown in Table 3-7. CAWG used weather-related PCFs in three cases (CAWG Nos. 11, 18, and 48). Fifty-nine percent of the 65 collisions occurred in clear visibility. Twenty-five percent occurred in cloudy visibility; and 17 percent occurred in rain, fog, and snow.

Table 3-7. Collisions by Weather, 1997 through 2002

Visibility	Count	Percent
Clear	38	58.5
Cloudy	16	24.5
Rain	4	6.2
Fog	5	7.7
Snow	2	3.1
	65	100.0%

Casualty

The 65 collision cases are 'accidents' in the sense that physical damage well exceeded the Federal Railroad Administration reporting thresholds. CAWG emphasizes main-track train collisions are often associated with human casualty as shown in Table 3-8. The 65 main-track train collisions resulted in 16 total fatalities and 531 injuries. There were 14 employee fatalities and 128 employee injuries; 2 passenger fatalities and 403 passenger injuries.

Table 3-8. Collisions by Casualty Type, 1997 through 2002

Type	Fatalities	Injuries	Total Casualty
Employees	14	128	142
Passengers	2	403	405
total	16	531	547

One passenger collision in Placentia, CA (No. 39), accounted for all of the passenger (2) fatalities and 163 passenger injuries.

Property Damage

The amount of property damage in the 65 main-track train collisions varied (Table 3-9). The most damage in one collision (Pacific, MO, No. 49) was $7,855,920. Track and switch, lading, and equipment damage in the 65 collision cases totaled $83,108,072, an average of $1,278,586 per collision (Table 3-10). Eighty-five percent of total property damage is to equipment.

Table 3-9. Frequency of Lading, Track and Switch, and Equipment Damage, 1997 through 2002

Total Damage ($millions)	Count	Percent
0.0 – 0.09	7	10.8
0.1 – 0.40	17	26.2
0.5 – 0.90	16	24.5
1.0 – 1.90	15	23.1
2.0 – 4.90	7	10.8
5.0 – 7.80	3	4.6
total	65	100.0%

Table 3-10. Value of Lading, Track and Switch, and Equipment Damage, 1997 through 2002

Damage	Total $	Percent	Average $

Type			per Collision
Lading	2,299,500	2.8	35,377
Track and Switch	10,142,905	12.2	156,045
Equipment	70,665,667	85.0	1,087,164
total	$83,108,072	100.0%	$1,278,586

Hazmat

There were 42 hazardous material cars derailed with four hazmat releases (Table 3-11). [Note to FRA: include in NTSB response.]

Table 3-11. Hazmat Summary for Collisions, 1997 through 2002

CAWG No.	Location	Date	Striking Train	Struck Train	Count of Hazmat Cars Derailed	Count of Cars Releasing Hazmat
1	Kenefick, KS	07/02/97		yes	14	0
43	Jacksonville, TX	09/07/01		yes	7	1
7	St. Albans, WV	06/07/97		yes	5	1
48	Swenney, TX	12/01/02		yes	5	0
12	Navasota, TX	10/29/97	yes		4	0
18	Stryker, OH	01/17/99	yes		2	2
23	Cincinnati, OH	09/04/00	yes		1	0
25	Bellemont, AZ	10/31/00	yes		1	0
25	Bellemont, AZ	10/31/00		yes	1	0
37	Fullerton, CA	11/18/99		yes	1	0
52	La Porte, IN	02/03/02		yes	1	0
		total	5	7	47	4

Speed at impact

Table 3-12 indicates the frequency of traveling speeds for both the violating and non-violating trains.

Table 3-12. Collisions by Speed, 1997 through 2002

Speed Category (mph)	Violating Train	Percent	Non-Violating Train	Percent
0 – 10	13	19.7	44	64.7

11 – 20	18	27.3	13	19.1
21 – 30	21	31.8	8	11.8
31 – 40	14	21.2	3	4.4
total	66	100.0%	68	100.0%

Tack density

Table 3-13 shows the annual track density in millions of gross tons for collision location.

Table 3-13. Collisions by Annual Track Density (millions of gross tons), 1997 through 2002

Track Density	Count	Percent
less than 16	16	29.0
16 – 50	18	27.7
greater than 50	21	38.2
total	*55	100.0%

* Track density not available for all 65 collisions.

FRA track type

Table 3-14 shows the distribution of collisions by FRA track type.

Table 3-14. Collisions by FRA Track Type, 1997 through 2002

FRA Track Class	Definition of FRA Track Class	Count	Percent
1	1=10 mph freight, 15 mph passenger trains	2	3.1
2	2=25 mph freight, 30 passenger trains	9	14.1
3	3=40 mph freight, 60 passenger trains	13	20.3
4	4=60 mph freight, 80 passenger trains	32	50.0
5	5=80 mph freight, 90 passenger trains	8	12.5
	total	*64	100.0%

* FRA Track Class not available for all 65 collisions.

Train length

Table 3-15 shows the distribution of collisions by train length.

Table 3-15. Main-Track Train Collisions by Train Length,

1997 through 2002

Train Length (feet)	Violating Trains	Percent	Non-Violating Trains	Percent
Under 4000	16	28.1	10	16.4
4000 – 5999	17	29.8	23	37.7
6000 and over	24	42.1	28	45.9
total	*57	100.0%	*61	100.0%

* Train length was not available for all trains involved in the 65 collisions.

Time on duty

Table 3-16 shows the distribution of collision by time on duty for both the crew of the violating and non-violating trains.

Table 3-16. Time on Duty for Crew Members of Violating and Non-Violating Trains

Time on Duty (hours)	Violating Train	Percent	Non-Violating Train	Percent
under 3	37	25.7	16	13.3
3 – 5:59	64	44.4	47	39.2
6 – 8:59	30	20.8	37	30.8
over 9	13	9.0	20	16.7
total	144	100.0%	120	100.0%

4. REVIEW AND ANALYTICAL METHODS

4.1 Overview

This section presents collision concepts and analytical aids CAWG used to review and analyze the 65 main-track train collisions, and to make findings and recommendations based on the commonality of facts among collisions. Information contained in this section – including the Findings, Discussions, and Recommendations – is based solely on review and analyses of 65 main-track train collisions occurring from 1997 through 2002. CAWG did not consider results of other investigations, reviews, and analyses of main-track train, or other types of collisions. CAWG results are specific to its data.

CAWG's causality concept is based on identifying all of the possible contributing factors for each collision without ranking the factors in importance. Ranking often involves subjective judgment, creates difficulty in gaining consensus, and is simply not necessary if the purpose is identifying commonalities. CAWG's collision causality approach is well suited to its purpose of finding commonalities among collisions so collision-preventive recommendations can be made and expediently implemented.

4.2 CAWG Database

Initially, CAWG recorded data from its review and discussion of the first 27 collision cases (CAWG No.s 1-27) in Microsoft® Excel files, one workbook per case with multiple spreadsheets for general, locomotive and equipment, crew, and consensus information. Although the spreadsheet files provided a well-structured approach for recording information, CAWG realized this method would not provide a rapid and practical method of searching for commonalities across cases once information from all 65 collisions was entered.

Anticipating rapid information retrieval would be essential to developing accurate findings and recommendations, CAWG obtained expert technical support to develop a software database system using Microsoft® Access to address the retrieval shortcomings of the spreadsheet approach. The Access database became known as the 'CAWG Database.' The information for the 27 cases in Excel workbook files was 'rolled over' into the CAWG Database. All subsequent reviews were entered into the CAWG Database.

The CAWG Database is a permanent resource to reside in the Federal Railroads Administration's Office of Safety, available to the railroad-safety community studying main-track train collisions and responding to new collision events with the need for background information. Future collision reviews by CAWG, or other safety groups, can be appended to the 65 collision cases, creating an even richer repository of collision information.

4.3 Distinguishing Violating and Non-Violating Trains

One of the first analytical decisions CAWG made in reviewing each collision case was determination of which train or trains was likely at fault. In 64 of the collision cases, one of the trains was determined to be the *violating train*. In the other collision case (North Bay, CA, No. 8), both trains involved were designated as *violating trains*. Thus, there were 65 collision cases and 66 violating trains.

Of the 66 violating trains, 59 were considered the striking train by CAWG, and 7 were considered struck. Table 4-1 shows the violating trains by consist type, 82 percent being freight.

Table 4-1. Violating Trains in Main-Track Train Collisions by Consist Type, 1997 through 2002

Consist Type	No.	Percent
Freight	54	81.8
Passenger	6	9.1
Commuter	3	4.6
Light locomotives	2	3.0
Unattended cars	*1	1.5
Total	**66	100.0%

* Cars occupied the main track in violation of track warrant authority.
** Sums to 66 because one collision (CAWG No. 8) had two violating trains.

4.4 Approach to Alertness

CAWG adopted a data driven approach that focuses on observable behaviors of alertness, i.e., attention to and appropriate responses to one's surroundings rather than the less exact term *fatigue* that has various meanings for different people. CAWG used judgments of a sleep expert to estimate the cumulative amount of sleep employees could have received before going on duty. The expert corroborated CAWG's independent alertness evaluations. Alertness, and its analytical methods, are discussed in the Findings, Discussion, and Recommendation section.

4.5 CAWG's Approach to Causality

Historically, the railroad industry has reported collisions as due to one cause. However, rarely are main-track train collisions the result of a single factor or cause. Review of the 65 collisions clearly establishes that most collision events are a combination of unrelated factors and deviations occurring at the same time, at the same location, and on the same train. Sometimes, these factors and deviations do not rise to the level of identifiable violation of operating regulations and/or standards. The greater the number of factors and deviations present, the more likely is a collision.

The cases reviewed by CAWG appear to involve human error. CAWG's style of research and review regarded human error in a way similar to Dekker (2002): "human error is systematically connected to features of people's tools, tasks, and operational/organizational environment."[21] CAWG approached the cases with an attitude described by Dekker: "The new view of human error wants to understand why people made the assessments or decisions they made – why these assessments or decisions would have made sense from the point of view inside the situation." [22]

CAWG developed an approach to collision causality based on consideration of an often complex combination of rail-system operating characteristics, conditions, and events. CAWG in determining causality does not attempt to rank these factors, usually expressed as Possible Contributing Factors (PCFs). The SOFA effort demonstrated how PCFs can empower the railroad industry to identify and address specific issues where risks and exposures can be further reduced. CAWG views causality as a web of interrelated factors. CAWG found that collisions do not result from chance, randomness, or bad luck.

CAWG used the FRA's *Train Accident Cause Codes*[23] and its own defined codes as the basis for PCFs. Each collision was assigned as many PCFs as CAWG believed applied; however, the number of PCFs applied to a collision case did not go beyond the number necessary to capture the essence of the identified factors. CAWG avoided redundancies, and causal information not appropriately captured by a PCF was described in narrative form.

4.6 Human Factor Possible Contributing Factors

Possible Contributing Factors (PCF) for the 65 collisions involve human factor issues: alertness, which can be degraded by temporary and chronic lack of sleep, circadian rhythm phasing, drugs (both prescription and illegal), alcohol, and boredom; operating capability contingent on training, experience (both general railroad knowledge and that specific to a territory), and judgment; and crew utilization, involving crew resource management.

Only one collision is assigned a PCF for a known signal failure; and three collisions are assigned mechanical PCFs. This does not mean signal and mechanical failures are the sole cause of those collisions – only a PCF. Weather is not generally a PCF consideration. CAWG used weather-related PCFs in three cases (CAWG Nos. 11, 18, and 48), otherwise weather is not a factor. Drugs and alcohol are not generally factors. CAWG used H101 – *Impairment of efficiency or judgment because of drugs or alcohol*, as a PCF in two cases (Nos.12 and 40).

4.7 Overall Frequency of Possible Contributing Factors

In reviewing the 65 main-track train collision cases, CAWG used 37 different PCF codes. As shown in Table 4-2, H215 – *Block signal, failure to comply*, used in 31 collision cases; and H216 – *Interlocking signal, failure to comply* are the most frequently applied PCFs as would be expected since most of the collisions involve signal non-compliance.

[21] Dekker, S. (2002). The Field Guide to Human Error Investigations. *Ashgate*: Burlington, VT. P. vii.
[22] ibid, p. 64
[23] Contained in Appendix C, pages 1-11, of the *FRA Guide for Preparing Accident/Incident Report*. Federal Railroad Administration. 1997.

H605 – *Failure to comply with restricted speed*, the third most frequent PCF, is used in 12 cases (18.5 percent). On average, CAWG used 2.5 PCFs per collision.

Table 4-2. Frequency of Possible Contributing Factors (PCFs) in 65 Main-Track Train Collisions, 1997 through 2002

1	H215	Block signal, failure to comply	30
2	H216	Interlocking signal, failure to comply	28
3	H605	Failure to comply with restricted speed	12
4	H989	Lack of skill or practical wisdom gained by personal knowledge or action	11
5	H104	Employee asleep	10
6	H316	Poor Intra-crew communication	10
7	H999	Other train operation/human factors	6
8	H318	Poor crew utilization	5
9	H204	Fixed signal, failure to comply	6
10	H199	Employee physical condition, other	3
11	H317	Failure to communicate unsafe condition	3
12	H398	Poor Inter-crew communication	3
13	H404	Train order, track warrant, track bulletin, or timetable authority, failure	3
14	M104	Extreme environmental condition – dense fog	3
15	E03C	Obstructed brake pipe (closed angle cock, ice, etc.)	2
16	H499	Other main track authority causes	2
17	H101	Impairment of efficiency or judgment because of drugs or alcohol	2
18	H603	Train inside yard limits, excessive speed	2
19	H702	Switch improperly lined	2
20	H299	Other signal causes	1
21	E03L	Obstructed brake pipe (closed angle cock, ice, etc.) locomotive	1
22	H099	Use of brakes, other	1
23	M199	Other extreme environmental conditions	1
24	H203	Fixed signal improperly displayed	1
25	H992	Operation of locomotive by uncertified/unqualified person	1
26	H211	Radio communication, improper	1
27	H212	Radio communication, failure to give/receive	1
28	H401	Failure to stop train in clear	1
29	H799	Use of switches, other	1
30	H510	Automatic brake, insufficient (H001) – see note after cause H599	1
31	H307	Shoving movement, man on or at leading end of movement, failure to control	1
32	H604	Train outside yard limits under clear block, excessive speed	1
33	S099	Other signal failures (Provide detailed description in narrative)	1
34	H599	Other causes relating to train handling or makeup	1
35	H502	Improper placement of cars in train between terminals	1
36	H509	Improper train inspection	1
37	H991	Tampering with safety/protective device(s)	1

4.7 Frequency of Codes Used with H215 and H216

PCF code H215 was used in 31 main-track train collision cases; and H216, in 28 cases. To be expected, these PCF were the most frequently used as mentioned above. While these two codes indicate the act, other PCF codes are needed to indicate the why. Tables 4-3 and 4-4 show the frequency of other PCF codes used with respectively H215 and H216.

Table 4-3. H215 – *Block Signal Failure to Comply*: Other PCFs Used with H215, by Collision Count

PCF	Collision Count	PCF	Collision Count
H216-Interlocking signal, failure to comply	9	H318-Poor crew utilization	1
H104-Employee asleep	6	H499-Other main track authority causes	1
H989-Lack of skill or practical wisdom gained by personal knowledge or action	5	H603-Train inside yard limits, excessive speed	1
H605-Failure to comply with restricted speed	3	H702-Switch improperly lined	1
H316-Poor Intra-crew communication	3	H799-Use of switches, other	1
M104-Extreme environmental condition – dense fog	3	H991-Tampering with safety/protective device(s)	1
H510- Automatic brake, insufficient (H001) – see note after cause H599	1	H992-Operation of locomotive by uncertified/unqualified person	1
H203- Fixed signal improperly displayed	1	H999-Other train operation/human factors	1
H299- Other signal causes	1	H398-Poor Inter-crew communication	1

Table 4-4. H216 (Interlocking Signal, Failure to Comply): Other PCFs Used with H216, by Collision Count

PCF	Collision Count	PCF	Collision Count
H215-Block signal, failure to comply	9	H101-Impairment of efficiency or judgment because of drugs or alcohol	2
H989-Lack of skill or practical wisdom gained by personal knowledge or action	5	H203-Fixed signal improperly displayed	1
H999-Other train operation/human	4	H204-Fixed signal, failure to comply	1
H104-Employee asleep	4	H398-Poor Inter-crew communication	1
H316-Poor Intra-crew communication	4	H502-Improper placement of cars in train between terminals	1

H318-Poor crew utilization	3	H510-Automatic brake, insufficient (H001) – see note after cause H599	1
H605-Failure to comply with restricted speed	3	H603-Train inside yard limits, excessive speed	1
H199-Employee physical condition, other	3	H604-Train outside yard limits under clear block, excessive speed	1
M104-Extreme environmental condition – dense fog	2	H317-Failure to communicate unsafe condition	1

4.8 Collisions Cases Without H215 and H216

H215 and H216 were used in 59 main-track train collision cases. H605 – F*ailure to comply with restricted speed* was used in the remaining 6 collision cases to indicate the main act resulting in the collision. While these three codes indicate the act, other codes are needed to indicate the why. Table 4-5 lists the PCFs used with H605.

Table 4-5. Main-Track Train Collision Cases with H605 – *Failure to comply with restricted speed* – Where H215 and H216 Were Not Used, 1997 through 2002

CAWG No.	8	13	28	33	60	61
H605-Failure to comply with restricted speed	1	1	1	1	1	1
H204-Fixed signal, failure to comply		1				
H212-Radio communication, failure to give/receive		1				
H307-Shoving movement, man on or at leading end of movement, failure to control		1				
H318-Poor crew utilization		1				
H398-Poor Inter-crew communication				1		
H404-Train order, track warrant, track bulletin, or timetable authority, failure	1			1		
H989-Lack of skill or practical wisdom gained by personal knowledge or action	1					
H999-Other train operation/human factors		1				
M199-Other extreme environmental conditions			1			

4.9 PCF Definition of H989

CAWG uses Possible Contributing Factor (PCF) H989 – *Lack of skill or practical wisdom gained by personal knowledge or action* when an individual crew member's performance exhibits a lack of practical understanding of a particular situation. Consideration going into the use of H989 includes: training, experience, and circumstances unique to each collision. CAWG used H989 11 times, as shown in Table 4-6. There are 10 collision cases (15.4 percent of 65 collisions) where H989 is particularly influential in collision events.

Table 4-6. Eleven Main-Track Train Collisions with PCF H989 – *Lack of skill or practical wisdom gained by personal knowledge or action*, 1997 through 2002

CAWG No.	Location	Date
2	Jacksonville, FL	July 1, 1999

4	Alvord, TX	November 3, 1997
6	Lagro, IN	May 31, 1997
8	North Bay, CA	October 16, 1997
15	Butler, IN	March 23, 1998
17	Orin, WY	September 12, 1998
19	Momence, IL	March 23, 2003
34	Wickes, AR	September 13, 1999
42	Ransom, IL	August 20, 2001
51	Bradford, IL	January 1, 2002
58	Baltimore, MD	June 17, 2002

4.10 Philosophy of Collision Avoidance

James Reason created The Swiss Cheese Model[24] to demonstrate the multiple defenses (barriers, rules, procedures, systems, training, communications) set up to prevent human-factor accidents like the 65 main-track train collisions. A representation of his model is shown in Figure 4-1. Only when a "straight shot" is created to the target through all the barriers does a human-factors collision occur.

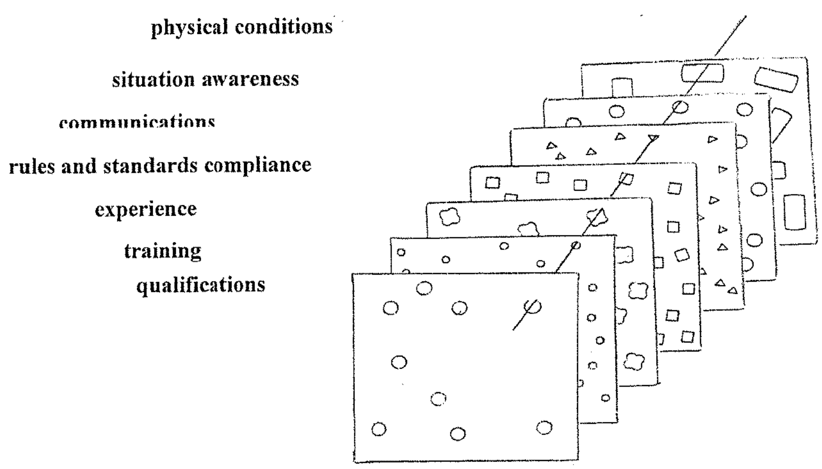

Figure 4-1. Swiss Cheese Model of Collision Causation.

[24] James Reason, 1997, *Managing The Risks of Organizational Accidents*

The Swiss Cheese Model helps in demonstrating myths about collisions. First, collisions usually involve several factors. Rarely are collisions the result of a single cause. CAWG has carried over from its work in Switching Operations Fatality Analysis (SOFA) the concept of a sequence of events leading up to, in its case, a switching fatality, which often involves human-factor issues. To describe the switching-fatality process, SOFA used the same Possible Contributing Factors (PCFs) approach that CAWG is using to analyze the 65 main-track train collisions. SOFA rejected the more restrictive, and less amenable to prevention, idea of a single *cause*. SOFA demonstrated the use of PCFs can empower the railroad industry to identify and address specific issues where risks and exposures can be further reduced.

The second collision myth is that only primary causes are important. Rather, CAWG believes only by focusing on *all* causes can complete prevention be achieved. The experience of Chuck Yeager is instructive. The legendary pilot believes that his greatest aviation accomplishment was not his decorated military career, or his test pilot experience, or even his world flight records. Chuck Yeager is most proud of his role in reducing military air flight catastrophes by focusing on finding *all* causal areas.

The third myth is for a collision to take place there must necessarily be a direct violation of FRA, AAR, ASLRRA and/or carrier operating rules. Not true. Rules and standards cannot cover every operational situation and contingency. And, importantly, rules and standards cannot always account for combinations of factors leading up to a collision.

In order to understand all the causes of a collision, there must be a complete data-gathering, collision investigation. Some investigations fail to identify the correct cause. Others compound this shortcoming by failing to focus on all causes. These failures derive from a number of issues:

- Lack of a systematic/analytical approach – sloppy investigation
- Not getting the data and facts
- Lack of motivation –nobody cares
- Poor communications and cooperation
    - inter-department and stakeholder
    - cross-department
- Rushing; not enough time; being rushed
- Looking for the obvious cause (s)

Finally, concerning collision causes, it must be recognized that fallibility is part of the human condition. The railroad industry cannot change the human condition. However, the conditions under which its employees work can change. The challenge is to find the latent and organizational conditions leading up to a collision. The key to human factor collision prevention is accurate, timely, and unbiased determination of the root causes, and the implementation of targeted corrective actions.

5. FINDINGS, DISCUSSIONS, AND RECOMMENDATIONS

5.1 Introduction

The Findings, Discussions, and Recommendations in this section are based solely on the review and analyses of 65 main-track train collisions occurring from 1997 through 2002. CAWG did not consider results of other investigations, reviews, and analyses of main-track train, or other types of collisions. CAWG results are specific to its data.

After reviewing 65 collision cases, CAWG found situations increasing the risk of a collision. In order to prevent future main-track train collisions of a similar type, CAWG wants the railroad industry to be aware of these situations. As mentioned in the Descriptive Overview section, mechanical and signal failures are generally not involved; nor are degraded weather conditions, or drugs and alcohol.

Findings and recommendations in this study apply to main-track train collisions and not to yard, highway-rail, or switching operation collisions.

5.2 Crew Composition and Experience

Findings and Discussion: Crew Composition and Experience
For freight trains, the conductor and engineer work as a team. One member points out situations that may have escaped the other's attention. In theory, this team concept should prevent collisions, but on occasion, collisions do occur. It is interesting to note of the six Amtrak collisions in this study, four involved one person in the locomotive cab. Two of four cases (CAWG Nos. 2 and 44) may have been avoided if a second crew member was present in the cab. A third collision (CAWG No. 3) possibly could have been avoided with an additional member. In all three cases (CAWG Nos. 2, 3, and 44) the engineer was not asleep. CAWG found, in fact, extraneous circumstances played a role in these three cases.

Table 5-1 shows the years of experience for conductors of violating freight trains and non-violating freight trains. In Table 5-1, the non-violating trains form a basis for comparing experience levels. Based on a small sample of 33 trains, an estimate of the percentage of conductors who have experience between 7 and 22 years is 21.2 percent. CAWG has surveyed other industry sources that suggest the percentage of conductors (road and yard) in this experience range could be as high as 42 percent.

Conductors with 7 to 22 years experience were not crew members of any violating trains. This suggests conductors in this experience range fulfill their role as additional safeguards in preventing collisions of the CAWG's criteria type.

Table 5-1. Conductor Experiences: Violating and Non-Violating Trains

	Violating Train		Non-Violating Train	
Experience	Number	Percent	Number	Percent
Under 7 years	20	48.8	15	45.5
7-22 years	0	0.0	7	21.2
over 22 years	21	51.2	11	33.3
Total*	41	100.0%	33	100.0%

* Conductor experience information was not available in all 65 collisions. More experience was available for conductors of violating (62 percent) than non-violating (51 percent) trains.

CAWG used two statistic tests to compare the difference in proportions (0.0 percent v. 21.2 percent) for conductor experience between 7 and 22 years between the violating and non-violating trains. If appropriate statistical tests are used, adjustment is made for small sample size. Both tests indicate the difference in conductor experience between violating and non-violating trains is significant at the 95 percent level.[25] While significant, CAWG expresses a general caution in interpreting statistical tests of findings from any investigatory studies.[26]

Note: Conductors with fewer than 7 years of experience were involved in 48.8 percent of the collisions, very close to the baseline percentage of 45.5 percent for the non-violators (control group). This difference is not statistically significant.[27] CAWG cannot conclude conductors in this experience group present an unacceptable risk.

However, when both the engineer's and conductor's combined experience is under 5 five years, the level of risk increases, as Table 5-2 indicates.

Table 5-2. Total Crew (Engineer and Conductor) Experience

Violating Train	Non-Violating Train

[25] First test: Z-value of 3.10 was calculated using the standard Difference between Two Proportions test (0.0 percent v. 21.2 percent). P-value = 0.0019, two-tailed test. Second test: An exact Difference between Two Proportions test, more appropriate for smaller samples and proportions than the first test, resulted in a p-value = 0.0024 after the first iteration.

[26] If enough statistical tests are applied to differences uncovered during an investigatory study, 'statistical significances' can result simply by chance. At the 95 percent level of significance, 1 in 20 tests could indicate 'statistical significance' just by chance. For this reason, CAWG limited the number of statistical tests it applied. Additionally, caution is advised in applying statistical tests to investigatory studies because both discovery and proof is being attempted on the same information (data).

[27] A Difference between Two Proportions test was performed. The Z-value was not significant at the 95 percent level.

Experience	Number	Percent	Number	Percent
under 5 years	11	27.5	2	6.9
5-35 years	13	32.5	17	58.6
over 35 years	16	40.0	10	34.5
Total*	40	100.0%	29	100.0%

* Engineer and conductor experience was not available in all 65 collisions. More experience was available for engineers and conductors of violating (61 percent) than non-violating (45 percent) trains.

Violating train crews, where combined engineer and conductor experience is under 5 years, are involved in 27.5 percent of the collisions compared to 6.9 percent for the non-violating crews (control group). Using the same two statistical tests as applied to conductors with 7 to 22 years of experience, this difference is statistically significant at the 95 percent level. [28]

Five of the eleven cases where crews had less than 5 years of experience involve PCF H989 – *Lack of skill or practical wisdom gained by personal knowledge or action.* (See page 55 for definition of *PCF*.) These crews, with under 5 years total experience, account for almost half of the H989s used in coding the PCFs of the 40 violating trains for which engineer and conductor experience is available. Table 5-3 shows the indicators of inexperience.

Table 5-3. Indicators of Crew Inexperience in Five Main-Track Train Collisions

CAWG No.	Location	Indicators of Inexperience
4	Alvord, TX	Crew did not recognize there was a brake pipe obstruction.
6	Lagro, IN	Crew was relatively unfamiliar with the territory.
8	North Bay, CA	Train exceeded restricted speed and the conductor failed to question the engineer.
9	Wickes, AR	Crew was relatively unfamiliar with the territory.
42	Ransom, IL	Conductor did not take independent action to stop the train.

Table 5-4 suggests pairing an experienced crew member with an inexperienced crew member does not increase risk for the experienced crew member. Crews with an experience difference over 20 years are involved in 17.5 percent of the collisions, almost

[28] First test: Z-value of 2.16 was calculated using a standard Difference between Two Proportions test (27.5 percent v. 6.9 percent). P-value = 0.031, two-tailed test. Second test: An exact Difference between Two Proportions test, more appropriate for smaller samples and proportions than the first test, resulted in a p-value = 0.0243 after the first iteration.

the same as the baseline percentage of 17.2 percent for the non-violating crews (control group).

Table 5-4. Experience Difference Among Crew Members

		Violating Train		Non-Violating Train	
Experience Difference Between Crew Members		**Number**	**Percent**	**Number**	**Percent**
Under 3 years		17	42.5	11	37.9
3-20 years		16	40.0	13	44.8
over 20 years		7	17.5	5	17.3
	total	40	100.0%	29	100.0%

Recommendation: Crew Composition and Experience
CAWG cannot conclude conductors with fewer than seven years experience are at a higher risk. However, when possible, an inexperienced crew member should be paired with an experienced crew member. Such pairing reduces the risk for the inexperienced crew member; but does not, as CAWG collision cases show in Table 5-4, increase the risk for the experienced crew member.

5.3 Alertness

The methodology employed by CAWG in studying alertness included: (1) defining alertness, for purposes of railroad operations, as to whether or not any action was taken; (2) examining available information concerning each crew member's sleep history, sleep period, work period, and time of event; and (3) consulting a sleep expert to independently evaluate CAWG's assessment of cases involving alertness.

After completing its review of each collision case, CAWG found that 19 of 65 cases – nearly 30 percent – involved alertness as a PCF.

Findings and Discussion: Alertness
Research indicates that degradation of employee alertness can lead to lapses in attention, slowed reactions, and impaired reasoning and decision-making that have been shown to contribute to accidents, incidents and errors in a host of industrial and military settings. Collectively, these effects have been described as 'fatigue' or 'impaired alertness'. CAWG adopted a data driven approach that focuses on observable behaviors of alertness, i.e., attention to and appropriate responses to one's surroundings rather than the less exact

term *fatigue* that has various meanings for different people. Some collisions appear to reflect impaired alertness since appropriate actions were not taken. Impaired alertness may be traced to a number of variables. Here the focus is on two main *causes*:

- Amount of sleep a person has had in the recent past
- Time of day

Many sleep experts believe the average person should obtain about eight hours of sleep per day to maintain peak alertness. Sleep induced impairments in alertness fall into two main categories. The first kind of problem occurs when a person does not get sufficient amounts of sleep each day, extending over a series of days. This produces what is called a sleep debt, a difference between the average amount of sleep actually obtained and the amount of sleep the person needs to maintain alertness. This may be caused by a number of factors including, but not limited to, problems obtaining sleep during off duty time (trying to sleep during the day or in an unfavorable environment), excessive work and associated work demands, such as commuting. Such chronic sleep debt factors may limit the amount of time to get sleep, compromise the quality of sleep or involved sleep disorder, such as sleep apnea. All of these factors can cause an accumulated sleep debt that can impair alertness.

The second kind of sleep problem occurs when a person has been awake more than sixteen hours since their last major sleep episode, called acute sleep debt. Ideally, people sleep eight hours a day and are awake for sixteen hours. Once the awake period exceeds sixteen hours, there is increasing pressure to go to sleep, which is reflected as a gradual loss of alertness and an increased potential for lapses. Problems from acute sleep debt can occur even when a person has been generally getting eight hours of sleep per day. A classic example of acute sleep debt can occur when a person awakens in the morning at 6 am after sleeping regularly from 10 pm to 6 am and does not take any naps prior to going to work in the evening. If work starts twelve hours after awakening and the work period is eight hours long, the person will have been awake for twenty hours at the end of the shift and may experience an acute impairment of alertness during the last half of the work period.

The time of day can induce problems with alertness because the human body has a biological rhythm that modulates alertness. People who are adjusted to day-time work are generally most alert during the hours from 8 am to 8 pm and experience impaired alertness between midnight and 6 am. This is called the circadian rhythm and is a property of many biological systems, including the brain. The exact timing of the rhythm can be changed by environmental factors. For example, when traveling to a new time zone, it can take many days for the rhythm to realign to the new time for sleep and wakefulness. If a person shifts from a day job to a night job, requiring sleep during the day, it may take many days or weeks for that person to adjust to that new routine. During the period of adjustment, the person will experience impaired alertness.

The two causes of impairments to alertness – sleep debt and time of day – are additive. A person working at four in the morning will be more impaired if also sleep deprived compared to a person at that same time who has been getting plenty of sleep and has been awake for only a few hours.

In summary, there are a number of variables that can impair alertness: chronic sleep debt, hours since awakening, and time of day. To determine the level of alertness impairment a crew member might experience, CAWG gathered evidence from numerous sources, including witness statements and interviews, event recorder data, and available work/rest histories of the crews. CAWG reviewed and analyzed each crew member's sleep history, sleep periods, work periods, and time of event.

After completing its review of each collision case, CAWG found that 19 of 65 cases – nearly 30 percent – involved alertness as a PCF. Realizing the importance of the alertness issue, CAWG asked Dr. Stephen Hursh, a sleep expert already working for FRA, to independently review CAWG's findings concerning each of the 19 cases. Material reviewed by Dr. Hursh originated from Federal Railroad Administration investigations, and in some cases National Transportation Safety Board investigations. CAWG then compared his alertness assessment with that of its independent findings, the result being that CAWG's methodology was determined sound.

There are several general patterns of work and sleep history. Nearly all the collisions that had an alertness component occurred between midnight and eight in the morning. Hence, they all involved a circadian component.

Alertness Scenario #1

Scenario #1 (Table 5-5) would seldom be described as *fatigue* in the usual sense of the word. An employee had one or more days off prior to the day of the collision. There was ample opportunity for the employee to obtain at least eight hours of sleep on the day prior to the collision. But the work period started in evening and extended into the early morning hours. The call to work may have been unexpected; and, the likelihood is low the employee took an evening nap in preparation for work. As a result of this pattern, the employee experienced the combined effects of poor time of day and acute sleep debt (long hours since awakening).

Table 5-5. Alertness Scenario #1

CAWG No.	Location
1	Kenefick,
2	Jacksonville
19	Momence
32	Perkins
45	Wendover
59	North Platte

62	Vader (engineer)
65	Valley Pass

Alertness Scenario #2

Scenario #2 (Table 5-6) involves an employee's accumulated sleep debt that is the result of having either limited opportunity to sleep or to sleep only during day light hours. Usually the event occurs immediately after a day in which the available time to sleep is unfavorable for restorative sleep, perhaps combined with a chronic sleep debt, and with an unfavorable time of day. To document accumulated sleep debt in this scenario, a detailed, long-term work/rest record is required.

Table 5-6. Alertness Scenario #2

CAWG No.	Location
62	Vader (conductor)
64	Des Plaines (engineer)

Alertness Scenario #3

Scenario #3 (Table 5-7) is similar to Scenario #2. Here, there is no evidence of accumulated sleep debt over many days, but there were two work periods in a single 24-hour period and the opportunity to sleep immediately preceding the work period of the collision was in the afternoon hours when sleep is most difficult to achieve. As in the other scenarios, the work period extends into the early morning hours so this acute sleep deficit combines with an unfavorable time of day.

Table 5-7. Alertness Scenario #3

CAWG No.	Location
15	Butler
21	Palm Springs
34	Wickes
49	Pacific

Alertness Scenario #4

Scenario #4 (Table 5-8) contains five cases. These cases include medical (e.g. sleep disorders) and other issues that adversely affected the employee's alertness.

Table 5-8. Alertness Scenario #4

CAWG No.	Location
12	Navasota
38	Racine
44	Hallsville
46	Andersonville
51	Bradford

Alertness Scenario #5

Four of the 19 cases involved impaired alertness factors, but the collected data did not support inclusion into any of the above scenarios. These cases are shown in Table 5-9.

Table 5-9. Alertness Scenario #5

CAWG No.	Location
6	Largo
21	Palm Springs
50	Kenner
64	Des Planes (conductor)

The collision at Largo (No. 6) was reviewed and compared to the criteria used to classify the other twenty-one cases into one or more of the five alertness scenarios presented above. CAWG was unable, however, to conclusively classify this case as an alertness issue.

Recommendation: Alertness

CAWG makes several general observations suggesting avenues for improvements in railroad industry habits and procedures to reduce the incidence of impaired alertness. First, working between midnight and 8 am is an operational necessity that entails an operational risk. This risk needs to be further recognized and countered by the railroad industry. The circadian impairment in alertness that occurs at this time of day is a biological fact. No amount of training, conditioning, or motivation can eliminate the risk of lapses in attention that can occur at these hours. Procedural innovations should be devised to create redundancy and error checking to counter this natural phenomenon.

CAWG believes adequate sleep leading up to night work and napping immediately prior to a night shift are important countermeasures for minimizing the effects of the circadian reduction in alertness occurring between midnight and 8 am. Getting this sleep is a shared responsibility of employees and management. The employees must be trained and encouraged to:

- Understand the importance of adequate sleep and good sleep hygiene.

- Make personal decisions to incorporate evening naps into their daily routines.

- Plan activities so sleep is properly timed to minimize both chronic and acute sleep debt.

Management has a major role in enabling these behaviors. Unexpected or unplanned calls to work in the evening make it difficult for employees to take naps in anticipation of an evening call. It is unrealistic to expect employees to take naps in the evening when the family is at home unless there is a reasonable expectation they will be called to work. In short, evening calls for night work should be as predictable as possible. An unexpected call in the morning for a day shift is almost never a problem for alertness because it usually follows a night of sleep and coincides with the up-swing in normal circadian alertness. Unexpected calls in the evening are precisely the opposite; the person has already been awake for ten to twelve hours and will experience acute sleep debt. The work shift will coincide with the down-swing in circadian alertness. Operational procedures that increase the predictability of evening and night calls make it possible for employees to take necessary naps that minimize impairments to night-time alertness.

5.4 Intra-crew Communication

Findings and Discussion: Intra-crew Communication

CAWG examined the interviews conducted and data reported for the crews, attempting to document each individual's performance of assigned duties during the time previous to the collision when track authority was exceeded and up to the actual impact, noting whether the crew member stayed aboard or jumped.

CAWG experienced a wide variance in the number, extent, and completeness of written statements in the interview files. CAWG focused on factual content of data and interviews addressing individual performance of assigned duties. CAWG initially identified forty-two cases from reviewing the completed CAWG Matrix, using the perspectives defined in situations #1 through #4, shown in Table 5-10. CAWG reviewed each of the forty-two cases, establishing consensus on the ten cases that potential lack of proper intra-crew communication may have been a possible contributing factor to the collision. CAWG also focused on what could have prevented the collision and what recommendation would facilitate safety of operations by the train crew members.

Table 5-10. Intra-crew communication

CAWG No.	Location	Situation			
		#1	#2	#3	#4
5	Hummelstown, Pennsylvania	X			
6	Largo, Indiana		X		
8	North Bay, California		X		
15	Butler, Indiana	X	X		

16	Creston, Iowa					X
17	Orin, Wyoming			X		
20	Mount Pleasant, Texas				X	X
31	Woodburn, Iowa		X			
51	Bradford, Illinois		X	X		
55	Clarendon, Texas		X			
10 cases		totals	5	5	1	2

Situation #1: Cases with Possible Contributing Factor (PCF) H316, *Poor intra-crew communications.*

Situation #2: Cases with PCF H989, *Lack of skill or practical wisdom gained by personal knowledge or action.*

Situation #3: Cases with PCF H215, *Block signal, failure to comply*; PCF H216, *Interlocking signal, failure to comply*; PCF H605, F*ailure to comply with restricted speed.*

Situation #4: Cases where crew of probable violator was not performing duties during the time previous to the collision when track authority was exceeded.

Recommendation: Intra-crew Communication

When there are two or more train and engine service employees in the cab of a locomotive, there should be an established process to ensure that every wayside signal, directive, instruction, and order is clearly and completely understood and properly executed by every crew member. Other activities must not interfere with the safe operation of the train. Particular attention to movement authority is needed when trains meet, one train overtakes another train, or when train operations occur in the vicinity of yards or industries where other train movements take place. There are ongoing crew resource management efforts.[29]

[29] The FRA's Human Factors Research Program and the Office of Safety have jointly sponsored an extensive program of research and development on crew resource management (CRM) training in the railroad industry. The CRM program has four components: 1) a review of CRM training methods, the types of teams found in the railroad industry, and the matching of team types with the most appropriate CRM training methods; 2) the development of curricula appropriate for CRM training for crews in transportation crafts (locomotive engineers, conductors, dispatchers, switchmen, brakemen), engineering crafts (MOW, signal maintainers, electrical catenary crews), and mechanical crafts (machinists, electricians, pipe fitters, carmen); 3) the implementation and evaluation of a pilot training program at a Class I railroad; and 4) the development of a business case for CRM training in the railroad industry.

Reports on the components of the CRM program are under review and will be posted on the FRA website when approved for publication. In addition to these reports, training course materials for the transportation, engineering and mechanical crafts will also be available.

5.5 High-Risk Holiday Periods

Findings and Discussion: High-Risk Holiday Periods

While main-track train collisions have occurred at any time of year, based on the 65 collisions reviewed by CAWG, there are two high-risk periods for main-track train collisions:

- One week period bracketing Independence Day (July 4th.).
- Three-week period bracketing Christmas (December 25th) and New Year's Day (January 1).

As shown in Table 5-11 in the six-year period 1997 through 2002, there were 10 collisions during the four-week (per year) holiday period. This exposure over the six-year period equals 24 weeks (6 x 4). Ten collisions over 24 weeks is an incidence risk of 0.42 collisions per week (10 / 24 = 0.42). The remaining 55 collisions occurring over the complementary six-year, 288-week period (6 x [52 – 4]) corresponds to an incidence risk of 0.19 (55 / 288 = 0.19). The relative risk (RR) for the four-week holiday period is 2.21 (RR = 0.42 / 0.19). A statistical test applied to the differences in incidence risk indicated significance at the 95 percent level.[30]

Reasons for the increased risk are not apparent from the review of the 65 main-track train collisions. If train traffic is reduced during the two holiday periods above, then the increase in risk during these four-weeks is more dramatic. Three other holiday periods – Memorial Day, Labor Day, and Thanksgiving – were not found to be at higher risk.

Table 5-11. Four High-Risk Weeks for Main-Track Train Collisions, 1997 through 2002

High-Risk Weeks: One week surrounding Independence Day; and three weeks surrounding Christmas and New Year's Day

	Four High-Risk Weeks	Forty-Eight Other Weeks
Collisions	10	55
Number of weeks	24	288
Collisions per week	0.42	0.19

30 Chi-square (χ) = 6.82 with a p-value = 0.009. The 95 % confidence interval for the RR is 1.28 to 3.71, a range excluding the relative risk (RR) null value of 1.00.

Fatalities and injuries occur in main-track train collisions. Thus, there is also a risk for increased casualty to train crew members. The risk for these four weeks compared to the risk of all other weeks (Table 5-12) is 1.33 v. 0.41, a relative risk of 3.24 (RR = 1.33 / 0.41 = 3.24).

Table 5-12. Four High-Risk Weeks for Employee Casualties in Main-Track Train Collisions, 1997 through 2002

High-Risk Weeks: One week surrounding Independence Day; and three weeks surrounding Christmas and New Year's Day

	Four High-Risk Weeks	Forty-Eight Other Weeks
Fatalities and injuries	32	119
Number of weeks	24	288
Casualties per week	1.33	0.41

The SOFA Working Group (SWG) found a similar high-risk period existed in its review of 124 switching fatalities occurring, 1992 through 2003. The risk for these four weeks compared to the risk of all other weeks (Table 5-13) is 0.31 v. 0.19, a relative risk of 1.63 (RR = 0.36 / 0.16 = 1.63). SWG, too, could not find an explanation based on review data developed from FRA investigations.

Table 5-13. Switching Fatalities, January 1992 through December 2003

High-Risk Weeks: One week surrounding Independence Day; and three weeks surrounding Christmas and New Year's Day

	Four High-Risk Weeks	Forty-Eight Other Weeks
Switching fatalities	15	109
Number of weeks*	*48	**576
Fatalities per week	0.31	0.19

* number of high risk weeks = 12 years multiplied by 4 weeks/year.
** number of other weeks = 12 years multiplied by 48 weeks/year.

Recommendation: High-Risk Holiday Periods

The potential exists for the industry to better understand the reasons for the high-risk periods for main-track train collisions. Identifying the reasons could bring opportunities for prevention. Studies directed towards understanding should be undertaken. These studies need not be specific to main-track train collisions. Studies could include all human-factor related undesirable outcomes including collisions and employee casualties. These findings may identify and reduce risk during holiday periods.

The industry should alert employees to the increased risk during these periods.

5.6 End of Train Devices (EOT), *49 CFR Part 232, Subpart E*

Findings and Discussion: End of Train Devices (EOT)
CAWG could find little evidence of testing and data collection on the effects of EOT activation in emergency train brake applications. How much stopping distance was actually saved by simultaneous application of the EOT? Obviously, train speed effects distance in feet. CAWG wonders whether it is proportional for speed, or if the percent benefit in stopping distance saved is greater for higher train speeds. CAWG conducted a literary search for industry data on any available research and testing on this issue. CAWG was unable to establish any definitive research or studies.

CAWG canvassed the railroad industry with little success. A few railroads responded with experience, mostly anecdotal [spelling correction] that with the existing train brake system, "The automated feature for the 2-way valve on the rear of the train has minimal affect on stopping distance. If the emergency application actually occurred simultaneously at both ends of the train (as simulations we performed were done to evaluate this issue) stopping distance is improved approximately 10%."

Recommendation: End of Train Devices, 49 CFR Part 232, Subpart E
Training programs should be created, conducted, and documented on a continuing regular basis to ensure engineers are able to instinctively activate the EOT when the train brakes are put into emergency. CAWG suspects that junior engineers are probably made aware and qualified during their training. More senior engineers are of greater concern to CAWG, since instruction and review of the practice must overcome years of experience without a two way EOT to activate. This shortcoming potential for more senior engineers may manifest itself under time-critical performance of operational duties. EOT training should be included in locomotive engineer evaluations and, when possible, in rule efficiency checks. Training should also include train crew awareness of whether or not the locomotive in the lead that they are operating will activate the EOT automatically; or whether it requires manual activation. This question becomes critical as more of the new locomotives come on line.

All locomotives ordered on or after August 1, 2001, or placed in service for the first time on or after August 1, 2003, shall be designed to automatically activate the two-way, end-of-train device to effectuate an emergency brake application whenever it becomes necessary for the locomotive engineer to place the train's air brakes in emergency. [from 49CFR Part 232.405(f)][31]

Data driven simulation and actual research should be conducted and published for the railroad industry, and train crews in particular, to clearly understand the impact and importance of this issue; and the effects of EOT activation when the train brake is placed in emergency from the lead locomotive.

5.7 Crashworthiness

Findings and Discussion: Crashworthiness
Locomotive crashworthiness is important to the survivability of locomotive crews given that a collision has occurred. The intent of CAWG was not to determine the crashworthiness of various locomotives, or the advisability of crews staying in, or jumping from, the locomotive given collision certainty. However, from the review and analysis of the 65 collision cases, information was generated of likely interest to those engaged in locomotive crashworthiness. CAWG wants to make those interests aware of this information now contained in the CAWG Database.

Some analysis, however, was performed. Logistic regression was used to analyze the risk of injury and fatality in collisions from the decision to jump from, or stay in, the locomotive. This multivariate technique controls for confounding variables while testing the effect of interest – whether the employee's decisions to exit or stay, given collision certainty, changed the risk of injury or fatality. Factors controlled for affecting the risk were: train speed, collision type, whether the locomotive was built to S-580 standards. The current S-580 standards are contained in the Appendix. CAWG again stresses that crashworthiness was not a study purpose, and its review and analytical methods did not include a study design to best capture crashworthiness information.

The analysis produced the following results:

- The probability of injury was greatly affected by the decision to exit or stay with the locomotive. Eighty-seven percent of employees who exited the locomotive were injured compared to 51 percent who stayed with the locomotive.

- There was no significant indication in the data that the decision to exit or stay with the locomotive changed the likelihood of fatality. The probability of a fatality was greatly affected by train speed.

Recommendation: Crashworthiness
CAWG suggests that future groups studying crashworthiness may find our efforts of some use as a baseline point as enhanced safety equipment and changes brought on by

[31] During the 1990s, prior to this requirement, several railroads had initiated this practice.

the continued development of S-580 standards. (Refer to Federal Railroad Administration's (FRA's) Website for existing crashworthiness studies.[32])

5.8 Operating Methods

Findings and Discussion: Operating Methods
CAWG compared collisions occurring in Traffic Control System (TCS) territory to those occurring in train order territory[33] (e.g. track warrant territory). The purpose of the comparison was to determine whether the number of collisions per million train miles are different in one type of territory versus another. The comparison was difficult to conduct because the current accident reporting form does not have a consistent process of reporting methods of operations. (See the finding on accident reporting below.)

After considerable review and discussion, CAWG was able to determine the method of operation for all collisions. Table 5-14 shows 45 CAWG collisions in TCS territory and 12 collisions for train order territory.[34] The remaining 8 collisions occurred in other situations.

Table 5-14. Collisions by Territory Type

Territories from Volpe Center Study	Train Miles from Volpe Center Study	CAWG Collisions	Collisions per million Train Miles
Auto	44,220,891	6	
CTC	300,580,358	39	
Total for TCS	**344,801,249**	**45**	0.131
ABS	80,773,696	8	
Dark	58,600,600	4	
Total for Train Orders	**139,374,296**	**12**	0.086
Interlockings, Yard Limits, Form Bs	-----	8	-----

[32] On Federal Railroad Administration's (FRA's) Website: Click on 'Research and Development', then 'Research Reports'. Studies include DOT/FRA/ORD-02/03, DOT/FRA/ORD-01/23, DOT/FRA/ORD-95/08, and DOT/FRA/ORD-95/08I through 95/08V.

[33] *Train order territory* is defined herein as territory within which written authority is required for train movements.

[34] Again mentioned, *train order territory* is defined herein as territory within which written authority is required for train movements.

Using estimated train miles by territory from a Volpe Center study,[35] CAWG was able to form an estimated collisions per million train miles for each type of territory. The collision rate for train order territory, 0.086, is not higher than the collision rate, 0.131, for TCS territory. CAWG expected the collision rate for train order territory[36] to be significantly higher than TCS territory, so this is a surprising result. Most expected the additional computer assisted data and information developed with TCS to reduce exposure unique to train order territory, where additional manipulation and oversight by crew members is required; and thus, train order territory would be expected to be subject to additional human failure.

Two study limitations may account for this unexpected result:

- CAWG collisions do not represent all collisions.[37] For example, CAWG selected only those collisions having an FRA HQ investigation number; and from those, collisions where trains exceeded authority. Situations where crews improperly gave up authority, such as misaligning a manual switch, are not covered by CAWG.

- Collisions for 2003 and 2004 are not covered in this report. Adding CAWG collisions for these years could change the estimated collision rates in a significant way.

A PCF profile of the two types of territories sheds light on the different collision rates associated with the two territories (Table 5-15).

Table 5-15. PCFs by Territory Type

Possible Contributing Factor	Definition	Train Order Territory	TCS Territory	Remarks
E03C	Obstructed brake pipe (closed angle cock, ice, etc.)	1		
E03L	Obstructed brake pipe (closed angle cock, ice, etc.) (locomotive)		1	
H101	Impairment of efficiency or judgment because of drugs or alcohol		2	
H104	Employee asleep		8	This PCF only occurred in TCS territory.
H199	Employee physical condition, other (Provide detailed description in narrative		3	
H203	Fixed signal improperly displayed		1	
H204	Fixed signal, failure to comply	2	5	
H211	Radio communication, improper	1		

[35] *Base Case Risk Assessment: Data Analysis & Tests*. Study done by the John Volpe National Transportation Systems Center for the Office of Safety, Federal Railroad Administration. RSAC/PTC Working Group Risk 2 Team. Updated April 19, 2003.
[36] *Train order territory* is herein defined as territory within which written authority is required for train movements.
[37] The Volpe Center study formed rates by territory from approximately 800 collisions. These collisions were selected based on being preventable by a Level 3 PTC system and having total damages exceeding the FRA's monetary reporting threshold.

H212	Radio communication, failure to give/receive		1	
H215	Block signal, failure to comply	4	24	
H216	Interlocking signal, failure to comply		21	
H299	Other signal causes (Provide detailed description in narrative)		1	
H307	Shoving movement, man on or at leading end of movement, failure to control		1	
H316	Poor Intra-crew communication (CAWG only)	4	5	One-third of CAWG collisions in train order territory have this PCF. This is significantly higher than TCS territory.
H317	Failure to communicate unsafe condition		2	
H318	Poor crew utilization	1	4	
H398	Poor Inter-crew communication (CAWG only)	1		
H401	Failure to stop train in clear	1		
H404	Train order, track warrant, track bulletin, or timetable authority, failure	3		
H499	Other main track authority causes (Provide detailed description in narrative	2		
H509	Improper train inspection	1		
H510	Automatic brake, insufficient		1	
H599	Other causes relating to train handling or makeup (Provide detailed description)		1	
H604	Train outside yard limits under clear block, excessive speed		1	
H605	Failure to comply with restricted speed	3	8	
H702	Switch improperly lined	2		
H799	Use of switches, other (Provide detailed description in narrative)	1		
H989	Lack of skill or practical wisdom gained by personal knowledge or action	4	6	
H991	Tampering with safety/protective device(s)		1	
H992	Operation of locomotive by uncertified/unqualified person		1	
H999	Other train operation/human factors (Provide detailed description in narrative)	1	5	
M104	Extreme environmental condition - DENSE FOG		3	
M199	Other extreme environmental conditions (Provide detailed description)	1		
S099	Other signal failures (Provide detailed description in narrative)		1	

In train order territory, Table 5-15 identifies problems with intra-crew communication in 4 of the 12 cases; this is a significantly higher ratio than the corresponding ratio for TCS of 5 out of 45 cases.

Table 5-15 also shows all collisions where at least one employee was asleep occurred in TCS territory. Table 5-15 indicates alertness is more of a risk factor in this type of territory. The 12 cases in train order territory did not identify any employee being asleep. This risk factor may partially explain why TCS territory does not exhibit a lower CAWG collision rate than train order territory.

Recommendation: Operating Methods

CAWG suggests a potential finding of differences in crew alertness between TCS and train order territory, but does not make a recommendation. Future studies may look at the performance of visual tasks, written communication requirements, and other train crew activities.

5.9 Collision Investigating and Reporting

Findings and Discussion: Collision Investigating and Reporting

Collect Human Factor Data

After reviewing the first 14 collision cases, CAWG decided to rate the quality of the Federal Railroad Administration's investigation as shown in Table 5-16. Seven cases (14 percent) were rated 'very good'; 26 (50 percent), 'good'; 17 (34 percent), 'fair'; and 1 (2.0 percent), 'marginal.'

Table 5-16. Quality Ratings of Main-Track Train Collision Investigations, 1997 through 2002

Number of Cases	Rating	Percent
7	Very Good	14
26	Good	50
17	Fair	34
1	Marginal	2
totals *51		100.0%

* After reviewing 14 collision cases, CAWG decided to rate the investigation quality of the remaining 51 cases.

Those cases rated as either very good or good contained detailed information concerning each employee's work history, experience, training, the level of management oversight, and work/rest histories going back at least 10 days. Those cases rated fair or marginal by CAWG did not contain many of the items listed for various reasons. These findings led CAWG to discussing how FRA conducts a collision investigation, what is required, and why FRA does not, as a rule, investigate and document an employee fatality as the result of a human factors collision with the same level of thoroughness as an employee on duty fatality (FE).

Where human factor issues were not fully developed in cases, CAWG felt that "root cause analysis," with accurate conclusions and beneficial recommendations, could not always be clearly established. However, since the end of the CAWG study period (2002) additional training has been provided for FRA Inspector forces; and regional management has been re-trained on Accident/Incident Investigation Review. This effort, along with personnel changes at FRA's Accident Analysis Branch have led, in many cases, to a more comprehensive and standardized final report, particularly over the last four years. Additionally, the FRA and some railroads are in the process of developing new human factor tools that have the potential to be useful when applied to accident/incident investigation.

Recommendation: Collision Investigating and Reporting

Collect Human Factor Data

FRA should identify and document all relevant human factor data. This data includes crew members' experience on the territory where the collision occurred, their age, experience in craft, and railroad seniority of each of the crew members in the collision (striking and struck crews). A work/rest history that clearly indicates off and on-duty times for both train crews and accompanying paperwork on how off duty time was spent, if possible, should go back a minimum of 10 days. CAWG recommends a review of management oversight for all of the violating train crew-members. The oversight should include training results and a review of the number of efficiency tests performed on each crew member during the last 6 months, the number directly related to the incident and the number of tests passed and failed.

Findings and Discussion: Collision Investigating and Reporting

Update CAWG Database

The experience gained by the Switching Operations Fatality Analysis (SOFA) Working Group (SWG) development and analysis of a data matrix was valuable to the CAWG's work and endeavors. The SWG entered detailed information on the 76 switching fatalities upon which its October 1999 [38] study was based, into a Microsoft® Excel spreadsheet. By continuing to review and add switching fatalities to its 'SOFA Matrix', the SWG created retrievable, electronic records of 124 fatalities. Integrating the information on the additional 48 switching fatalities with that of the original 76 fatalities allowed the SWG to further identify additional operational exposures to fatalities, in the form of Special Switching Hazards, to employees engaged in switching operations. CAWG would benefit from additional case analysis.

Recommendation: Collision Investigating and Reporting

Update CAWG Database

The CAWG Database allows for quick retrieval and querying of information on the 65 main-track train collisions occurring from 1997 through 2002. CAWG recommends that its Database be updated for 2003 and 2004 collisions meeting the established criteria. Additional years of information will allow for up-to-date querying to determine present risk factors and commonalities with past collision events.

Findings and Discussion: Collision Investigating and Reporting

Reporting Signal Information

CAWG notes that some collisions occurred in territory where the transiting train encountered the sequence GREEN, YELLOW, RED. CAWG considered the benefit of a fourth signal: FLASHING YELLOW, or two consecutive YELLOWs, giving a greater advanced warning time to an absolute stop signal. Changes in the configuration of

[38] *Findings and Recommendations of the SOFA Working Group*. October 1999.

existing signals may have provided beneficial results to safe operations in some of the collisions reviewed. However, the data files, which CAWG had available and reviewed, did not contain sufficient data and information on signal systems to establish and/or evaluate. Therefore, CAWG could not make a determination about the collision-prevention value, if any, of a four- signal sequence as opposed to a three.

Many cases contain information about crew members' perceptions of signal aspects prior to a collision. This information was derived from testimonies taken from those affected during post-collision interviews. Given that Distant Signals (the signal preceding a Home Signal) are not routinely equipped with recording devices and therefore cannot create a record of what aspect the Distant Signal was displaying, the investigation regarding specific signal aspects preceding the collision is based upon the testimonies of carrier officials, affected train crew members, signal tests that have been performed on the signals in question and information gleaned from data and event recorders at the Control Point or Interlocking where the collision took place. When these tests and signal reports contradict the crew member's testimony, it is assumed that the crew member did not correctly remember the signal indication. It appears that at times, detailed information on signal issues is not identified, collected, documented, and reported. Until this information is systematically collected, a system wide database cannot be developed capable of being queried regarding the number of collisions occurring in three signal-sequence territory, as opposed to the number occurring in territory equipped with a four sequence-system. Without this level of relevant information and data, CAWG believes that future working groups will be unable to establish specific conclusions and effect meaningful safety improvements.

Recommendation: Collision Investigating and Reporting
Reporting Signal Information
In an effort to build a reliable data base, CAWG recommends that reporting of post incident testing involving signal systems include information on the type of signal system, model number of signal apparatus, and aspects from each signal. Aspect information should be gathered from an adequate number of signals to clearly identify all those relevant to the incident. Signal apparatus information should include the type and number of heads located on each signal mast.

Finding and Discussion: Collision Investigating and Reporting
Reporting Method of Operations
CAWG found inconsistencies regarding the entries made to field number 30 (Methods of Operation) on form *FRA F6180.39* used by FRA Investigators to record objective data about the accident they are investigating. Often, commingling signal authority with safety overlays. For instance, a train operating in Traffic Control System (TCS) territory will also be governed by automatic block signals; therefore, it is redundant to use both the "e" and the "g" codes. Further, the practical difference between "I"-Timetable/train order, "j"-Track warrant, and "k"-Direct traffic control is negligible when annotating a block used to indicate a "method of operation" and could certainly be spelled out later on in the report if necessary to clarify why the accident occurred as the result of one of these

methods of operation and may not have happened using another. [Deleted paragraph beginning with:" Additionally,..."

CAWG invested considerable effort to convert the reported codes into a framework that was useful for analysis.

Recommendation: Collision Investigating and Reporting

Reporting Method of Operations

FRA should review block 30 on the most recent form *FRA F6180.39* (Revised July 2003) and determine which methods of operation belong in the block, which methods of operation should be combined, and which methods should be removed. CAWG believes FRA would create a more standardized and efficient way of sorting on the method of operation in effect at the time of the incident.

EPILOGUE

Only in its Epilogue have CAWG members consciously offered interpretations based on their railroad experience. Such is the purpose of an epilogue. The body of a report contains factual, data-based information. An epilogue allows authors more leeway in drawing upon their experiences in interpreting data-based information.

The railroad industry is making substantial progress reducing incidents. Many of the easily identified and understandable causes – track and mechanical – are being addressed and dangerous exposures substantially reduced or eliminated.

However, over the past ten years, the industry found no clear and identifiable trend of improvement in human-factor related collisions. Review of the 65 collisions comprising this study established that many of these events were a combination of unrelated factors and deviations occurring at the same time, at the same location, and on the same train. Sometimes, these factors and deviations do not represent a readily identifiable violation of operating regulations and/or standards: the more factors and deviations present, the more likely a collision.

The railroad industry has undergone revolutionary change over the past generation. Deregulation forced railroads to become far more efficient and price-competitive than at any time in their history. These pressures were exacerbated as the U.S. economy increasingly adopted "just-in-time" manufacturing and inventory procedures.

The industry's optimization of capacity and introduction of innovative technologies, which began after World War II, picked up steam in the 1980s. By the turn of the 21st Century, employee headcounts had steeply declined, while the number of Class I railroads dwindled to single-digits and networks of Shortline carriers grew.

The operating employee of today works in a vastly different environment than his or her predecessor. It is marked by unit trains, blocking by destination, replacement of the caboose by end of train devices (EOTs), distributed power, wayside detectors, and various means of auditory and visual communications.

By far the most noticeable change for operating employees has been the reduction of crew size made possible by technology. While error-free job performance by crew members has always been the standard, that mandate is heightened in a reduced crew environment, because the observational redundancy provided by the "eyes and ears" of the third, fourth and fifth crew members no longer exist.

This is not to say that crew size reductions have made the industry less safe. Not only does the dataset not support such a conclusion, the purpose of our review was to investigate why human factor accidents are not trending downward, not because of any increase.

Nevertheless, one important point must be made. The technology enabling the reduction of crew sizes is most adept at detection and documentation of human error. However, some of this technology does not function preventively, as would a warning from a crew member devoting an extra pair of eyes and ears to a task.

Many devices now available need further examination to evaluate their potentials to assist crew members to maintain a fail-safe job performance level. Furthermore, when new technologies are considered and designed, the industry should not lose sight of the totality of the functions being replaced, rather than merely the minimal aspects the technology will assume.

Mergers and "spin offs" during the last twenty years further complicate current methods of train operations. There has been a marked expansion of joint operations, major changes to and expansions of seniority districts, and foreign line train operations on a routine basis. Such complications require that today's road freight crews be qualified on more operating rules and physical characteristics than their predecessors could have imagined, a burden that constantly tests one's situational awareness.

For example, one collision we studied occurred when a foreign line crew failed to understand the correct meaning of a "red, over red, over yellow" signal as "restricted proceed." This mistake may have been made because the meaning on their "home" road was "diverging route approach." In another case a home signal imperfectly displayed, should be understood as a "stop." The experienced crew failed to understand that the signal they thought they observed (diverging route approach) could not be displayed at this geographic location. Although these examples are isolated, and somewhat rare, they point to the need to include situational awareness as a factor when changes to operations are being considered.

The composition of the general population from which operating employees are being hired is different than previous generations. New employees in the railroad industry have different interests, abilities, and skills than their predecessors. New railroad employees entering the work force today are more computer literate. Adolescent activities and learning processes of many new railroad employees were based on electronic and computer fundamentals.

An unique opportunity exists to tap into these skills to improve training and abilities. New methods should be developed to exploit their potential. It is easier to use potential skills to jump-start understanding of complex processes for relatively new employees. Such new methods, when implemented, could further improve safety of operations. Although education and training have a constant impact on job performance, however, they cannot substitute for on-the-job experience.

In this regard, it might be tempting to point to downsizing, outsourcing, attrition, and retirements as the cause of a drain in railroad industry knowledge levels, and stagnating human factor accident rates. The reality is much more sophisticated than that simple overview. Better training and tools should become the cornerstone for modern collision investigation and implementation of safety improvements, and we believe that a clear mandate exists to improve investigation techniques.

The cases studied demonstrate that a measurable benefit to safety can be realized from meaningful assessment of the overall processes of train movements in main track operations. While there is much commonality in the operating rules across America's railroads, there also is much divergence. Each railroad has developed its own system of rules and procedures to reflect the geographic, climatic, shipper, and cultural base unique to it, and numerous rules are grounded in a particularly tragic or catastrophic event a railroad endured. In some cases, implementation of rules and procedures over the years have established standards and processes that are more complicated than required, especially for new and relatively inexperienced employees.

Thus, when a detailed study of accidents is undertaken, it is natural to inquire whether – and to what extent – a particular railroad's unique "operating culture" was related to an accident. Any examination and evaluation of the overall process of train operations must be inclusive of all possible elements and parameters.

Some past investigative efforts were piecemeal, and assumed existing methods of train operations to be inviolate and immutable. Others limited themselves to regional or seniority district boundaries. Better results may be possible when these arbitrary barriers are broken down and novel solutions are considered and implemented.

Unfortunately, these changes in culture occasionally involve shifts in authority and "new ways" of operating. It is easy to argue against such initiatives, and the interests of various industry stakeholders are going to be different. However, all stakeholders must seek common ground, and compromises are both necessary and inevitable. It will take time to successfully implement resulting methods, standards, and processes. There must be a total commitment by all stakeholders for successful implementation of significant changes, with enhanced safety being the commonly-shared goal.

The railroad industry's greatest challenge has always been to maintain or improve safety while increasing productivity.[39] Everyone wins when railroads move more freight and do it safely. However, operating employees are under more pressure than their predecessors to fulfill demand for greater productivity. Those men and women have answered the call, and the productivity of the contemporary operating employee is truly remarkable.

Nevertheless, so long as trains move by the grant of authority from wayside signals, written communications, or verbal directives perceived, received, and acted upon by human beings, the greatest influences on railroad safety will be the decisions made by the human beings in the control cab of a locomotive.[40] As the industry's technology is poised on the threshold of a new era, it is critical that all stakeholders exercise prudence and care

[39] See chart on Ton Miles/Employee in *Appendix*.
[40] As Dekker (2002) says, "People are the only ones who can hold together the patchwork of technologies introduced into their worlds; the only ones who can make it all work in actual practice." (p. 103)

to ensure that technological evolution does not unintentionally erode the significant progress made to date in the safety of railroad operations.

Statement of
Richard F. Timmons, President
American Short Line and Regional Railroad Association
before the
U.S. House of Representatives
Committee on Transportation and Infrastructure
July 25, 2006

I appreciate the opportunity to appear this morning on behalf of the American Short Line and Regional Railroad Association (ASLRRA). Nationwide there are over 500 short line railroads operating nearly 50,000 miles of track and employing over 23,000 individuals.

As I will discuss in a moment, there are differences in the operating environments of the short line railroads and their Class I counterparts and those differences make this a somewhat easier subject for the short line industry. Notwithstanding those differences I want to emphasize our support for the points Mr. Hamberger made in his remarks, particularly with regard to the Hours of Service Act. As I have said at each one of these hearings, the efficiency, competitiveness and profitability of the short line industry is directly related to the efficiency and competitiveness of our Class I connections. Mr. Hamberger's observations on the interplay between the Hours of Service Act, railroad scheduling requirements and collective bargaining agreements are very important and I hope the committee will take those observations to heart.

The tempo of short line railroading is different than that of the Class I's and that difference affects how we think about the issues you are considering today. Short lines are generally operating in a much smaller geographic area than the Class I railroads. These shorter distances combined with slower speeds and smaller consists produce more predictable work schedules and more routine patterns of interchange and delivery. We are better able to anticipate work loads, design train and car trip plans, regularize train crew schedules, plan for maintenance crew operations and right of way and equipment inspection programs.

This more routine and predictable tempo has contributed to what we believe is an impressive and improving safety record as documented by the FRA's safety statistics. In 1990 the Class II and III industry experienced 651 human factor accidents. Last year we had 242, and to date in 2006 we have had 63. Any accident is one too many and tireless effort is required to continue to improve our record. But the trend line for small roads has been headed in the right direction for some years now.

Our improving record is also evidenced by another set of numbers used by short lines. Class II and III railroads rely on a severity index to assess our safety performance each year. We believe this more accurately measures our progress and allows us to target resources in areas where they can do the most to alleviate the worst. Ten years ago serious injuries among all short lines totaled 1,426. In 2005 serious injuries totaled 25.

While I believe the nature of our operations contributes to our favorable safety record, there are two other factors that have contributed. First, we take safety training very seriously and we at the association are constantly looking for ways to enhance existing training and to encourage individual short lines to do more of it. In January of 2005 we entered into a new partnership with the National Academy of Railway Sciences to facilitate short line use of this outstanding training facility. Short line attendance has increased steadily since the new partnership was announced.

Second, the short lines are making every effort to improve our track. As you know, the short industry inherited the worst of the nation's track infrastructure when we began taking over these properties in the 1980's. Today short lines plow almost a third of their annual revenues back into infrastructure improvements. That is more than any other industry in the country. Beginning in 2005 we have been able to increase that investment thanks to the new rehabilitation tax credit that so many of you were helpful in securing. As our track improves, our safety record will improve and we think the statistics I mentioned bear that out.

I am encouraged by our improving record and I am optimistic that continued attention to safety training and track upgrades will help us continue that improvement in the future. But there are other factors that we must focus on continuously to avoid accidents. I will not dwell on these in detail but believe that it is important to highlight them briefly:

- Drug and alcohol testing must be steadily pursued with serious determination. This is an on-going human factors aspect of all work forces today and we take it very seriously.

- Failure to comply with established rules and procedures is a critical human factor dimension that requires constant attention. To counter this compels consistent and tireless emphasis and correction by supervisors. Taking shortcuts and ignoring established rules must be corrected through observation, counseling and retraining.

- Insuring adequate supervisory oversight is the most challenging and in some respects the most important human factor consideration for the small railroad industry. Not checking, not validating, not compelling compliance and not taking the appropriate corrective actions all lead to bad habits, potential accidents and poorly managed railroads. To counter this requires vigilance by supervisors at every level. When problems are identified they must be corrected immediately. Recently the ASLRRA has initiated the **SAVE** program. The Safety and Validation Evaluation (SAVE) inspection places our most experienced operating staff members on the short line system for several days to assess and educate short line railroaders at their work sites. While a small step, the initial returns are significantly improving operating procedures and compliance with rules.

Short line operations are different than those of the Class I railroads and those differences have made our job somewhat easier when it comes to human factor issues. Nonetheless we are far from immune from human errors and such issues as fatigue. It is for this reason that we introduced the fatigue program for Class II and III railroads in March 1999. We are proud that our numbers are improving but we strive to do better.

I thank you for your time and attention today and would be pleased to answer any questions you may have at the appropriate time.

BEFORE THE

UNITED STATES HOUSE OF REPRESENTATIVES

COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

SUBCOMMITTEE ON RAILROADS

HEARING ON

RAILROAD INDUSTRY HUMAN FACTOR SAFETY ISSUES

JULY 25, 2006

TESTIMONY OF

JOHN P. TOLMAN
VICE PRESIDENT & NATIONAL LEGISLATIVE REPRESENTATIVE
BROTHERHOOD OF LOCOMOTIVE ENGINEERS AND TRAINMEN,
A DIVISION OF THE RAIL CONFERENCE
OF THE INTERNATIONAL BROTHERHOOD OF TEAMSTERS

Thank you Mr. Chairman, Madame Ranking Member, and Members of the Subcommittee. My name is John Tolman, and I am the Vice President and National Legislative Representative of the Brotherhood of Locomotive Engineers and Trainmen, which is a division of the Teamsters Rail Conference. On behalf of more than 33,000 BLET members and 70,000 Rail Conference members, I want to thank the Subcommittee for holding this hearing on human factor safety issues in the railroad industry and for the opportunity to testify.

I would like to focus today on three subjects. First, I want to underscore prior BLET testimony concerning fatigue, and how the industry's rampant manipulation of the Hours of Service Act and governing FRA regulations contribute to this growing problem. Second, I am going to address the nexus between inadequate training and human factor accidents. And, third, I want to inform the Subcommittee of a couple of potential hazards inherent in some of the technologies that promise to eliminate human factor accidents.

A little less than three weeks ago, the National Transportation Safety Board adopted a report determining that the 2004 Macdona, Texas, collision and toxic chlorine release, which killed three people, was caused by a fatigued crew's failure to respond to wayside signals. The crew was criticized for failing to effectively use off-duty time, thereby not obtaining sufficient restorative rest prior to reporting for duty, and Union Pacific was criticized for train crew scheduling practices that created inverted crew members' work/rest patterns.

The NTSB's determination illustrates a problem that has increased in severity in recent years. For many decades, then-prevailing industry practices worked to minimize or camouflage potential fatigue problems. Much larger crew sizes greatly reduced the likelihood that an entire crew would be working while fatigued. Moreover, collective bargaining agreements contained maximum mileage regulations — that were strictly enforced — under which a worker would be marked off for the remainder of the month when the maximum was exceeded.

Over the past 50 years, technology has reduced crew size from five or six to two or three. Notwithstanding this fact, the supply of locomotive engineers, conductors and brakeman has not kept up with demand, creating enormous pressure on the industry to work crews above agreement-based mileage levels. The desire of railroad workers to improve, and not just maintain, their standards of living created similar pressure on unions to permit crews to continue working when those mileage levels were exceeded. As a result of these factors, today's smaller crews work far more trips and miles than their historical predecessors.

Compounding these changes is something called "limbo time," the rampant abuse of which by the nation's railroads is producing intolerable working conditions for train crews. As you know, the Hours of Service Act was enacted in 1907 and has been amended several times since. It currently is codified at Chapter 211 of Subtitle V to Title 49 of the United States Code.

Section 21103 prohibits operating employees from working more than twelve consecutive hours in any 24-hour period, with limited exceptions. If a train cannot reach its destination within the twelve hours, the crew must stop in time to cease all work prior to the expiration of the twelfth hour, at which point they are considered "outlawed." A railroad that requires an operating employee to perform service covered by the Act beyond the twelfth hour, unless the circumstances are excepted by statute, is subject to a civil penalty.

Under current law, "[t]ime spent in deadhead transportation to a duty assignment is time on duty, but time spent in deadhead transportation from a duty assignment to the place of final release is neither time on duty nor time off duty." 49 U.S.C. § 21103(b)(4). Thus, a crew who stops their train short of the destination terminal because they have "outlawed" are in "limbo" status with respect to the Hours of Service Act while deadheading from where they stop to their off-duty point.

The history of the Act shows a pattern of abuse by carriers that continues to this very day. For example, the Supreme Court rejected an argument by a railroad that it should not be fined for violating the Act because a delay to the train caused the crew to "outlaw." Missouri K & T Ry. Co. of Tex v. U.S., 231 U.S. 112 (1913). That court also rejected the argument that time spent by the crew waiting for their locomotive to be watered and repaired should not be included in calculating the hours of service, because the crew was "under orders, liable to be called upon at any moment, and not at liberty to go away. Their duty was to stand and wait." Id.

The evolution of the current problem caused by railroad abuse of "limbo time" is set forth in detail in Brotherhood of Locomotive Engineers, et al., v. Atchison, Topeka & Santa Fe Railroad Co., et al., 516 U.S. 152 (1996). Prior to amendments made in 1969, all deadhead time — whether to or from a duty assignment — was considered off-duty time. 516 U.S. 152, 159, citing United States v. Great Northern R. Co., 285 F. 152, 153 (CA9 1922). In 1969, Rail Labor sought to correct this problem by proposing that all deadhead time be considered on duty time; the industry balked over liability for civil penalties in the event of a "miscalculation" in relieving crews, and Congress created "limbo time" as a compromise solution. Id. at p. 160.

On its face, Section 21103(b)(4) is clear with respect to time spent in the vehicle providing deadhead transportation: it is neither on-duty time nor off-duty time. The issue that confronted the Supreme Court was "how to classify the time the outlawed crew spends waiting for the deadhead transportation to arrive" at the location where they outlawed. Id. at p. 155. The Ninth Circuit had held that such waiting time was time on duty, while the Seventh Circuit, *en banc*, held that it was limbo time. Id. In resolving this disagreement between the circuits, a unanimous Supreme Court held "that Congress intended that time spent waiting for deadhead transportation from a duty site should be limbo time." Id. at p. 162.

The decade since the Court's decision has seen both the number of crews stranded waiting for transportation and the length of limbo time increase. Indeed, the problem has become so prevalent in recent years that the December 16, 2003 BLE National Agreement included language committing that participating carriers would "make reasonable efforts to relieve and expeditiously transport [outlawed crews] to the tie-up point." Unfortunately, however, things have only deteriorated since that commitment was made.

Over the past nine months, we have received many thousands of reports of excessively long tours of duty. Our staff presently is assembling these data into a usable form; a project we expect will be completed later this year. However, I can tell you that the preliminary information we have is shocking.

According to data prepared by one of the four largest Class I railroads — covering the first six months of this year — on average, work tours for over 224 crews exceeded 14 hours every day! An average of nearly 103 crews a day work tours in excess of 15 hours, and over 46½ work tours in excess of 16 hours. Almost 20 crews every week for the first six months of this year had a work tour more than 20 hours long; that's 12 hours of work followed by more than 8 hours of deadhead/limbo time.

In 2002, an average of just under 90 crews per day on this railroad had duty tours in excess of fourteen hours, and over 33½ had tours over fifteen hours. Last year, the average number of crews exceeding fourteen hours had more than doubled — to over 218 per day — and the average number of crews exceeding fifteen hours had more than tripled, to nearly 105 per day. As I testify today, we are now in our nineteenth month of such excessive limbo time.

Data provided to us by a local BLET official concerning one terminal on another Class I railroad is similarly troubling. In this one terminal alone, an average of 15 crews had work tours in excess of 13 hours every two days between February 1st and June 30th of this year. One third of those crews had work tours in excess of 14 hours.

The industry makes two responses to its self-created limbo time crisis. One is that crews are not disadvantaged because they are paid for their excessively long work tours. Very frequently that is not the case. Under existing national agreements, road freight crews are not entitled to overtime until they have "run off" the mileage for their trip. For example, crews on pools in excess of 200 miles one way would not accrue overtime until well after twelve hours have been spent on duty. Some system and local agreements provide for overtime at a point prior to when the miles have been "run off," but many do not. The undisputable fact is that crews do not receive any compensation for this time is a large percentage of cases.

The other industry response is that safety is not diminished because the crews are not performing service. This claim is misleading, at best. Many times, a crew will be instructed to not secure their train when the railroad plans to not remove that crew until its relief has arrived. This is done so that the train can be further advanced toward its destination during the period when the crew would otherwise be securing the train.

Furthermore, whether the train has been secured or not, the crew continues to be governed by operating rules requiring that they remain alert and observant, and that they take any action necessary to protect the train against unanticipated mechanical problems or vandalism. In a November 21, 2001 Opinion Letter, FRA's Assistant Chief Counsel for Safety stated that requiring a crew to attend to its train in this manner will be considered limbo time provided that the crew is permitted to leave the train when its relief arrives. Significantly, it was after the issuance of this Opinion Letter that the number of instances of excessive limbo time began to skyrocket.

You will hear testimony today from someone far more qualified than me about how changing work/rest cycles exacerbate fatigue and make it more difficult to achieve and maintain full alertness. However, two observations are worth making at this point. The first is that the maximum work cycle under the Hours of Service Act — 12 hours of work followed by 10 hours off duty — is not, in and of itself, very disruptive of the human circadian cycle, unless it continues unabated for a period of time. The other is that when one adds to the mix limbo time of two, four, six, eight, or more hours on a consistent basis, work/rest cycle begins to sound like an oxymoron.

As a matter of fact, the preliminary NTSB report concerning Macdona indicates that one of the new recommendations the Board intends to issue will be addressed to FRA, urging the agency to "[e]stablish requirements that limit train crewmember limbo time to address fatigue." Given the 1996 Supreme Court ruling, and in light of the 2001 interpretation of the Chief Counsel's office, we are not certain at this time whether FRA can address this recommendation via regulation alone; indeed, it may develop that the only solution to the limbo time crisis is legislative. In either case, the elimination of abusive limbo time is one fatigue-fighting option that is available for implementation today.

In our opinion, the industry has been and remains in a state of denial concerning fatigue. The North American Rail Alertness Partnership — or NARAP — was chartered in 1998, and is comprised of management, labor and government officials. Although NARAP has met quarterly for the past eight years, it has failed to meet its promise to date. In fact, labor withdrew from a project to create a NARAP website earlier this year because the industry insists on limiting its scope to educating workers on how to maximize rest during off-duty periods, which reflects the industry's continuing position that it bears no responsibility to manage in ways that mitigate fatigue.

A similar outcome was the fate of the work of the Collision Analysis Working Group, or "CAWG." CAWG was created in 2002 at the suggestion of then-Federal Railroad Administrator Allan Rutter, and also was comprised of management, labor and government officials. The group performed a root cause analysis of 65 human factor accidents that occurred on main track, all of which were investigated by FRA Headquarters. These accidents resulted in 16 fatalities, 531 injuries and over $83 million in track, signal, lading, and equipment damage.

CAWG concluded that fatigue was a possible contributing factor in 19 — or nearly 30% — of the 65 accidents studied. Its Final Report proposed three specific fatigue-mitigation areas in which workers should receiving training. However, the Report also concluded that management plays a "major role" in fatigue management, in particular minimizing or eliminating unexpected and unplanned calls for duty. The release of CAWG's Final Report has been delayed for nearly a year because the industry withdrew from the project after drafting was completed, largely because of CAWG's conclusions concerning fatigue.

You will no doubt hear the industry repeat past promises to make significant headway in the battle against fatigue, and you may even hear that the Hours of Service Act is an impediment to a solution. However, the real problem is the industry's continuing denial of any responsibility towards its workers in mitigating or preventing fatigue. In fact, the Act was amended almost twelve years ago to include a process whereby labor and management could jointly petition FRA for a waiver of the Act's requirements, for up to two years, for purposes of implementing a pilot program to achieve the Act's goals by alternative measures. No railroad has made any proposal to us that would justify such a petition for waiver during this period.

It bears repeating: of all the various factors that can cause and contribute to fatigue among operating crews, the one that can be resolved today — and simply by better management — is excessive limbo time. To the extent that some crews in some areas are receiving additional pay for this time, curbing limbo time abuse also contributes to the industry's bottom line. We believe the industry's position concerning this subject is indefensible, and we hope the Subcommittee will hold the carriers' feet to the fire on this issue.

The second subject I want to address today concerns the nexus between training and the incidence of human factor accidents. As we stated last month, in testimony before this Subcommittee concerning hazmat issues, the industry is in the midst of a generational turnover triggered by the first retirements of Baby Boomer railroad workers. For this reason, the industry faces a pair of training-related problems.

One concerns the quality and quantity of training for new hires into a particular craft and for promotion, as in the case of Locomotive Engineers. If proper forecasting has not been done, the railroad will find itself pressured to rush training in order to deploy the new workers. It is our understanding, for example, that in some places there is such a shortage of trained Remote Control Locomotive Operators that some railroads are combining RCO training and Conductor training into a single program in order to meet their needs.

This has created such a significant safety concern that the FRA has created a RCO Training Working Group — composed of appropriate industry stakeholders, including the BLET — to review the RCO training model from the ground up, focusing as much on quality as on quantity. That Working Group will meet for the first time this afternoon and we look forward to participating in developing a national training standard.

The other training-related problem flows from pairing relatively inexperienced workers when calling a crew. Classroom training and on-the-job field training provide a necessary foundation for working safely; however, they are merely a foundation. Working safely and efficiently also is a product of experience. Standardized training programs only scratch the surface of the theory of train operation, and offer but a glimpse of the many real-world problems that may arise — often without any forewarning — during a trip or a tour of duty.

The CAWG Final Report I cited earlier noted that the difference in experience between crew members in 42.5% of trains involved in a rule violation was less than three years. Further, no

Conductors with from 7 to 22 years of experience were a member of a crew of a violating train. When the combined Engineer/Conductor experience is less than five years, CAWG found that the accident rate was significantly higher, as compared to the study's control group.

We believe that CAWG has identified a factor that is properly considered a training issue, because railroad workers learn with each new experience in the field. When one member of a crew has significantly more experience than the other, that crew member can both take action to avoid a problem and instruct the junior crew member on how to identify that particular problem and what range of preventive actions are available. The absence of sufficient experience on the part of the entire crew means the lesson will be learned the "hard" way, perhaps with catastrophic consequences. Accordingly, we concur with CAWG's recommendation that experienced workers be paired with junior workers, because it enhances safety.

Finally, I want to give some perspective to technologies that are promoted on the basis that they will vastly reduce, if not eliminate, human factor accidents. Each of these technologies brings with it significant change to the operating environment. For example, several recently-released reports concerning remote control have discussed how the loss of what human factors researchers term "kinesthetic sensation" — and what we Locomotive Engineers call the "seat of your pants" feeling — can cause loss of situational awareness. In other words, if you cannot see or feel what is happening with the train, you may end up confused about the direction of movement, which could lead to an accident.

Likewise, FRA has noted that the computer-controlled power and braking algorithms on a remote control locomotive are not sufficiently sophisticated for main track usage, except in extremely limited circumstances. When an on-board computer senses increased resistance to attempts to increase speed, it will increase the throttle, regardless of the reason. An experienced Locomotive Engineer whose seat tells him of a sudden increase in resistance could be a derailed car out of his line of sight will immediately stop and investigate. The unthinking computer will simply continue to increase power, which could produce a derailment of significantly greater severity.

For all the benefits positive train control will bring, there also are potential hazards that are inherent in the technology. The Locomotive Engineer will have many new tasks to perform, and a number of current tasks will have to be performed differently. Moreover, the Engineer's current strict attention to conditions ahead will be divided between watching the road and monitoring the PTC screen or screens. Indeed, it is our opinion that the Conductor's role with a PTC system will be no less important than it is today.

Further, every study of semi-autonomous control systems, such as PTC, cautions against a system design that fosters reliance on the part of the crew. Reliance on the system creates two problems. First, over-reliance leads to dependency by the Locomotive Engineer, and could lead to a tragic outcome when the Engineer relies on the system over what his or her own eyes, ears and seat are indicating. Second, reliance on the system leads to atrophy of the Engineer's decision-making and operational skills over time, which could lead to accidents if the system fails and the Engineer must rely upon skills that are stale. For these reasons, PTC is safe only as an overlay and an assisting technology, rather than an automated operational system.

If PTC is designed, tested and implemented in ways that avoid these potential hazards, the industry will take a giant step toward significantly reducing the number of human factor caused accidents. Ignoring these hazards will only replace one set of accident causation factors with another. We will continue to monitor these developments closely and will keep you informed of how we view the evolution of PTC.

While it is true that one human factor caused accident is too many, it also is true that humans make mistakes. A well rested, properly trained and experienced crew, provided with technological assistance that supports — rather than replaces — their skill set is far less likely to be involved in a human factor caused accident that a fatigued, poorly trained, inexperienced crew. We fully support bringing the railroad into the 21st Century by improving performance in all three of these areas, leaving none behind.

Once again, I thank the Subcommittee for inviting and hearing me today, and would be pleased to address any questions you may have.

STATEMENT OF HONORABLE DON YOUNG
RAILROAD SUBCOMMITTEE HEARING:
HUMAN FACTORS ISSUES IN RAIL SAFETY
JULY 25, 2006

THANK YOU, MR. CHAIRMAN. I COMMEND YOU ON THIS TIMELY HEARING ON HUMAN FACTORS ISSUES IN RAIL SAFETY. A MAJOR PORTION OF THOSE ISSUES RELATE TO ONE THING—FATIGUE. IT IS COMMON SENSE THAT IF YOU'RE WORKING TIRED, YOU'RE NOT WORKING SAFE. THIS IS ESPECIALLY TRUE AROUND RAILROADS, WHERE ONE MOMENT OF INATTENTION CAN MEAN SERIOUS INJURY OR DEATH.

WE HAVE AN HOURS-OF-SERVICE SETUP FOR RAILROADS THAT IS LOCKED INTO STATUTE—UNLIKE ANY OTHER MODE OF TRANSPORTATION. AND IT'S A 1907 MUSEUM PIECE. FOR YEARS, THE EXPERTS HAVE URGED A MODERNIZED FATIGUE-MANAGEMENT

SYSTEM THAT TAKES INTO ACCOUNT CURRENT MEDICAL KNOWLEDGE ABOUT WAKE-SLEEP CYCLES.

IT HASN'T HAPPENED YET, MAINLY BECAUSE BOTH LABOR AND MANAGEMENT ARE, YOU MIGHT SAY, FINANCIALLY INVESTED IN THE STATUS QUO. SEVERAL YEARS AGO, BOTH SIDES CAME VERY CLOSE TO SEVERING THE PAY SYSTEM FROM THE HOURS OF SERVICE ACT, BUT IT DIDN'T PAN OUT. I HOPE THAT WITH THE CURRENT INFORMATION WE HOPE TO GATHER TODAY, BOTH LABOR AND MANAGEMENT WILL MAKE A RENEWED EFFORT TO COME UP WITH A VIABLE PROPOSAL FOR A TRULY MODERN FATIGUE-MANAGEMENT SYSTEM. THROUGH A STRONG JOINT EFFORT, THEY PRODUCED THE MOST SUCCESSFUL RAILROAD RETIREMENT REFORMS IN TWO DECADES JUST 5 YEARS AGO. I AM SURE THEY CAN DO IT AGAIN IF THEY TRY.

THANK YOU, MR. CHAIRMAN.

Final Draft

Current Status of Fatigue Management In the Railroad Industry

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Supplemental Testimony Submitted to the

U.S. House of Representatives

Committee on Transportation and Infrastructure

Subcommittee on Railroads

July 25, 2006

Table of Contents

List of Figures

Executive Summary

Since the Author's last review in 2000, the US railroad industry has continued to its effort to manage fatigue related risk in its operations through a combination of educational efforts, adjustments to work schedules, sleep disorder screening programs, collaborating in the development of a scientific model of fatigue and alertness and experimentation with technological aides to fatigue management. Although the emphasis has shifted from specific work schedules to a more flexible approach, in some cases the industry has achieved as high as 85% scheduled operations. Elsewhere the industry has utilized a modified scheduling such as the 7-on 3-off approach called the 7-3 overlay that provides employees with optional designated days off. In addition, the majority of the industry has moved towards a practice of a minimum of 10 hours undisturbed rest following an 8 hour period of duty.

The opportunity for major improvement still exists in the industry and joint efforts between labor and management to resolve these issues are needed. While some of the work schedules provide for designated time off, the possible effects of restricted sleep and accumulated sleep debt on performance will require additional attention. Because the industry is built around a continuous 24/7 operating system progress needs to be made to address the cumulative effects of fatigue that may result from the number of consecutive days worked. In addition, operational practices have yet to address the circadian nature of the fatigue on human performance. Current practices also do not take into account the so-called "limbo time" spent off-duty but on the train awaiting transport. While not an immediate safety issue, these time periods contribute to total time awake and subsequent hours asleep. Labor and management need to work on these problems together because the existing pay structure provides incentives to both labor and management to maintain the status quo and provides incentives for employees and management to push the limits of the envelope in of fatigue and human performance.

The railroads have experimented with a number of different work schedule options. Different approaches were tried in different locations in keeping with the lesson that "one size doesn't fit all" in the railroad industry. Various compressed schedules (7 on- 3 off, 8 on – 3 off, 10 on – 5 off, etc.) were tried. Some are still in effect today. However, with the impact of 9/11 and the turbulence in the economy there has been some consolidation in approaches with railroads focusing on achieving a scheduled railroad, a 7-on/3-off overlay (BNSF), use of meet and return (CN), and the implementation in many locations of a mandatory 10 hours undisturbed rest rule have become the norm. Additional progress towards improved predictability of start times is needed.

The National Transportation Safety Board (NTSB) has indicated that fatigue is a possible contributing factor in the 18 accidents investigated in a ten year period and has investigated over seventeen accidents that were thought to have fatigue as a possible contributing factor. However, given the fact that there are close to 10 million crew starts in a given year, with relatively few accidents identified as having fatigue as a causal factor, it is difficult to quantify the contribution of fatigue to railroad safety. The railroad industry has acknowledged the role of fatigue and has engaged in considerable effort to attempt to manage the effects of fatigue related risk in the railroad operating environment. It should be apparent however that fatigue, while present, needs to be carefully managed from a *risk-based* perspective as opposed to a *prescriptive* mandate applied system-wide.

Fatigue has been addressed through the utilization of a number of different counter measures outlined in an industry statement dated on February 23, 1998 which noted that an effective Fatigue Countermeasures Program (FCP) should consider, but is not limited to, the following:

a. Education and Training
b. Employee and Train Scheduling Practices (e.g., line-ups, calling times, work/rest cycles, relief-staffing, employee availability, shift predictability)
c. Emergency response requirements short-term (e.g., derailments) and extended (e.g., natural disasters)
d. Alertness strategies (e.g., napping, employee empowerment)
e. Evaluation of policies and procedures (e.g., effects on fatigue issues)
f. Rest environments (e.g., lodging)
g. Work environments
h. Implementation strategies and review of FCP effectiveness.

Railroads have engaged in a major effort to develop and disseminate information on the factors that influence human fatigue, the countermeasures that can be used to address it, and the impact of fatigue on performance. Significant efforts have been made to develop and disseminate educational materials to railroad employees in all of the major railroads. These range from short safety videos describing the dangers of sleep deprivation to more sophisticated training materials including at least a dozen videos on special topics related to fatigue management, a computer based education program that can be completed online, brochures, educational materials for employees and families, and even educational materials designed for elementary school students. The FRA co-sponsored a major effort to educate family members and children of railroad employees to the effects of fatigue and offer suggestions as to how family members could support and encourage fatigue management. Most importantly the railroads have incorporated fatigue education in their required periodic training for employees. These efforts have resulted in the "institutionalization" of the dissemination of fatigue management information as part of the railroad's "way of doing business." In essence, fatigue management has begun, as one railroad management executive put it "to become standard operating procedure."

The railroad industry has improved its sleep disorder screening and updated its procedures for ensuring that railroad employees are fit for duty. A safety advisory was issued by the FRA, following the determination by the NTSB that the probable cause of the November 15, 2001, Canadian National/Illinois Central Railway CN/IC accident in Clarkston, Michigan, was crewmembers' fatigue primarily due to the engineer's untreated and the conductor's insufficiently treated obstructive sleep apnea. The Safety Board examined the adequacy of rail industry standards and procedures for identifying and reporting potentially incapacitating medical conditions. The NTSB recommended (NTSB, 2002) that the railroad industry update its medical screening procedures to include sleep disorders. The resulting combined efforts of the railroad industry, labor, and the FRA have resulted in a new safety advisory that addresses the need to screen for the effects of health and physical conditions that might impact safety on the railroad -- specifically the need to screen for sleep disorders. Work is in progress on developing a set of medical standards that will include sleep disorders and other factors that might affect alertness.

In April of 2003 the Canadian Minister of Transport put into effect new rules for fatigue management in the rail industry affecting both Canadian and US railroads with Canadian operations. The new rules set a maximum of 12 hours for a single shift. The rules also allow an employee to work more than one shift per day, up to a maximum of 18 hours in total. In addition to daily limits, the new rules also included a weekly cap of 64 hours. Previously, no explicit weekly cap existed. Most importantly, the new rules also required that fatigue management plans be filed with Transport Canada describing industry plans for addressing fatigue on the railroad. This rule required most US railroads with operations in Canada to draft fatigue management plans and submit them to the Canadian government.

Two new efforts to improve technology associated with fatigue management have included efforts to validate a mathematical model that enables the prediction of the likely level of fatigue at a given point in time based on previous work/rest history. Railroads have provided work/rest histories and accident data to the FRA to support the validation process. In addition, several studies have looked at the use of actigraphs in the operating environment as a means of providing accurate measurements of the effects of work/rest practices in the operating environments. An actigraph is a wristwatch-like device that records wrist movement. Decreased movement indicates the person is probably asleep and data from the device can be used to track sleep / wake cycles. Also, the use of performance feedback actigraphs has been examined as well. These show considerable promise to be useful tools for the industry in order to evaluate levels of work at different points on a railroad and to objectively measure any changes resulting from a countermeasure. While FRA has also said the model could be useful for determining whether fatigue might have contributed to an accident there is general agreement that models are far from able to serve as a fitness for duty screening device for an individual employee.

This monograph reviews previous data, practices, projects and programs that have continuing significance and describes the current educational interventions, recent technological developments, scheduling approaches, and both previous and current scientific developments on human fatigue as it applies to the railroad industry. It also discusses a variety of interventions that have been tried in an attempt to address fatigue in the railroad industry. The study concludes with a review of the current status of fatigue countermeasures and identifies a number of key features found in successful programs.

Chapter 1. The Background

The Early Years

The development of the rules and practices regarding work and rest in the railroad industry dates from the early 20th century. Congress enacted the Hours of Service Act in 1907 to enhance railroad safety by limiting the number of hours that railroad engineers and other railroad employees can work. The Act was subsequently revised in 1969, 1976 and 1988. Currently, locomotive engineers and other transportation employees can work a maximum of 12 consecutive hours followed by at least 8 hours off duty.

In 1872 an article the Saturday Review concern with fatigue on the railroad and its relationship to accidents was noted in a characterization of railroad operations as an experience in which trains, "fly through junctions where the nodding pointsman has wakened with a start to turn the switches," as a speeding train approaches.

Hugo Munsterberg (1913), the father of industrial psychology, noted that, "We have in the literature concerned with accidents in transportation numerous popular discussions about the destructive influence of loss of sleep on the attention of the locomotive engineer." Subsequently, in 1917 a task force of scientists gathered to study the effects of fatigue on vehicular accidents. In 1937 Congress passed hours of service regulations for commercial drivers to address these concerns (additional discussion below). However, due to the ever-changing complexity of the demands faced by drivers and operators in all modes of transportation, this topic continues to be the focus of intense study (Sherry, Bart, & Atwater, 1997). Over the past few years there have been increased efforts to address the problems of fatigue in the railroad industry. A USDOT/FRA report in 1991 (Pollard, 1991) identified causes of railroad employee fatigue. These are: uncertainty about the time of one's next assignment, excessive working hours, long commutes and waiting times before beginning work, unsatisfactory conditions for sleeping at some terminals, and the decision not to rest during the day even when subject to call the next night. Suggestions for remedying the situation included: a minimum of eight hours notice before being called to work, greater predictability in scheduling trains, and division of assignments according to blocks of time.

Traditionally, locomotive and train crews work a 9.5-hour day. The work period can begin at any time during the day or night. The assignment begins with a phone call announcing the assignment, typically one-and-half to two hours in advance. Crews are expected to report for duty in that time. Upon reaching at the railroad facility, the crews go on duty and may immediately depart on their train, wait for the train to arrive, or may travel by vehicle to another location to reach their train. Once on the engine, crews usually remain on duty for a continuous period until the end of the duty period. However, upon completion of the run crews might have to wait up to an hour or more for transport to arrive at the terminal or lodging facility. After completing their paperwork, the crews are considered off-duty and have at least eight hours before they can be required to be on duty again. During this time they must eat, sleep, attend to family business and otherwise rest. The typical engineer or conductor will work approximately 20 duty starts over a 30-day period.

A decade and a half ago, the NTSB pointed out, in its 1985 report on collisions in Wiggins, Colorado, and Newcastle, Wyoming that railroad crews are subjected to the most unpredictable work/rest cycles in the transportation industry. Soon thereafter, the 1988 Thompsontown, PA accident apparently caused by an engineer falling asleep and resulting in four crewmember fatalities stimulated Congressional concern over the hours of service. The NTSB first addressed the issue of operator fatigue in transportation in 1989 in three recommendations issued to the Secretary of Transportation calling for research, education, and revisions to existing regulations. These recommendations were added to the Board's Most Wanted List in 1990, where the issue remains to this day.

The 1990's

FRA responded with several projects that explored various aspects of crew performance and hours of service including a study of crew scheduling issues and locomotive diaries. In the first phase of the work, interviews were conducted with crew-management and crew-scheduling personnel at seven Class I roads. Focus groups with engineers were also conducted at three locations. The information gathered was used to prepare a report, "Issues in Crew Scheduling," published in 1991.

A later report by the GAO (GAO, 1992) found that railroads were essentially complying with the Hours of Service Act. In fact, it was found that 99.4 % of the time engineers were given at least 10 hours off duty following a work period of 12 or more hours. Further, the investigators found no instances in which an engineer received less than 8 hours off duty in any 24-hour period. It was also found that engineers rarely worked more than two consecutive shifts with fewer than 9 hours off duty between shifts. The report indicated that reducing the maximum number of hours allowed per shift from 12 to 10 would have little effect on the number of accidents that occur. It was found that only 4.5% of all human factors caused accidents occurred after 10 hours in an engineer's shift. The report cautioned that reducing the "maximum allowable work/off-duty periods from the current 12 hours on, 10 hours off cycle to a 10-on, 10-off cycle could increase the variability – the change in work period start times from day to day – of engineers work cycles." The report cited research that suggested that variability in work cycle start times disrupt natural human sleep-wake cycles, which in turn can lead to fatigue.

The GAO study found that more human factor caused rail accidents occurred from 2 a.m. to 6 a.m. than in any other 4-hour segment. Incidentally, the overall accident rate (which includes all causes) between 2 a.m. and 6 a.m. was higher than at other times. "The start time variability of engineers work cycles was quite pronounced during the 2 a.m. to 6 a.m. time period." The report authors speculated that, "Higher levels of start time variability increase the likelihood that engineers will experience fatigue." (GAO, 1992, p. 3)

In the early part of 1990, the railroad industry recognized the importance of the fatigue issue and began to study as well as to educate its employees. The railroads also began to distribute booklets and videos describing health habits and bean to look at the levels of fatigue within its workforce.

At a July 1992 Congressional hearing, conducted by Representative Al Swift, Chairman of the House Subcommittee on Transportation and Hazardous Materials, the GAO presented its study entitled "Engineer Work Shift and Schedule Variability." While this review concluded that carriers were complying with the Hours of Service Act and that most work shifts are less than 10 hours, the study expressed concern about schedule variability.

A 1992 study (Kuehn, 1992) observed four engineers operating under two different simulated schedule regimens, a normal schedule and a fatigue work schedule. The study concluded that deterioration in engineer performance, regardless of schedule, coupled with the irregular sleep/work patterns of the subjects suggest the need for continued research which focuses on sleep work patterns and performance. While as a group the study participants did not differ in overall performance in the simulator, they were observed to incur speed limit infractions, failures to blow the horn for crossings, rapid throttle changes, and application of excessive train forces. Thus, specific instances of performance decrements were observed.

In 1992 railroads began a study of work/rest and fatigue issues in the railroad industry. The industry initiated the formation of a Work Rest Task Force with a number of participants from the Association of American Railroads, major railroads, and representatives from the Brotherhood of Locomotive Engineers (and Trainmen) and the United Transportation Union. The Task Force sought to better understand the issue by investigating a number of questions concerning crew scheduling, shift length, start frequency, start variability, and the occurrence of accidents and injuries. This effort included an evaluation of more than 5 million employee schedule records and lead to some preliminary conclusions in late 1994. Continued analysis suggested a relationship between incidents and work schedules but the Task Force was unable predict the occurrence of accidents based on work schedules. Nonetheless, the work of this Task Force paved the way for additional measures throughout the industry.

In November of 1995, The Department of Transportation published a report titled "Focus on Fatigue" (DOT, 1995). The report documents the activities and projects supported by the DOT in the area of fatigue. According to the document "FRA's fatigue research is concentrated on those jobs most directly responsive for the safe operation of trains, i.e. locomotive engineers and dispatchers." Two research projects were identified in the report as being directly related to railroad activity. These included "Enginemen Stress and Fatigue: Phase II" a study designed to determine whether work schedules that comply with hours of service requirements resulted in stress and fatigue of such magnitude to cause safety concerns. Preliminary results suggested that performance deteriorated over the course of testing. The FRA also sponsored the development of a device designed to measure fatigue affected neurobehavioral functioning thought to be related to fitness for duty of employees reporting for work.

In 1995 the NTSB and NASA in cooperation with the Department of Transportation sponsored a symposium on fatigue. The conference was thought to be a first step in raising awareness and educating diverse groups in the transportation industry to address the fatigue issue. One presenter at the conference, summed up the intent of the proceedings in his address: "An important theme expressed throughout the entire symposium was that *there is no magic bullet* to eliminate human fatigue in transportation operations.... Every participant is encouraged to take some action to educate, address a scheduling issue, use a countermeasure or apply some piece of knowledge.... to improve transportation safety." (NTSB, 1995).

Also in 1995 the FRA simulation of railroad work schedules study was followed up by a more recent study of 55 engineers monitored while operating on two different railroad work schedules (Thomas, Raslear, and Kuehn, 1997). The first schedule group was designed to run "faster" than another group running "slower" in terms of frequency of train operations. Engineers operated trains in a simulator for a ten-hour shift. Participants had at least an average of 9.3 hours off duty for the "fast" group and 12 hours off duty for the "slow" group. Results showed that the "slow" group got about 6.1 hours of sleep per night compared to 4.6 hours for the "fast." Performance measures in this simulation included number of missed horns sounded at crossings and cumulative pounds of fuel used. Results showed that the "fast" group missed about one third more horns at crossings than did the "slow" group. Furthermore, the simulation showed that the "fast" group would have used about 200 pounds more fuel per trip segment than did the "slow" group.

In 1995 a collaborative effort between major Canadian railroads and their employees launched *CANALERT*, the first fatigue countermeasures program which included a scientific evaluation of effectiveness. Using small but representative samples of railroad employees, this program utilized scientific principles of human fatigue to pioneer basic techniques that would be the foundation for later efforts. These include Time Pool scheduling (employees given predictable future work assignments), additional rest between assignments, improved lodging facilities and on-duty napping. At this same time, several other railroads began experimenting with provisions allowing additional rest on demand and scheduled time off.

In 1997 one US railroad compared the effects of two types of fatigue countermeasures: time windows and assigned days off to the fatigue levels of members of a control group receiving no fatigue countermeasures. Statistically significant results indicated the effectiveness of these countermeasures for reducing fatigue levels in railroad employees. Subsequently, additional investigations have been initiated that were designed to add to the knowledge of the effective countermeasures.

In late 1997, the Federal Railroad Administration invited labor and management to form the *North American Rail Alertness Partnership* or NARAP. This group was formed with the intention of collaboratively applying resources that address fatigue as a human factor cause of accidents, incidents, and injuries in the railroad industry. Many of the speakers at the 1998 Congressional hearings commented that NARAP was an important part of the current effort to address fatigue in the railroad industry.

In September of 1998 hearings were held by the Senate Committee on Surface Transportation. Statements were submitted by members of the unions, the Federal Railroad Administration, the Association of American Railroads, and various scientific authorities on the subject of fatigue. The President of the Brotherhood of Locomotive Engineers (and Trainmen) noted "Through a cooperative approach, rail labor and the railroad industry can ensure fatigue countermeasures are a part of railroad culture. Through the AAR Work/Rest Task Force, NARAP, and a Canadian project called CANALERT, this industry has moved further and faster to address the problem of fatigue than any other mode of transportation." (Monin, 1998) The Executive Vice President of the Association of American Railroads suggested that "While fatigue in the workplace has been studied for many years, there is still much to be learned about how to apply the acquired scientific knowledge to operational settings. Great strides have been made by the cooperative efforts of rail labor and management to explore a variety of fatigue countermeasures." (Dettmann, 1998)

The formation of the NARAP partnership created a forum for the discussion and dissemination of current scientific information, a discussion of the results of pilot projects, and a venue for the exchange of views around important policy issues. This partnership is significant for the simple fact that it is unique in the transportation industry. NARAP also serves the industry by assisting in the education of key labor and management personnel as well as driving the understanding of fatigue issues throughout various organizations. All member organizations have a voice in the activities of the group. As a result of this process NARAP members have agreed on several key points that should be included in fatigue management plans in various organizations. No other coalition has been formed in other modes of transportation to address the issues of fatigue on neutral ground. This partnership is one of the key reasons why the railroad industry is the leader in fatigue countermeasures in the transportation industry.

The AAR Work Rest Task Force continued its efforts to address the fatigue concerns in the industry. The Task Force collaborated with the North American Rail Alertness Partnership (NARAP), consisting of members from FRA, rail labor unions, and the railroad carriers, to identify the key principles of an effective fatigue countermeasures program. Based on the recommendations from NARAP on February 23, 1998 a committee of senior railroad executives officially endorsed a list of key counter measures that they would seek to implement. According to the recommendations an effective Fatigue Countermeasures Program (FCP) should consider, but is not limited to, the following:

a. Education and Training
b. Employee and Train Scheduling Practices (e.g., line-ups, calling times, work/rest cycles, relief-staffing, employee availability, shift predictability)
c. Emergency response requirements
   short-term (e.g., derailments) and extended (e.g., natural disasters)
d. Alertness strategies (e.g., napping, employee empowerment)
e. Evaluation of policies and procedures (e.g., effects on fatigue issues)
f. Rest environments (e.g., lodging)
g. Work environments
h. Implementation strategies and review of Fatigue Counter measures programs effectiveness.

The railroad industry was among the first to adopt a set of principles for fatigue management in the transportation industry (Sherry, 2003). This set of principles led to an increase in the number of efforts to introduce education and scheduling practices. These practices have been documented in the previous version of this series. Considerable progress was made in identifying approaches to scheduling and time off that would alleviate fatigue without seriously interfering with railroad operations. Subsequently, a number of innovative scheduling projects were initiated along with efforts to develop education and training programs.

The NTSB published a review of the safety efforts of the railroad industry with respect to fatigue in 1999. The following points are taken from the Board's report:

1. Since 1989, the U.S. Department of Transportation initiated a wide range of research projects to address the issue of operator fatigue in the transportation environment, with the exception of pipeline operations.

2. Since 1989, the Federal Aviation Administration, the Federal Highway Administration, the Federal Railroad Administration, and the Federal Transit Administration developed and disseminated various educational materials, including brochures and videotapes, to the industry on the detrimental effects of fatigue in the transportation environment. The Research and Special Programs Administration and the U.S. Coast Guard need to make a more concerted effort to develop and disseminate educational information on fatigue in pipeline and marine operations, respectively.

3. Despite the acknowledgment by the U.S. Department of Transportation that fatigue is a significant factor in transportation accidents, little progress has been made to revise the hours-of-service regulations to incorporate the results of the latest research on fatigue and sleep issues.

As a result of this safety report, the National Transportation Safety Board made the following safety recommendations:

To the U.S. Department of Transportation:

Require the modal administrations to modify the appropriate *Codes of Federal Regulations* to establish scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements. Seek Congressional authority, if necessary, for the modal administrations to establish these regulations. (I-99-1) (Supersedes I-89-3)

To the Federal Railroad Administration:
Establish within 2 years scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements. (R-99-2)

The New Millennium

The Safety Board's 1999 study of the role of operator fatigue in transportation industries argued that the problem of fatigue was very prevalent. An operator of a vehicle without adequate rest, in any mode of transportation, was seen to present an unnecessary risk to the traveling public. The Safety Board concluded that the laws, rules, and regulations governing this aspect of transportation safety are archaic and are not adequate to address the problem. This report was generated during the time that the hours of service rules for motor carriers were being hotly debated.

Hours of Service

In 1995, Congress ordered the FHWA to revise the existing commercial motor vehicle HOS rules.[1] Specifically, it provided that the FHWA should issue an advance notice of proposed rulemaking dealing with a variety of fatigue-related issues pertaining to commercial motor vehicle safety (including 8 hours of continuous sleep after 10 hours of driving, loading, and unloading operations, automated and tamper-proof recording devices, rest and recovery cycles, fatigue and stress in longer combination vehicles, fitness for duty, and other appropriate regulatory and enforcement countermeasures for reducing fatigue-related incidents and increasing driver alertness (US Court of Appeals, 2004)).[2]

The motor carrier hours-of-service regulations were developed in 1937 and remained essentially unchanged until 2003 when the Federal Motor Carrier Safety Administration issued a new rule on hour-of-service regulations. Aviation limits were addressed in the Civil Aeronautics Act of 1938 and the Federal Aviation Act of 1958. In 1985, domestic flight limitations and some commuter limitations were updated; flag and supplemental operations were not. The work-hour regulations for marine are specified in Title 46 United States Code 8104 and date back to the early part of the 20th century. The Oil Pollution Act of 1990 contained work-hour limitations for tank personnel of 15 hours per 24 hours and 36 hours per 72 hours.

[1] (US Court of Appeals, 2004)
[2] (US Court of Appeals, 2004)

In April 2003, FMCSA issued the first significant revision to the HOS regulations in over 60 years. [3] The new regulation provided an increased opportunity for drivers to obtain necessary rest and restorative sleep, and at the same time reflect operational realities of motor carrier transportation. According to Laux:

> The rules specified a 14-consecutive-hour window, after which a property-carrying commercial motor vehicle driver would not be allowed to begin driving, although such a driver is allowed to continue to do other work, which must be charged against the overall 60 hours in 7 days or 70 hours in 8 days on-duty time limit. A property-carrying driver is allowed to drive for up to 11 hours after having 10 hours off duty.[4]

The new HOS rules were struck down in July of 2004, by the US Court of Appeals because the FMCSA had failed to consider the effects of the hours-of-service rules on driver health, as required by Congress. Congress passed legislation in the so-called "highway bill", in September 2004, that extended for another year the current federal hours-of-service rules for commercial motor carriers.[5] However, On August 19, 2005, the U.S. Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) announced the new hours-of-service (HOS) regulations.[6] The new rule contains most of the major provisions of the 2003 hours-of-service regulations with the exception of sleeper berth and short haul regulations.[7]

The Final Rule, promulgated in April 2003 (Federal Register 22,456, 2003) included the following provisions: (from the FMCSA web site: www.fmcsa.dot.gov/rules-regulations/adminsitration/fmcsr/395.3.htm)

> 395.3 Maximum driving time for property carrying vehicles (subject to exceptions in 395.1)
>
> (a) No motor carrier shall permit or require any driver used by it to drive a property-carrying commercial motor vehicle, nor shall any such driver drive a property-carrying commercial motor vehicle:
>
> (1) More than 11 cumulative hours following 10 consecutive hours off duty; or
>
> (2) For any period after the end of the 14th hour after coming on duty following 10 consecutive hours off duty, except when a property-carrying driver complies with the provisions of 395.1(o) or 395.1(e)(2).
>
> (b) No motor carrier shall permit or require a driver of a property-carrying commercial motor vehicle to drive, nor shall any driver drive a property-carrying commercial motor vehicle, regardless of the number of motor carriers using the driver's services, for any period after

[3] (NTSB, 1999, pg. 24)
[4] (Laux, 2004)
[5] (Laux, 2004)
[6] http://www.fmcsa.dot.gov/rules-regulations/topics/hos/HOS-2005.htm
[7] http://www.fmcsa.dot.gov/rules-regulations/topics/hos/HOS-2005.htm

(1) Having been on duty 60 hours in any 7 consecutive days if the employing motor carrier does not operate commercial motor vehicles every day of the week; or
(2) Having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week.

(c) [*Moreover* .. (added by author)]

(1) Any period of 7 consecutive days may end with the beginning of any off duty period of 34 or more consecutive hours; or
(2) Any period of 8 consecutive days may end with the beginning of any off duty period of 34 or more consecutive hours.[8]

The sleeper berth provision for the 2005 rule reads as follows:

- CMV drivers using the sleeper berth provision must take at least 8 consecutive hours in the sleeper berth, plus 2 consecutive hours either in the sleeper berth, off duty, or any combination of the two.[9]

The new short haul provisions for the 2005 rule were as follows:

Drivers of property-carrying CMVs which do not require a Commercial Driver's License for operation and who operate within a 150 air-mile radius of their normal work reporting location:

- May drive a maximum of 11 hours after coming on duty following 10 or more consecutive hours off duty.
- May not drive after the 14th hour after coming on duty 5 days a week or after the 16th hour after coming on duty 2 days a week.[10]

As noted previously, following considerable debate, discussion, testimony and review the 2003 rule was adopted with minor modifications in 2005 and became law. The new rules increased the time that truck drivers must rest in a twenty-four hour duty period. Drivers were also given the opportunity to increase their rest from eight hours to ten. In addition, the total number of hours that a driver can be on duty was changed from 15 to 14 hours. The new regulation permits drivers to spend eleven hours on duty, which is one more hour than previously permitted. Drivers are not allowed to drive after being on-duty for 60 hours in a seven-consecutive-day period or 70 hours in an eight-consecutive-day period. This on-duty cycle may be restarted whenever a driver takes at least 34 consecutive hours off-duty. Short-haul truck drivers (those drivers who routinely return to their place of dispatch after each duty tour and then are released from duty) may have an increased on-duty period of 16 hours once during any seven-consecutive-day period.

Another significant change is that the new regulation requires drivers to include as work hours the time spent waiting at loading docks or refueling. Thus, under the new

[8] [68 FR 22516, Apr. 28, 2003]

[10] http://www.fmcsa.dot.gov/rules-regulations/topics/hos/HOS-2005.htm

rule, delays at loading docks and refueling could become quite costly to trucking companies as they directly impact the availability of driver operating time.

This rule is noteworthy for the railroad industry for several reasons. First, it represents a significant change in the amount of time that drivers are expected to rest. Currently railroad personnel are also expected to obtain needed rest in an eight hour period. Previously, eight hours was thought to be sufficient time for drivers to recover from a duty period. This change was made on the basis of the accumulated scientific evidence which pointed to a longer time needed for recovery. Second, the amount of time that a driver is on-duty, regardless of whether they are driving or not, was considered a more accurate indicator of the extent to which a person was likely to be fatigued. Time awake was considered the more relevant variable in determining fatigue. In contrast, a railroad employee is not considered to have exceeded the hours of service if he or she is not actually operating the equipment. In short, congress has set a precedent by recognizing and changing the hours of service for the trucking industry, the science is the same for the railroad industry. In making the new rule considerable effort was expended to obtain the needed scientific evidence to support the new rules. The scientific evidence, based as it is upon human performance, is applicable to the cognitive task of driving a truck or a locomotive. Accordingly, since there are many similarities between the two operations and both involve human drivers and therefore human performance, the conclusions drawn about the effects of circadian rhythms, the performance of drives on restricted or partial sleep deprivation schedules, issues of recovery time or amount of time off needed to recover. The industry should continue to consider the effects of research and regulation in the trucking industry and to determine its applicability and usefulness in the railroad environment.

At the same time that the FMCSA was working on the commercial motor vehicle regulations the railroad industry was also working on several initiatives. For example, in 2000 several US railroads implemented scheduling programs designed to give employees designated days off. These various programs consisted of schedules that permitted employees to know in advance when they would be able to be off-duty and when they would have to work. One particularly popular initiative, the 7/3 overlay has been widely used to provide employees a regular 7 day work cycle followed by 3 days off. These rest days are not mandatory however and may be worked at the discretion of the employee. Variations on this approach are being used by different railroad such as an 8 and 2 or a 10 and three in some locations.

Safety Board Investigations of Railroad Accidents

Three more recent accidents have also triggered additional developments relative to fatigue. The first accident investigated by the Safety Board (DCA-03-FR-001) involving a Union Pacific Railroad Company near Des Plaines, Illinois on October 21, 2002, At about 10:38 p.m.,, a westbound train struck an eastbound train that was moving through a crossover at Norma Interlocking in Des Plaines, Illinois. The lead 3 locomotives of the striking train, as well as 6 cars positioned 20 cars behind the locomotives, derailed. Three cars of train eastbound train derailed, and three others were damaged. About 5,000 gallons of diesel fuel from the derailed locomotives spilled onto the ground. The two crewmembers of the striking train sustained non-life-threatening injuries.

The investigation of the accident revealed that the engineer had most likely fallen asleep just prior to the collision and was thus unable to safely operate the train. The NTSB also noted that, "Contributing to the engineer's falling asleep was likely his use of prescription medications that may cause drowsiness, as well as his lack of sleep in the 22 hours preceding the accident." The effects of the medication and lack of sleep likely combined to make the situation extremely unsafe.

A second accident occurred near Clarkson, Michigan where at 5:54AM, November 15, 2001 two CN/IC trains collided. Southbound train 533, traveling at 13MPH, struck northbound train 243 after failing to obey the stop indication before proceeding on to the mainline track. Both crewmembers of northbound train 243 were killed and the two crewmembers of southbound train 533 were seriously injured.

The Safety Board concluded that the untreated obstructive sleep apnea, and resultant chronic fatigue, experienced by the engineer of train 533 likely incapacitated him to the point that he did not attempt to stop the train prior to the collision with train 243. It was also noted that the conductor of train 533 also likely suffered incapacitating fatigue as a combined result of his unpredictable schedule (he was on the extraboard) and his insufficiently treated sleep apnea.

NTSB investigations into the background of the engineer revealed that he passed the re-certification physical examination and did not indicate any sleep related problems, nor did the examination inquire about such problems. It was discovered however, when reviewing the medical records from his private physician, that the engineer complained of "snoring with pauses" and was ultimately told that he likely suffered from obstructive sleep apnea and that such a condition could impair his ability to operate either his car or the train safely. It was recommended that he undergo a sleep study, however, he did not do so. A conductor who worked with this engineer on several other occasions indicated that the engineer would fall asleep while operating the train and would have to be awakened to respond to a signal or to blow the horn at a grade crossing.

Investigation into the background of the conductor also revealed that he too suffered from obstructive sleep apnea, however, results of the company provided physical examination did not indicate that the conductor was being treated for apnea. Although he had been using a Continuous Positive Airway Pressure (CPAP) device since being diagnosed, he never returned to the clinic to ensure that the CPAP was in fact working effectively. He reported that he did not feel that device was working very well and that he often felt tired.

The NTSB offered the following recommendations:

To the Canadian National Railway:

Require all your employees in safety-sensitive positions to take fatigue awareness training and document when employees have received this training. (R-02-23)

To the Federal Railroad Administration:

Develop a standard medical examination form that includes questions regarding sleep problems and require that the form be used, pursuant to 49 *Code of Federal Regulations* Part 240, to determine the medical fitness of locomotive engineers; the form should also be available for use to determine the medical fitness of other employees in safety-sensitive positions. (R-02-24)

Require that any medical condition that could incapacitate, or seriously impair the performance of, an employee in a safety-sensitive position be reported to the railroad in a timely manner. (R-02-25)

Require that, when a railroad becomes aware that an employee in a safety sensitive position has a potentially incapacitating or performance impairing medical condition, the railroad prohibit that employee from performing any safety-sensitive duties until the railroads designated physician determines that the employee can continue to work safely in a safety-sensitive position. (R-02-26)

The significance of these accident investigations is the fact that both of them were influenced by medical conditions and the employees compliance with the subsequent treatment that had been prescribed. In the first accident the medications had an unfortunate side effect when combined with the work schedule to produce an unsafe situation. In the second accident, both crewmembers had diagnosed sleep disorders but had discontinued treatment resulting in an unsafe circumstance.

The recommendations of the Safety Board have influenced the railroad industry. First of all, the Federal Railroad Administration issued a safety advisory ((Notice of Safety Advisory 2004-04; Effect of Sleep Disorders on Safety of Railroad Operations (Oct. 1, 2004; 69 Fed. Reg. 58995) relative to the assessment and diagnosis of sleep disorders. The FRA advisory included the assertion that "Approximately 35% of all train accidents reported to FRA are attributed to human factors, of which fatigue, and more particularly, sleep disorders, play an undetermined role. Most employee casualties in train incidents and non-train incidents also involve a human factor component." This recommendation also led to a review of the pre-employment medical screening and engineer recertification screening.

Sleep disorder screening is not new to the railroad. As early as 1998 the former Conrail expanded its alertness and fatigue program to include sleep apnea screening and treatment. The program was offered to approximately 9000 employees who worked in safety critical positions. Information packets were provided to supervisors and union representatives and later confidential questionnaires were mailed directly to the employees. Because confidentiality was critical to assuring employees that participation in the program would not negatively impact employment, Conrail employed the services of Dr. Martin Moore-Ede to conduct the sleep disorder assessments and to provide all respondents information about their personal results. Dr. Moore-Ede had earlier collaborated with Transport Canada to develop the CANALERT project with Canadian railroads and labor. Employees identified as borderline or high risk for sleep apnea by the initial screening questionnaire were contacted by phone to discuss their results and encourage them to receive treatment.

Railroad Division	Surveys Mailed	Surveys Returned	High Score	Borderline Score	Low Score	Participants To Date
1	1,117 (2/98)	168 (15%)	68 (40%)	27 (16%)	73 (43%)	44
2	2,355 (3/98)	293 (12.4%)	82 (40.6%)	46 (15.7%)	128 (43.7%)	46
3	2,016 (4/98)	164 (8.1%)	67 (40.9%)	24 (14.6%)	73 (44.5%)	TBD
4	2,196 (5/98	230 (10.5%)	84 (36.5%)	34 (14.8%)	112 (48.7%)	TBD
5	1,256 (6/98)	116 (9.3)	51 (44%)	12 (10.3%)	53 (45.7%)	TBD
Totals	8,940	971	359	143	439	90

Two temporary sleep laboratories were set up at two different locations. Of the 168 respondents, 68 were identified as likely to be experiencing sleep apnea. A total of 44 of the 168 later agreed to participate in the screening program and following an initial consultation 15 employees received testing. Later, an additional 13 employees agreed to receive testing but were not available during the testing phase at their location. These individuals were referred to a Sleep Disorder Center for examination. Complete test results available on 10 patients were as follows:

- Four patients had severe obstructive sleep apnea
- Three patients had moderate to severe periodic limb movement syndrome with mild to moderate sleep apnea
- Three patients had mild or minimal sleep apnea not requiring treatment
- Of these 10 patients, six were prescribed Continuous Positive Airway Pressure (CPAP).
- One person refused the CPAP treatment but five others initiated treatment with the devices.

The program demonstrated that the practical result of a screening program was to identify about 5% of the sample as likely having a sleep disorder. This is about the same as would be expected in the population as a whole, working in the railroad industry or otherwise. Due to the fact that the survey respondents volunteered to participate in the study they were most likely more motivated than most people to complete and return the survey. While we are unsure of the true incidence of sleep apnea in the railroad population these survey data provide one estimate of the prevalence in that might be somewhere around 6 to 8 percent (68/1117 or 95/1117). These results are consistent with those of other studies that have found an incidence of 4-8 percent in men and 2-4 percent for women in the general population. Thus, a small percentage of the workforce is likely at risk for these types of disorders. Screening programs and medical examinations would likely identify persons who are at risk for these conditions and minimize the risk of accidents results from excessive sleepiness.

The third major accident investigated by the NTSB where fatigue was a contributing factor was the collision of a UPRR train and a BNSF train at Macdona, Texas in June 2004. Here the findings cited fatigue and the inability of the UP crew to respond to signals and properly operate the locomotive. The Safety Board concluded that "Contributing to the crewmembers' fatigue was their failure to obtain sufficient restorative rest prior to reporting for duty because of their ineffective use of off-duty time and Union Pacific Railroad train crew scheduling practices which inverted the crewmembers' work/rest periods." The Board speculated that the unpredictable UPRR work schedules may have "encouraged them to delay obtaining rest in the hope that they would not be called to work until later on the day of the accident." (NTSB, July 25, 2006) This accident and subsequent investigation raises questions about schedule unpredictability and decisions that employees make relative to their own fatigue that increase the risk of operational errors and lack of attention to safety sensitive tasks. The challenge of educating railroad employees and managing high risk situations due to fatigue is a critical challenge faced by the industry.

Collision Analysis Working Group (CAWG)

Several labor organizations in collaboration with the FRA and a representative from the Short Line Association (SHL) undertook a re-analysis of the data collected in the original Switching Operations Fatality Analysis (SOFA) Group study. The members of the CAWG group were all members of the original SOFA group. According to the text, "Information contained in this report – including the Findings, Discussions, and Recommendations – is based solely on the review and analyses of 65 maintrack train collisions occurring from 1997 through 2002. CAWG did not consider results of other investigations, reviews, and analyses of main track, or other types of collisions. CAWG results are specific to its data." (CAWG, pg. viii) The data and facts surrounding these accidents and injuries, 14 of which resulted in a fatality, were examined by the CAWG group who examined the facts of the cases and made a determination as to whether fatigue was a possible cause of the accident. The assessments of these causes were corroborated by a sleep expert who also reviewed the facts available in the cases. The CAWG group and the sleep expert agreed that 19 out of the 65 accidents had fatigue or alertness as a possible contributing factor. Interestingly, all of these cases occurred between midnight and 6 am. The report concludes that fatigue was a possible contributing factor in 29.3% of the accidents. This is a very significant conclusion.

The results of this study are important in that they raise a number of questions about the role of fatigue in the occurrence of accidents and fatalities in railroad operations. The methodology utilized was limited to a subjective review of accident information by a panel of legislative representatives from various labor organizations and two accident investigators from the FRA. Greater confidence in the results could have been obtained if standardized methods for determining reliability of both rating criteria and agreement among raters had been employed and provided. Furthermore, given the lack of a control group, the small sample size which limits the generalizability of the conclusions, the lack of clear and objective criteria for defining fatigue and alertness, and the possibility of a variety of competing hypotheses or contributing factors that could not be ruled out these results must be interpreted with a great deal of caution and considered preliminary at best. Nevertheless, this is an important first step in beginning to develop an approach to identifying the possible contributing factors to accidents that occur. At the very least, however, follow-up studies should be conducted, with a larger sample size and more rigorous methodology that will enable a replication of these initial tentative conclusions.

The results of this study are important in that they raise a number of questions about the role of fatigue in the occurrence of accidents and fatalities in railroad operations. However, given the small sample size which limits the generalizability of the conclusions, the lack of clear and objective criteria for defining fatigue and alertness, and the possibility of a variety of competing hypotheses or contributing factors that could not be ruled out these results must be interpreted with a great deal of caution. At the very least, however, follow-up studies should be conducted, with a larger sample size that will enable a replication of these initial tentative conclusions.

Legislation and Liability

The New Jersey State Senate passed legislation, known as "Maggie's Law," on June 23, 2003. Named after a child who was fatally-injured in an accident caused by a fatigued driver, the law establishes fatigued driving as recklessness under the existing vehicular homicide statute (N.J.S.2C:11-5). This legislation overwhelming passed both chambers of the state legislature and represents the first bill in the nation to specifically address the issue of driving while fatigued. The bill defines "fatigue" as being without sleep for a period in excess of 24 consecutive hours.

As can be seen from this brief review, while the issue of fatigue in the railroad industry has been recognized for almost 100 years, serious efforts to manage fatigue with scientific studies and actual field tests only began in the last fifteen years. These include experiments with scheduling changes, time windows, napping policies, technological measures for counteracting fatigue, educational seminars, instructional videos, sleep hygiene and study materials. In addition, thousands of hours of meetings and discussions have taken place to work through the issues, brainstorm, and plan projects programs and policies that would lead to more effective management of fatigue. Some of the actions of the railroad industry have served as a model for other modes addressing similar concerns. Most feel that the railroad industry, while still having a long way to go, has made progress in acknowledging the role of fatigue in continuous operations and attempting to devise counter measures to deal with these issues.

Given the previous work in this area and the current legislative climate it was decided that an updated study of the current status of fatigue countermeasures was needed. The purpose of this monograph is to briefly review the development of fatigue counter measures in the railroad over the past decade. This will be followed by a description of the current fatigue counter measures in the railroad industry. The present document will also attempt to summarize much of what is known in about fatigue in the transportation industry. Finally, an assessment and summary of current status is offered.

Chapter 2. Scientific Studies of Sleep Fatigue and Performance

The effects of sleepiness, sleep loss, and fatigue have been the focus of literally hundreds of studies dating back to a study conducted by Patrick and Gilbert (1896) at the University of Iowa. These scientists studied the effects of keeping a group of subjects awake for over 90 hours. Using performance tests measuring reaction time, motor speed, and memory they demonstrated the deleterious effects of sustained wakefulness.

The "modern" study of sleep and performance began with the work of Williams (1959) who demonstrated that there was a progressive increase in reaction time across days of sleep deprivation. These findings were evident regardless of the nature of the reaction time task, the duration of the task, and whether the person received feedback on how they were doing. Dinges & Kribbs (1991) summarized Williams studies and noted that "both the number and duration of lapses increased dramatically as sleeplessness increased over three days, resulting in an increase in the unevenness of performance (From Monk, 1991, pg. 103). Dinges and Kribbs (1991) further noted that "there have been dozens of reports on sleep loss from numerous causes (leading to performance unevenness (variability) increasing on RT tasks involving sustained attention (e.g., Angus and Heslegrave, 1985; Bonnet, 1985, 1986; Dinges et al., 1987, Glenville et al., 1978; Herscovitch and Broughton, 1981, Lisper and Kjellberg, 1972; Tilley and Wilkinson, 1984, Wilkinson and Houghton, 1982) (as cited in Dinges 1991, pg 103)

Rhodes, Heslegrave, Ujimoto, et al (1996) reported that air traffic controllers perceived some degree of performance impairment the end of an 8-hour day and evening shift, but significantly greater performance impairment at the end of an 8-hour midnight shift. In fact, the degree of performance impairment at the end of an 8-hour midnight shift was similar to that of the end of a 12-hour day or evening shift. In terms of sleep, when air traffic controllers (ATCs) worked the midnight shift, they reported only about 5 hours of sleep on a daily basis and only about 6-6.5 hours on day shifts. As people age, their sleep may become "less deep" and controllers reported more difficulty with shift-work beginning between 35-39 years of age. Luna, French, and Mitchal (1997) also reported that ATCs on the night-shift of a forward rapid rotation shift schedule (current shift starts at a later hour than the prior shift) appeared to be falling asleep and reported increasing confusion and fatigue.

Some recent studies have begun to shed light on effects of work schedules that are more similar to those of railroad locomotive engineers. For example, Dinges et al. (1997) studied 16 young adults that had their sleep restricted to an average of 4.98 hours per night for seven consecutive nights. Three times a day they were assessed on their subjective sleepiness, mood, and performance on a psychomotor test (PVT), probed memory, and serial-addition testing. This sleep schedule resulted in statistically significant cumulative effects on performance. These results essentially demonstrate the cumulative effect of a sleep debt over a week long period.

In 2002 a study looked at the fatigue levels of train drivers and dispatchers in the British rail system. Results of a study of 126 male train drivers and 104 rail dispatchers showed that shift schedule and sleep length were explanatory variables in a model of sleepiness. Severe sleepiness was reported in 59% of train drivers and 50% of the dispatchers on night shifts and 20% and 15% for day shifts. Results showed that the odds of experiencing severe sleepiness was significantly higher in the night versus the day shift. Interestingly, the risk for increased sleepiness decreased as train drivers became older, while there was not change whatsoever with dispatchers. Most importantly, however, is that as the length of the increased the risk of sleepiness increased at a rate of 15% for each hour of the shift while sleepiness risk decreased by about 15% per hour during sleep. Unfortunately, the amount of time off did not appear to have any relationship to the amount of sleepiness. The authors concluded that adjustments in shift start-times, shift length, and off-duty time designed to increase amount of sleep off-duty were likely to result in decreased levels of sleepiness on the railroad. The authors suggested that adjustment of shift length, start time, and duration would assist in the management of fatigue and sleepiness in railroad employees. (Harma, M; Sallinen, M.; Ranta, R.; Mutanen, P.; Mueller, K., 2002)

Another study tested the effects of sleep restriction on vehicle operation. Twenty two subjects were assessed in a laboratory and on the highway while driving 10 hours in five different sessions. Sleep restriction produced significant performance degradation even though wake time and driving times were relatively short. Under the restricted sleep condition, some drivers presented and increase of 650 milliseconds compared to the laboratory condition. This delay is equivalent to an increase of 23 meters in braking distance at 75 miles per hour. (Phillip, Sgaspe, Taillard, Nicholas, 2005)

An interesting study of restricted sleep was conducted on 48 healthy adults over a 14 day period undergoing several conditions of 4, 6 or 8 hours of sleep per night. Chronic sleep restriction involved randomized sleep doses of 4, 6, or 8 hrs in bed per night pus total sleep deprivation for the equivalent of 3 nights. Results suggest that chronic restriction of sleep to 6 hrs or less per night produces cognitive performance deficits equivalent to up to 2 nights of total sleep deprivation. Thus, it appears that even relatively moderate amounts or doses of sleep restriction can seriously impair waking performance. During the study the participants were unaware of the increasing cognitive deficits. Physiological sleep responses to chronic restriction did not mirror waking neurobehavioral responses, but cumulative wakefulness in excess of a 15.84 hrs predicted performance lapses across all 4 experimental conditions. The results suggest that chronic sleep restriction of 6 hrs or less per night produced cognitive performance decrements equivalent to up to 2 nights of total sleep deprivation. In other words even moderate sleep restriction can seriously impair humans (Van Dogen, Maislin, Mullington, Dinges, 2003). Similar findings were also reported by Jewett, Dijk, Kronauer, and Dinges (1999).

Sleep Deprivation and Performance

Considerable attention has focused on the similarity in cognitive performance found between persons who have consumed alcohol and amount of sleep deprivation. While there are several criticisms of this approach, the attention that such studies have generated has focused discussion on the detrimental effects of prolonged sleep deprivation.

The first study of this sort was published by Dawson and Reid (1997) published in *Nature,* the prestigious British journal. This study demonstrated that healthy young adults who ingested 10-15 grams of alcohol every 30 minutes until they reached a blood alcohol level of 0.10% had cognitive performance that was similar to that of persons who had remained awake for 28 hours. Using a test of eye-hand coordination administered every 30 minutes, performance steadily declined in both conditions. A significant correlation between the relative performance of the alcohol consuming and the sleep deprived participants demonstrated a significant correlation between the two and showed that effects of moderate sleep loss on performance are similar to moderate alcohol intoxication.

Arnedt, Wilde, Munt, and MacLean (2001) compared the effects of alcohol use and sleep deprivation on driver performance using a simulator. Using healthy young adults the investigators demonstrated that as blood alcohol concentration increased, tracking variability, speed variability, and off-road events increased, while speed deviation decreased, with the result of Ss driving faster. Interestingly, similar decrements in tracking and speed variability were found for 18.5 and 21 h ours of wakefulness as those for 0.05 and 0.08% blood alcohol levels, respectively. The findings suggest that impairments in driving found at relatively modest blood alcohol levels found with exceeding the legal limit will occur in individuals awake for over 18.5 hours.

Similar findings were obtained by Falleti, Maruff, Collie, Darby, McStephen, (2003); Fairclough & Graham. (1999); Stein, Allen, Cook, (1985); and Williamson, Feyer, Mattick, Friswell, Finlay-Brown, (2001). The overall conclusion suggested by these studies is that when persons are awake for even what would be considered moderate amounts of time (18- 22 hrs) the result in cognitive performance is similar to what can be expected when persons have exceeded the legal limit of blood alcohol concentration. Thus, while sleep deprivation of this magnitude does not result in the gross motor deficit seen with alcohol impairment the cognitive deficits are noticeable and approximate a level not tolerated by society when it comes to the operation of motor vehicles. Therefore, one must question the safety of vehicle operation when such levels of fatigue or sleep deprivation are present.

Lamond et al. (2004) completed a study recently that looked at the looked at performance impairments associated with night shift work and impairments following alcohol ingestion. Study participants were given alcohol every hour until their blood alcohol level reached 0.10%. In another condition, participants worked seven simulated 8 hour shifts. Cognitive performance was measured at hourly intervals using the PVT. As expected, as blood alcohol level increased performance decreased. In addition, performance declined significantly over the first six simulated night-shifts. Performance impairment was varied over the course of the week with larger deficient observed after the first two shifts and lesser impairments observed following the third shift. However, these were greater than those obtained by persons having a blood alcohol content of .05%

While these studies are an interesting illustration of the similar effects of alcohol ingestion and fatigue, the latter can be overcome to some extent by various countermeasures such as caffeine or a nap while an intoxicated person can only return to sobriety by waiting until the alcohol has been metabolized.

Fatigue and Performance

Pilcher and Hufcutt's (1996) review of partial sleep deprivation findings have direct implications for the railroad industry. Given that the conditions of railroad work as noted above are characterized by variable start times and shift lengths the working conditions closely approximate the definition of partial sleep deprivation. Partial sleep deprivation in other words occurs when individuals are given the opportunity to sleep less than 5 hours of sleep in a 24 hour period. Their results suggested that cognitive performance was more affected by partial sleep deprivation over days than either short (≤ 45 hrs) or long (>45 hrs) duration total sleep deprivation. In other words, given the erratic nature of railroad work schedules it is likely that sleep schedules would be more similar to the partial sleep restriction than acute total sleep deprivation.

That this is likely the case was recently demonstrated by Sherry (2005) in an actigraphic study of railroad employees sleep it was found that the average amount of sleep per 24 hour period for the entire group of 33 individuals was 6.32±1.68 ranging from a low of 2.75 average hours of sleep per 24 hour period to a high as 10.02 hours of sleep. It was estimated that as many as 45.5% of the individuals averaged less than 5.93 hours of sleep or less during the assessment period. Thus, a substantial portion of the work force was similar to the partial sleep deprivation conditions described by Pilcher & Hufcutt (1996).

Rhodes, Heslegrave, Ujimoto, et al. (1996) found that performance errors in air traffic controllers increased 15% - 18% over a five-day midnight schedule workweek. In addition to perceived performance decrements, performance changes across various shifts were also demonstrated. The authors found that sleeping in the "morning (daytime) and in the evening resulted in significantly greater losses of sleep than sleeping during the night, with evening sleeps being 1.5 times shorter than day sleeps (3.5 hours vs. 2.2 hours, respectively, of lost sleep for a single sleep period - group means). In other words it appears controllers in the study got much less sleep during daytime and evening sleeps." (pg. xix) The results of these partial sleep deprivations on performance were significant as well. For example, using reaction time, reasoning, and spatial relations tasks, Air Traffic Controllers performance began to deteriorate 5 - 10% on the second midnight shift and by the fourth midnight shift a reduction in performance of 10 - 18% from baseline was observed. For the evening-day-day-midnight-midnight (EDDMM) shift, significant performance deterioration did not occur until the midnight shifts with a 6 - 12% reduction in reasoning, spatial orientation, and pattern recognition. For the EEDDMM shift, performance impairment of 5-15% was evident during the second day shift and during the midnight shift. This may be due to the fact that the length of the work day interferes with the person's ability to obtain rest in the time available a condition that is likely present in the railroad workforce.

Phillip et .al. (2003) found that under restricted sleep truck drivers had an increased reaction time of 650 milliseconds over baseline. The authors indicated that this would translate into an increase of 23 meters in breaking distance at a speed of 75 miles per hour.

Several sleep dose–response studies have been conducted which present strong evidence on the impact of restricted sleep over time. In a dose response study investigators are attempting to determine the relationship between amount of sleep and various behavioral outcomes. It is of great interest to know the specific number of units (i.e. Minutes or hours) of sleep that are required or necessary to produce specific levels of performance. Or put another way, the number of hours of sleep needed in order to maintain maximum performance. Or, at what point is the number of hours of sleep insufficient to produce optimal or even minimal levels of performance. In the first study, Dinges et al. (1997) found that 16 healthy young adults, who had their sleep restricted to an average 4.98 hrs per night for 7 consecutive nights, reported higher levels of subjective sleepiness and had significantly longer reaction times on performance tasks.

A study of the effects of various levels of sleep restriction was conducted in a laboratory setting with commercial truck drivers. Balkin et al. (2000) had participants sleep for three, five, seven, and nine-hour time in bed conditions respectively, and showed dose-dependent performance impairment related to sleep loss. Performance in the three hour sleep group typically declined below baseline within two to three days of sleep restriction. Performance in the five hour sleep group was consistently lower than performance in the seven and nine hour sleep groups. In contrast, performance in the seven and nine hour sleep groups was often indistinguishable and improved throughout the study. Virtually no negative effects on performance were seen in the nine hour sleep group.

This study is interesting from the railroad perspective in that it points to the importance of arranging work schedules so that individuals can obtain at least 7 hours of sleep. In the railroad operational environment under high demand situations it is likely that there will be an opportunity to get at most 6 hours sleep due to the fact that there is a minimum of 8 hrs undisturbed with at least a two hour call for wake up and commute time. In other words, it is necessary that there be at least the opportunity to get 7 hours of continuous uninterrupted sleep to be able to maintain performance over a period of time. This suggests then that if individuals are expected to work long hours, over consecutive days, it will be necessary for an individual to be able to obtain at least 7 hours of sleep in a 24 hour period in order to maintain maximum performance levels.

Balkin et al. (2000) found that following chronic sleep restriction, the first eight hours in bed (6.5 hours of sleep) was insufficient for restoration of performance on the PVT task. During the four day recovery phase (eight hours in bed each night), five and seven hour sleep groups showed minimal or no recovery, remaining consistently below the nine hour sleep group and below their own baseline levels for the PVT. The three hour sleep group showed some recovery for the PVT on the first day and more on subsequent days but also remained well below their own baseline and below the performance of the other groups. Subjects' recovery to baseline or near baseline levels of performance on the PVT often required a second or third night of recovery sleep. These data suggest that after sleep debt has occurred (three, five, seven hours time in bed) a single bout of eight hours of night sleep leads to recovery but not full recovery. While further sleep is required for full recovery, the number of subsequent sleep periods to reach full recovery is unknown. For the three hour group, the data suggests that even three nights of normal sleep (eight hours spent in bed on each night) is not sufficient to restore performance to baseline levels (depending on the task). Balkin et al. (2000) conclude that "this suggests that full recovery from severe, extended sleep restriction may require more than three nights of normal-duration sleep" (p. 2-85).

Belenky et al. (2003) examined a subset of the Balkin et al. (2000) study by examining the PVT data. For persons in a 3 hour condition performance on reaction time measures declined steadily over the 7 day period. For persons in the 5 and 7 hour conditions, performance initially declined followed by stabilization period. In the 9 hr group performance remained at the baseline levels. During the recovery period the performance levels did not return to baseline levels even after 3 days of recovery. Reaction times and lapses of the 3 hr group showed an initial recovery but only to the levels of the 5 and 7 hr condition, not baseline.

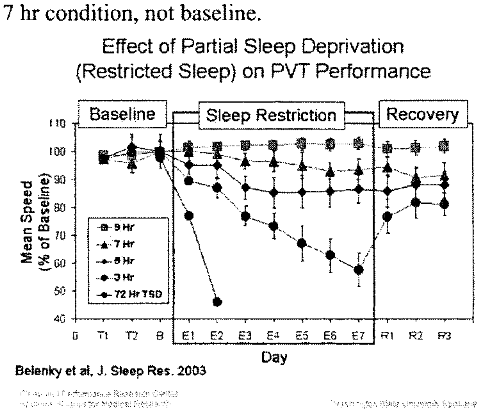


Figure 1. Sleep restriction and performance (permission pending).

Van Dongen, Maislin, Mullington, and Dinges (2003) also studied the effects of chronic sleep restriction by examining the effects of 4, 6 , or 8 hour sleep schedules on 48 healthy adults over 14 day period. Results indicate that restriction of sleep to 6 hrs or less per night produced cognitive performance deficits equivalent to up to 2 nights of total sleep deprivation. Cumulative wakefulness in excess of a 15.84 hrs predicted performance lapses across all 4 experimental conditions. Thus, it appears that even relatively moderate amounts of restricted sleep can seriously impair cognitive function.

Surprisingly, participants were largely unaware of these increasing cognitive deficits. Even mild restriction in the hours of sleep (5 hours a night rather than 7½) has been shown to result in progressive daytime sleepiness which is evident on the first day following a night of sleep restriction and worsens with successive such nights. The resulting sleepiness is only recoverable by rest. One night of rest following 1 week of sleep restriction only partially reverses the problem (Dinges, Pack, & Williams, et al., 1997). Artificial fragmentation of sleep also rapidly results in an increasing tendency to fall asleep (Roehrs, Merlotti, Petrucelli, et al., 1994). Plus, it has been demonstrated that sleepiness is influenced by time of day, increasing significantly in the early hours of the morning. Of particular interest from these findings however is the fact that a mild sleep restriction of less than six hours of sleep, can result in a performance decrement that persists despite opportunities for recovery sleep. Further research is clearly needed to determine quantify the amount of recovery time needed to reverse the effects of full or partial sleep deprivation over time.

Williamson, Feyer, Friswell & Finlay-Brown, (2000) looked at the effectiveness of professional long distance truck drivers working two consecutive 16 hour periods separated by six hour breaks. This was studied in a simulation mode as the hours of work would not have been legal. The results showed again that in rested drivers there were no significant fatigue effects after 16 hours of work, but that after only a six hour continuous rest break, significant fatigue effects occurred by around the middle of the second 16 hour shift. This indicates that longer hours or work may be possible provided that they are balanced by an appropriate period of longer rest.

Summary: Partial sleep deprivation can have a measurable impact on performance and characterizes much of railroad operations. The fact that the railroad industry is characterized by rules which permit an employee to be awakened after only 6 hours of sleep is similar to the definition of partial sleep deprivation that Pilcher and Hufcutt (1996) used in their meta-analysis. Their findings indicated that the negative effects of partial sleep deprivation were about 40% greater than either short or long duration total sleep deprivation. Consequently, conditions which promote partial sleep deprivation contribute to reduced cognitive performance.

Taken together these studies (Dinges et al., 1997; Belenky et al., 2003; Van Dongen , 2003) have provided consistent and strong evidence documenting the negative impact of restricted sleep on performance over time. For the railroad industry in particular, with the two hour call procedure these data suggests a need for attention to the lower levels of restricted sleep as a limit to minimum time needed to recover. These studies suggest that the effects of even partial sleep restriction can lead to noticeable reductions in performance. Accordingly, it should be apparent that there will be a need to minimize the occurrence of partial sleep reduction situations in the railroad working environment.

Sleep and Accidents

A New Zealand study investigated the relationship between fatigue and accidents in the forest industry. Using self-report measures feelings of fatigue were frequent in as sample of 367 workers, with 78% of workers reporting that they experienced fatigue at least "sometimes." Results of regression analyses showed that number of breaks and specific job/ tasks were associated with fatigue levels. In addition, "close calls" or near-miss situations were more likely among persons with higher levels of fatigue. Actual accidents were associated with length of time at work, ethnicity, and having had near-miss incidents. (Lilley, Feyer, Kirk, Gander, 2002)

A Swedish study of 126 male train drivers and 104 rail traffic controllers found that severe sleepiness was reported in 49% of the locomotive engineers and 50% of the dispatchers on shifts. Shift length increased the risk of self-reported severe sleepiness by 15% for each hour of the shift and main sleep period decreased the risk by 15% for each hour of the main sleep. Nevertheless, the risk of severe sleepiness was not consistently related to the amount of time off before beginning a shift alone. Other factors such as task complexity and previous work days may also influence these feelings. (Haermae, Mikko; Sallinen, Ranta, Mutanen, and Mueller (2002).

In the medical field, Todd, Reid, and Robinson (1989) found significantly lower levels of patient care associated with 12 hour shifts.

Rosa and Bonnet (1993) studied the effects of an 8 hour versus a 12 hour schedule in a sample of male utility workers. Cognitive performance/alertness data and self-report measures were obtained 2-4 times per week from study participants who worked a traditional 8 hr/5-7 day schedule then, additional data was obtained after a new 12 hr/2-4 schedule was implemented. Significant reductions in performance were found even after 10 months of adaptation to the 12 hour work schedule. Furthermore, participants obtained less sleep as the week progressed which were most noticeable on 12-hr night shifts. These progressive declines were correlated with decreased positive mood.

Another self-report study of fatigue and occupational injury was conducted by Melamed & Oksenberg, (2002). Self-report measures (including the Epworth) were administered to a sample of 532 non-daytime shift workers. A total of 22.6% had elevated scores on the Epworth and statistical analysis indicated that during the two-year period prior to the procedure, the odds of having a work related injury were 2.23 times higher even after controlling for type of factory, job and other environmental conditions.

Baldwin and Daugherty (2004) studied medical residents using a retrospective questionnaire. Results indicated that residents averaging 5 or fewer hours of sleep per night were more likely to report serious accidents or injuries, interpersonal conflict at work, alcohol consumption, and use pharmaceutical aids to prevent sleeping and stay alert. Most notably, they were also more likely to report working in an "impaired condition" and having made significant medical errors.

Barger et al (2005) completed a similar study a national sample of 2737 first year medical residents completed on on-line survey resulting in 17,003 monthly reports over a twelve month period. The reports provided information on hours worked, number of extended work shifts, motor vehicle crashes, near-miss incidents, and incidents involving involuntary sleeping. The results of the study showed that the odds of being involved in a motor vehicle crash after an extended work shift were 2.3 times greater than after having completed a regular shift. Interestingly, in a prospective analysis, a single extended workshift in a month increased the monthly risk of a motor vehicle crash by 9.1 percent and increased the monthly risk of a crash during the commute from work by 16.2 percent. When a person worked five or more extended shifts, the odds of falling asleep at the wheel or stopped in traffic was 2.39 and 3.69 respectively.

Summary

Taken together these studies suggest a number of important considerations relevant to the railroad industry. Research continues to support the existence of a relationship between increased hours of wakefulness and decreased cognitive performance and alertness. Variable results have been obtained with these studies suggesting that reaction time is most noticeably affected however, in some studies reaction time decreased but accuracy was maintained. The implications for performance in the rail industry suggest that to the extent that prolonged wakefulness occurs, similar incidents might also occur.

Despite the findings in the lab and with other occupations, the risk of accidents operating rail equipment after extended wakefulness has yet to be conclusively documented. There have been studies which have documented an increase in accidents in the hours between 2 am and 6 am. However, the number of accidents was not conclusively related to time on duty. Results of accident investigations by the Safety Board have prompted recommendations; however, in most cases there is a suggestion that fatigue may be a contributing factor. Despite the lack of conclusive evidence, the railroad industry has acknowledged that fatigue is present in the operational setting and needs to be managed.

Chapter 3. Education and Fatigue Management

Education was one of the primary fatigue countermeasures included in the recommendations of the Work Rest Task Force (AAR, 2000). Education is no substitute for getting enough sleep, the only method for reducing fatigue. However, for individuals to take advantage of available tools and resources they need proper training and an understanding of the effects of fatigue on safety, job performance and well-being. All of the railroads have tried to educate their employees to the dangers of fatigue and the possible risks associated with operating equipment under fatigue conditions.

The current state of fatigue can be likened to that of seat belts about 10 years ago. When the seat belt laws came into effect many people simply ignored them and went about their driving without giving a second thought to using a seat belt. Through a concerted educational effort and public awareness campaign and in some cases vigorous ticketing by the authorities, the use of seat belts increased dramatically. If people are to be motivated to use the tools available to them to combat fatigue it will be necessary to address fatigue through education and a vigorous public awareness campaign.

Earlier we noted that Pilcher and Hufcutt (1996) found that as the number of hours of wakefulness increased that reaction time increased and overall cognitive performance decreased. Summarizing data from 19 original research studies meta-analytic results reveal that sleep deprivation is negatively correlated with human performance. In addition, decreases in positive mood states tend to be more affected by sleep deprivation than cognitive performance. Somewhat surprisingly however, the effect of partial sleep deprivation or restricted sleep on performance was noticeably greater on performance functioning than either long-term or short-term sleep deprivation. In fact, the authors noted that partial sleep deprivation had a much stronger overall effect on the dependent measures than either short-term or long-term sleep deprivation. Specifically, participants in partial sleep-deprivation conditions performed *two standard deviations below the mean of normal non-sleep* deprived study participants compared to approximately one standard deviation for either short or long-term sleep deprivation. The researchers noted, "Although most of the sleep research community may concur with these results, there are a surprising number of scientists outside the sleep research field who have concluded that sleep deprivation has no profound effect on performance." (pg. 323) A similar situation most likely exists in the railroad industry where most understand that sleep deprivation is a fact of life yet few recognize or admit to the reduction in performance that follows short, long or even partial sleep deprivation. Thus, education is likely needed at all levels including professional and non-professional alike.

Education was a key component identified by the Work Rest Task Force and the NARAP groups. Railroads agree this is an essential activity in the development of an effective fatigue countermeasures program. The railroads and the FRA have engaged in a number of activities designed to develop and distribute educational material to the members of the railroad workforce to increase the likelihood that they will be better prepared to deal with and address fatigue in their work.

These efforts have resulted in a number of different products such as video tapes and pamphlets and CBT training programs. These programs, examples of which are at (http://www.du.edu/~psherry/narap/update.html), provide railroad employees with an understanding of the physiological aspects of fatigue, the impact of fatigue on performance and safety, and how to increase alertness through improved sleep hygiene.

One of the major findings of our study of the railroad industry has been that educational efforts began with the attempt to provide all employees with an introduction and an overview of the role of fatigue and circadian rhythms in the sleep and performance link. In other words, the railroads began to recognize that human fatigue was going to need to be addressed and that it could present a potential risk for employees. With the result of interactions with the key experts in the field they were able to identify and design short training courses that would educate the workforce as to the essential factors in diet, schedule, sleep habits and patterns, and the like that would lead to optimal performance.

In 1996 for example, the BNSF began developing a wide range of countermeasures to improve safety and efficiency and reduce fatigue on the railroad. The curriculum is representative of that found on other railroads. A primary effort was to provide Fatigue Information and Lifestyle training to the workforce and their families. The railroad covered the entire workforce (more thanr 28,000 people). The program was based on a seminar conducted by the NASA Ames Research Center Fatigue Countermeasures Program and reviewed by their staff for scientific accuracy.

The program covered a number of key areas in sleep hygiene education. The first topic dealt with the issues of physiological factors. It addressed the importance of the 24 hour nature of the railroad operations and the need for employees to be concerned about the possible effects of fatigue on the alertness and performance. While the course did not specifically state that fatigue causes accidents it included information the fact that the NTSB has identified fatigue as a contributing factor to several accident.

The BNSF program explained that fatigue is caused by a number of factors including sleep loss, the circadian rhythms of the human body, and work schedules. No matter how long a person's "day," the circadian clock still enforces an approximately 25-hour sleep wake cycle. Studies of the change in body temperature over a 24 hour period of sleep and wakefulness demonstrate the presence of the circadian effect. Additional research indicates that the circadian clock is affected by the presence of sunlight. So, when people are working in the night hours there is a tendency for the organism to experience the effects of fatigue. The body appears to respond to the changing nature of the daylight hours and to become entrained as it were to a natural clock that corresponds to the natural change in day and night periods. Other cues have been found to affect the setting of the natural clock such as certain social cues like meals and other activities. The overall goal of the education program was to alert railroad personnel to the need to take into account these factors when planning their work and rest activities.

The training materials explained that it is not possible to quickly reset the circadian clock to a new environmental time or to a work schedule change. A railroad worker experiencing an irregular work schedule may find it difficult to adjust. If the body adapts to a day-night cycle with a 24 hour clock then the body may not be expected to adapt to sudden changes and shifts in work schedule. It may take some time for the body to appropriately change in order to be able to function at a time when it was previously expecting to be sleeping. Research seems to suggest, that employees must realize that circadian adaptation to any one work rest pattern is minimal and that workers will revert easily to being day active on their days off.

Although somewhat predictable, shift work also creates problems for workers due to the fact that the body is entrained to be in a particular circadian cycle and that this cycle then will respond to the expected day – night pattern that is typically adapted to when not working shift work. Thus, circadian rhythms of shift workers are usually only partially adapted to their current work/rest scheduled. In addition most shift workers revert to being day active people when their shift duties expire. So, in railroad workers the shift work issues with the circadian rhythm are confounded with the social cues of day and night waking.

The effect of railroad operations on sleep is such that the irregular work periods interrupts or interferes with the regular patterns of sleep. The interference with the circadian rhythm makes it more difficult for the individual to sleep the amount prescribed by the natural rhythm. A person may become sleep deprived and even more fatigued by the extended periods of wakefulness. Slower working rotations such as changing the hours of work every 1 to 2 weeks is likely more effective and gives the circadian clock more time to get synchronized on a given work/rest schedule.

The training program stressed the importance of getting regular sleep. While unusual work hours on the railroad may be a factor, the work schedule is not the only cause of fatigue. Individual sleep rest and work habits can all combine to make it less likely that a person will be alert or feel fatigued when trying to perform their duties.

Employees were informed that sleep changes with age and that sleep becomes less deep as a person ages. This also leads to the likelihood of more disrupted sleep. While the total amount of nocturnal sleep increases with age, older individuals may find their sleep becomes more fragmented. Thus, older employees need to become more vigilant to ensure that they plan for more sleep opportunities.

The information presented not only relates to work but is equally important for employees when they are off duty. The modern economy requires 24-hour operations and railroad employees are more likely to be challenged because they may be awake when most people are sleeping. The education programs provide the tools for employees to increase their ability to successfully manage fatigue.

The course also discusses the effects of alcohol and medication on a person's ability to remain alert. Alcohol taken in sufficiently large quantities can affect alertness by disrupting the various stages of sleep. Alcohol also acts in an interactive and additive fashion when an individual is already fatigued. The combination of alcohol and fatigue can lead to more impaired performance and a greater propensity for sleepiness. Many over the counter medications come with warnings about driving or operating heavy machinery. The instructional materials provided in these courses are designed to ensure that the individuals realize that they are more likely to be drowsy and less alert when they are operating the locomotives if they have taken either prescription or non-prescription medication.

Adopting a more holistic approach to the need to educate employees to the effects of shift work on railroad employees was initiated by the Canadian Pacific Railway. They published a book entitled "Shifting to Wellness" in 1999. This book acknowledged that "Workplace performance is a function of personal lifestyle and wellness." (pg. iii) Furthermore, the book recommended that railroad shift workers become more aware of the effects of fatigue on their health and work life including the "need for sleep, nutrition, stress and an overall healthy lifestyle." (pg. iii). The program asserts that fatigue is a multifaceted and multi-determined phenomenon – not just due to the effects of a work schedule alone, but due to many different factors and also affected by individual choices and individual differences as well.

The table of contents of "Shifting to Wellness" reflects the change in focus from a simple "get more rest" approach to one in which a wide array of factors need to be considered. For example, the chapter headings include: Biological Clock, Fatigue, Alertness, Readiness for Behavior Change, Eating Wisely, Active Living, Managing Time, Managing Stress, and Involving the family.

In addition to these issues noted above, training courses typically include a discussion of the role of sleep disorders. These conditions, which can affect the alertness and performance of individuals during their waking periods, are somewhat rare. However, they can occur and do cause individuals to feel drowsy and sleepy during work times.

The principles in these educational programs have been reinforced with regular updates and are quite helpful in assisting the individuals in learning to moderate their habits somewhat.

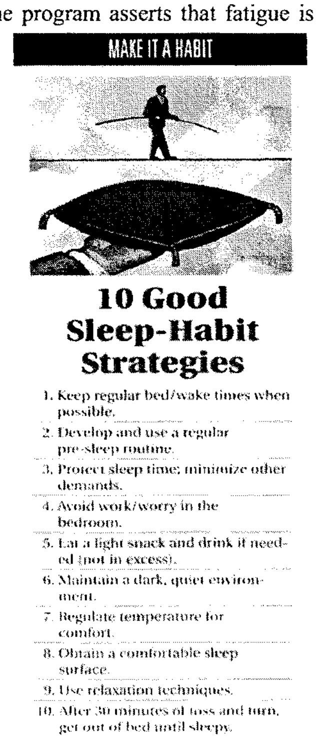


Figure 2. UPRR Educational Brochures.

The Union Pacific Railroad has been at the forefront of developing new and innovative educational materials to effectively communicate fatigue information to its workforce. Materials are professionally produced using state of the art information, marketing and graphics techniques. The materials have captured the essentials of their message and conveyed them to the railroad employees in a visually appealing and effective manner. A complete listing of the educational videos and brochures is available in Figure 3.

Recognizing that managers will come into contact with employees who have questions about fatigue related issues, the UPRR has also developed educational materials for its managers.

Videos

Fatigue and Family Support - This video helps reconcile the need for sleep with the need to be part of a family, including tips on how families can support shift workers.
History of Drowsy Driving - A light-hearted look at what happens when people who are suffering from fatigue get behind the wheel.
Insomnia - This video offers strategies for those times when you are unable to fall asleep or stay asleep.
Napping - This video outlines Union Pacific's Napping Policy and provides guidelines and recommendations for napping.
Sleep Basics - A primer on sleep basics, this video acquaints you with the circadian clock, how your sleep habits affect fatigue and what happens when you lose sleep.
Sleep Deprivation - Lack of sleep is costly to employees as well as the company. This video explains why and also discusses lack of motivation and response.
Sleep Disorders - Created by the Kansas City Southern, gives insight into signs and symptoms of sleep disorders, as well as treatment options available.
Strategies for Living - This video features strategies for managing fatigue, including good sleep habits and explains how your lifestyle affects your level of fatigue.
Sweet Dreams - An entertaining look at fatigue, this video describes sleep disorders and what you can do about them.
Z-9 Adolescents and Sleep - This informative video is your guide to adolescent sleep issues.

Brochures

Alertness Management Guide -This guide outlines the physiology of fatigue, along with strategies to improve your everyday performance.
Drowsy Driving - This brochure acquaints you with the characteristics of drowsy driving and how they contribute to accidents. It also offers strategies you can use before driving and while driving to stay safe.
Drugs, Alcohol and Fatigue - Long hours and irregular schedules can result in sleep loss and fatigue. These stressors are especially significant for workers in substance abuse recovery. This brochure offers information on alertness, fatigue and relapse prevention.
Fatigue and the Family - This brochure is for all employees who work long or erratic hours, travel or just plain work hard.
Fatigue Concerns and Myths - This brochure addresses some common myths about fatigue and demonstrates why this issue is relevant to all UP employees.
Good Sleep Habits - A variety of sleep habits can promote good sleep quality and quantity, both at home and on the road. This brochure offers strategies to help you get to sleep and stay asleep.
Guide for Day Sleepers - Designed for employees and their family members, this guide provides suggestions to help you get rest during the day, at home or while away.
Jet Lag - This brochure will familiarize you with the symptoms of jet lag and strategies to prevent or alleviate those symptoms.
Lodging Facilities - This brochure identifies factors in the sleep environment that can affect the quality and amount of sleep you get, along with tips on how to make your environment more conducive to good sleep.
Managers' Alertness Travel Guide - This brief guide provides information about the physiology of fatigue and jet lag, in addition to offering strategies to improve your performance on the road.
Planning Your Emergency Response - Designed for employers and managers who must respond to unscheduled or emergency work activities, this brochure will help you develop a plan of action for coping with fatigue before, during and after unscheduled events.
Pocket Guide to Alertness - This quick-reference guide will help you identify symptoms of fatigue or decreased alertness.
People Matter - Project AM/PM is a world-class alertness management initiative designed to protect the health and well-being of Union Pacific employees.

Figure 3. Industry Videos and Brochures.

The BNSF developed a short course based on the fatigue counter measures program designed by NASA. This course was presented to all Train, Yard and Engine (TY & E) employees in the late 90's. More recently, the BNSF has converted this course to an on-line course that is available to all BNSF employees. The course includes a number of key topics that are designed to address the sleep hygiene issues faced by railroad employees. They include discussion of circadian rhythms and the body clock, the need for appropriate amounts of sleep, and the use of various countermeasures.

In addition to these efforts, BNSF has also published several educational brochures addressing various fatigue issues. One brochure published in late 1998 was entitled, "Overview of Alertness Strategies." Six more brochures were published in 1999:

1. *Questions and Answers about Fatigue and Alertness;*
2. *Causes and consequences of Fatigue;*
3. *The Physiology of Sleep;*
4. *Napping Strategies;*
5. *Rest Environments; and*
6. *Diet/Exercise/Medications.*

BNSF also purchased the video "Day/Night Strategies for Shift Workers" developed by the National Sleep Foundation for use in educational and safety meetings with employees.

Combined Industry Efforts

After the initial effort by the railroads to educate their workforce regarding fatigue and its effects on operational activities and the various countermeasures available, the various railroads then each began to independently develop educational programs and materials for ongoing education of their respective employees.

In 2000, the FRA sponsored the development of a prototypical web site that was used to demonstrate how fatigue education information could be distributed to industry representatives. Subsequently, a group of labor and management representatives of the North American rail industry, concerned about fatigue and alertness in the workplace determined that a jointly sponsored web site could be developed. The web site was designed with the idea that it would be devoted to increasing awareness of the issues related to human fatigue and alertness in the railroad industry. One of the main goals of the web site is to promote awareness through the use of educational content information and course work. Members of the rail industry have agreed to support the project for three years.

The web page developers have agreed to provide the following:

1. Develop and maintain a web page for the rail industry with information periodically reviewed for up-to-date and accurate information by a panel of scientific experts.
2. Periodic updates on new research of interest to the industry will be posted on the subscriber section of the web page.
3. Information on fatigue countermeasures for railroad employees.
4. Educational material for subscribers that can be used by their individual organizations
5. Serve as a resource, repository and clearing house for fatigue related information.

The current web page is available at www.narap.net

Individualized Coaching

A pilot project was initiated on the Union Pacific Railroad designed to determine the effectiveness of individualized feedback and coaching on the extent to which individual railroad employees could be encouraged to change their behavior. The study was conducted in conjunction with the use of actigraphs which will be discussed in another section of this report.

The principle behind this approach is to focus on the individual and their specific responsibility for taking care to address individualized sleep hygiene issues. Accordingly, the importance of providing information to railroad employees on how best to utilize their off time and how to make good decisions about the amount and timing of sleep is essential. A significant component of any fatigue countermeasures program is the belief that individuals must be able to make effective use of their

The program was designed to work with a sample of locomotive engineers. Participants were asked to gather baseline data that could then be used to assist them in identifying possible behaviors that could be changed. Twenty-nine Engineers wore the actigraphs for thirty days. These devices were loaned to us from the Walter Reid Army Institute of Research, and were later used in a research project in that Iraq required the immediate deployment of several of the performance watches, thus leaving only 15 units to loan to the study. As a result, it was necessary for us to adjust the timeframe in which the study was conducted.

Individualized Feedback Sessions

Individual Feedback Sessions with study participants were then used to provide participants with information about the extent of their work/rest sleep wake cycle and behavior. Descriptive definitions of the information obtained from the sleep watch were discussed and each participant's real time data was provided to them. Specifically, researchers discussed the following:

	Dimension	Explanation
1.	Duration	Minutes from start to end of sleep interval
2.	Wake Minutes	Total minutes scored as Wake
3.	Sleep Minutes	Total minutes scored as Sleep
4.	Percent (%) Sleep	Percent of minutes scored as Sleep
5.	Sleep Latency	Minutes to start of 1st 20-minute sleep block. Coded as a 20 minute sleep block when a minimum of 19 minutes of sleep are recorded
6.	Wake after Sleep Onset	Minutes awake during 0-0 interval
7.	0-0 Duration	O-O Intervals are sub-intervals of the Down Intervals (down intervals represent the major sleep period of the day, when subjects are in bed and trying to sleep) that estimate the true sleep period.
8.	Wake Episodes	Number of blocks of contiguous wake epochs
9.	Mean Wake Episode	Mean duration of Wake Episode (minutes)
10.	Longest Wake Episode	Duration of longest Wake Episode (minutes)
11.	Mean Sleep Episode	Mean duration of Sleep Episode (minutes)
12.	Longest Sleep Episode	Duration of longest Sleep Episode (minutes)

Although researchers had access to even more in depth data, not all dimensions were discussed as it could prove confusing to an individual who has not previously studied sleep and sleep patterns. Through prior experience, we have learned that discussing key dimensions proves effective in helping Engineers to understand their individual sleep/wake patterns but that there is an optimal level of information to discuss – if the concepts are too in-depth and detail oriented participants get confused and lose interest. If the basics are discussed, participants become aware of how their sleep may be determined by their behavior and can then compare their sleep/wake patterns over the length of the study to see, objectively, what changes have occurred.

Participants were provided with a hard copy of their results, both in the form of a color coded chart where periods of sleep and activity were visually demonstrated and easy to understand and in the form of a written report that discussed the above dimensions. A University of Denver folder containing a cover sheet, a glossary of actigraph terms, suggested fatigue countermeasures, and the participants report (coded by number versus name in case the participant misplaced the report contents) was given to each person.

Following the receipt of work/rest information, a coaching session was held with each participant. The goal of these coaching sessions was to provide an intervention tailored to each individual that:

- Identified areas in need of improvement
- Identified three goals to address
- Discussed methods for making change
- Discussed how to use the information from the watch

Coaching Sessions

Individuals from the research team met with participants individually for approximately 60 minutes to provide feedback regarding the participants' sleep behaviors. Based on this information, participants set specific goals in order to improve sleep hygiene.

The research team then reviewed strategies to help participants reach their goals. These strategies included presentation of performance actigraphs and how such self-monitoring devices could be used in conjunction with fatigue countermeasures to help participants increase sleep. Again, participants were asked to maintain a sleep log. Members of the research team contacted participants via telephone and e-mail during the intervention phase to monitor progress and address possible concerns or questions.

Feedback was provided through the use of *Actigraph Technology,* specifically, performance feedback actigraphs or sleep watches were used. Prior to receiving the performance feedback actigraphs, individuals received training and education on individual cognitive-behavioral directed change management techniques designed to improve personal fatigue management hygiene. Specifically, researchers assisted study participants in identifying habits that could interfere with utilizing the knowledge and feedback obtained from the performance feedback actigraphs.

Within the scientific literature, there is a notion that feedback of any type can have a positive effect on safety behavior. The basic idea comes from operant theory (Skinner, 1953) as well as cognitive – behavioral theories on behavior change (Beck, 1993). Kinicki, Prussia, Wu, and McKee-Ryan (2004) found that cognitive processing of performance feedback is more likely to determine an individual's response to that feedback as compared to characteristics of the feedback itself, such as specificity and frequency. Hence the way in which feedback is delivered and then processed is an important determiner of behavioral change. As yet, it cannot be said with any certainty that feedback alone will increase performance as individuals may choose to ignore feedback for many reasons including task characteristics and personality variables. Research studies suggest that it is a combination of factors that work together to affect performance. To understand which factors have the ability to alter behavior, this study of performance feedback was done to assist in understanding the effects that performance feedback related to work/rest patterns may have on an individual's behavior.

Instruction on how to interpret the performance reading as well as instruction on various fatigue countermeasures was provided. For example, if an individual saw that his or her performance reading was in the 70's and knew that he or she was likely to be called to work in the evening, the merit of napping instead of completing domestic chores was discussed and emphasized. Two weeks after the performance watches were distributed, a researcher called each individual to inquire about how the watch was working and to address any questions and/or concerns that were presented.

Specifically, the protocol for goal setting was as follows:

1. "Based on what you have learned from your actigraph results, what behavior would you like to change"?
    a. Example: "I need more sleep"
        i. Suggestions: white noise, black-out curtains, turn off phone, etc.

2. After explaining the performance actigraph, and demonstrating how the watch worked, a researcher discussed with the participant how to use the performance reading to make decisions regarding work/rest. For example, researchers would say the following:

    > The Performance Actigraph that you will be wearing will give you an estimate, based on the amount of sleep you have had in the last 24-48 hours, of your overall performance efficiency at any given moment. In other words, the Performance Actigraph will keep track of the amount of sleep you have obtained and will calculate, using a mathematical algorithm, how well you can be expected to perform. The information from the Performance Actigraph should be used to guide you in your decision to increase the amount of sleep that you are getting. This can be in the form of a nap or a longer period of sleep, the use of caffeine, stretching, etc.
    >
    > It will take approximately 48 hours for the watch to become accurate in the performance readings that it displays. The range of numbers reported will be from, approximately, 68 to 97. You will never receive a reading of 0% if you are diligently wearing your watch as the watch is not calibrated in that manner,. However, if you take your watch off and leave it sitting for an extended period of time, the reading will approach zero.
    >
    > Here is an example of how the watch can be used:
    >
    >> You are 2X out and your performance reading is 78%, instead of mowing the lawn or going to a film, you should take the opportunity to take a nap.

The researcher would then ask the person to provide an example of another scenario to ensure that the he or she understood how to use the information correctly.

The following suggested fatigue countermeasures were discussed with each participant who in turn was encouraged to utilize these techniques when performance watch readings were low or when he or she was feeling tired.

1. Rest breaks and napping:
   a. In general, the effects of napping, following the elimination of sleep inertia (or grogginess), have positive effects on performance that can be seen as long as 4 hours after a nap has been taken.
   b. Naps as short as 20 minutes can be helpful.
   c. Naps can maintain or improve alertness, performance, and mood.
   d. Some people feel groggy or sleepier after a nap. These feelings usually go away within 1-15 minutes, while the benefits of the nap may last for many hours.
   e. The evening or night worker can take a nap to be refreshed before work.
   f. Studies show that napping at the workplace is especially effective for workers who need to maintain a high degree of alertness, attention to detail, and who must make quick decisions.

2. Caffeine:
   a. Should be used in moderation.
   b. Don't use 4 hours before sleep.
   c. Use decaffeinated beverages just after waking up so that caffeine will have a greater effect when needed to combat fatigue.

3. Maximize the likelihood of getting 8 hours of uninterrupted sleep to decrease fatigue:
   a. White noise (e.g., a small fan).
   b. Dark window covers.
   c. Phone ringer volume turned down.
   d. Ear plugs.
   e. Working with family to educate them on the importance of, and your need for, uninterrupted rest.

4. Take naps whenever possible. The closer you are to getting 8 hours of sleep in a 24 hr period the more effective you will be. Taking short naps, if that is all that is available, is better than not sleeping.

5. Stretching:
   a. Take a short walk, do some simple stretching exercises.
   b. Regular, light exercise such as walking has been shown to decrease fatigue.
   c. Relaxation exercises (e.g., deep breaths).

6. Drink plenty of fluids:
    a. Dehydration has been correlated with fatigue.

7. Diet:
    a. Try to eat three normal meals per day.
    b. Eat healthy snacks, avoiding foods that may upset your stomach.
    c. Drink less fluids before going to sleep.
    d. Avoid heavy meals close to bedtime.
    e. Eat a light snack before bedtime.
    f. Don't go to bed too full or too hungry.
    g. Avoid nicotine.

8. Exercise:
    a. Helpful in obtaining overall health.
    b. Should be avoided before sleep.

9. Alcohol:
    a. Don't stop for a drink after work; although at first you may feel relaxed, alcohol disturbs sleep.

10. Promoting Alertness at work:
    a. Talking with co-workers can help keep you alert and co-workers can be on the lookout for signs of drowsiness in each other.
    b. Try to exercise during breaks -- take a walk around the building, shoot hoops in the parking lot, or climb stairs.
    c. Exchange ideas with your colleagues on ways to cope with the problems of shift work. Set up a discussion group at work.

Prior to discussing the above fatigue countermeasures, participants were encouraged to identify what positive changes they could make in their environment to assist in the promotion of more restful sleep.

Initially clients had a very difficult time identifying changes that could be made. Many held the belief that improvements to sleep were impossible to make because of their work schedule. However, through much discussion and brainstorming, researchers assisted Engineers in identifying specific changes that could be made on a personal level. This often required asking the participant probing questions about his or her life. If, for example, an Engineer was hard pressed to identify what he or she could change, a researcher would ask about the following:

- Sleep environment?
- Eating habits (especially prior to sleep time)?
- Exercise habits?
- Alcohol intake?
- Water intake?

- Children in the home?
- Pets in the home?
- Concerns/worries?
- Divorce/other personal trauma?
- Pre-sleep rituals?

Answers to these questions were then used to design interventions on a person to person level. So for example, if an Engineer indicated that he or she had two 70 pound dogs that slept in the same bed or that he or she commonly ingested a heavy meal prior to bedtime, the researcher would help the person understand how these occurrences may affect both the quantity ad quality of sleep.

After identifying and recording areas of concern and behaviors for change, the researcher would then ask the participant how confidant he or she was that these changes could successfully be made. At all times researchers encouraged the participants to be realistic in his or her expectations.

In order to "prep" the participant for change, he or she would also be asked to identify possible obstacles to achieving the stated goals as well as strategies for overcoming those obstacles.

In many cases principles of learning and behavioral change were relied upon to assist the researchers in facilitating change. During the coaching sessions researchers encouraged participants to reflect on what is commonly termed the ABC's of behavior. Specifically, "A" stands for antecedent; "B" for behavior; and "C" for consequence, for clarity sake, here is an example; an Engineer tells a researcher that he or she always has a few alcoholic beverages to assist him or her with falling asleep. The researcher then explains that sleep studies have showed that while alcohol may help an individual to fall asleep more quickly, it ultimately leads to more disrupted sleep (tossing and turning) after a few hours. So in this example the "A" is alcohol, the "B" is trying to sleep, and the 'C" is disrupted sleep. Similarly, this concept can be used to help an individual understand how eating a carbohydrate laden heavy meal prior to bedtime can disrupt sleep as can caffeine ingested less than four hours prior to bedtime.

The intense coaching sessions were conducted so that an individual had better insight into what may be affecting his or her behavior and what changes could be made to alter negative practices and to increase the likelihood that more restful sleep could be obtained.

Engineers seemed to connect well with the research staff and to take these coaching sessions seriously, as evidenced by the extreme nature of the personnel information that was shared. It this safe environment, researchers heard about familial problems and issues that were not common knowledge.

Chapter 4. Scientific Models of Fatigue

Attempts to develop models to predict and explain natural phenomena date back to Archimedes (287-212 BC) who is credited with the defining the principle of the lever and inventing the compound pulley. According to various sources he is believed to have discovered the law of hydrostatics, which states that a body immersed in fluid loses with equal to the weigh of the amount of fluid it displaces. This discovery was thought to have been made when Archimedes stepped into his bath and perceived the resulting amount of water that overflowed.

In modern times statistical or mathematical models are used to predict and explain a number of different natural phenomena such as hurricanes, thunderstorms, and the average temperature, oil production and other important phenomena. However, models are only that, models. In statistics, it is taken for granted that "All models are wrong but some are useful" and, "Remember that all models are wrong: the practical question is how wrong do they have to be to not be useful," (attributed to George Box a professor of statistics at University of Wisconsin). (Box & Draper, 1987).

In psychology attempts to model human behavior and learning were undertaken in the heyday of behavioral psychology and culminated in the work of Clark Hull and Kenneth Spence at the University of Iowa. Later, Borbely (1982) in a classic article advanced the two process model of sleep regulation. The proposed model suggested that sleepiness increases during waking hours and declines during sleep. The process was thought to interact with a circadian process and was quantitatively modeled originally by Dan and Beersma 1984).

Since then a number of models of the sleep wake and performance behavior have been proposed. These were reviewed by Borbely and Achermann (1999) and were discussed in detail at a workshop in Seattle, WA in 2005. Results of the comparison of these models was discussed in detail in a number of papers that were later published.

Dawson & Fletcher

An Australian team worked to develop and devise a mathematical model that can account for the effects of sleep and wake cycles on work related settings. Roach, Fletcher & Dawson (2004) described the development of FAID which was developed primarily to be used in work-related settings and in particular with respect to duty rosters. According to Roach, Fletcher & Dawson (2004) the FAID model is based on "the fatigue value of work periods and recover value of non-work periods are dependent on their length, circadian timing, and recency. The overall fatigue level for an in individual at any point in time is the net worth of the fatigue and recovery tokens that he/she has accrued over the previous 7 days." (pg. A67). "The major advantage of this approach is that it does not require sleep times as an input but rather assigns a recover value to time away form work based on the amount of sleep that is likely to be obtained in non-work periods. Thus, FAID can be used to predict work-related fatigue associated with any duty schedule using hours of work as the sole input." (page A67)

The FAID model is based on the assumption that fatigue increases the longer a person is at work. In addition, work periods that occur during the midnight hours are more fatiguing than those that occur during daylight. Furthermore, the FAID model assumes that fatigue follows the circadian rhythm that has been found with the oscillating core body temperature. The circadian rhythm of core body temperatures has been set to vary over a 24 hour period with a peak level of alertness at 17:00 h and a minimum level of alertness at 05:00 h.

Dawson and Fletcher (2001) reported on their efforts to validate the model. Using previously published data the authors made comparisons between measures reported in the published works and the predictions of their model. Data provided in Dinges et al. (1997) study measures sleepiness, mood and performance in young adults during a sleep restriction protocol. The study was designed to parallel the amount of sleep typically obtained by shift work employees; namely greater than 4.5 hrs per night but less than 6.5 hrs per night. A total of 16 individuals were studied over 7 days of sleep restriction. Study participants completed the psychomotor vigilance task (PVT) and their lapses (reaction times 500 ms and PVT duration of the slowest 10% of reaction time responses were used as the measurement of interest).

Results reported by Dawson and Fletcher (2001) indicated that a correlation of r=.92 was obtained between the observed data and the predictions.

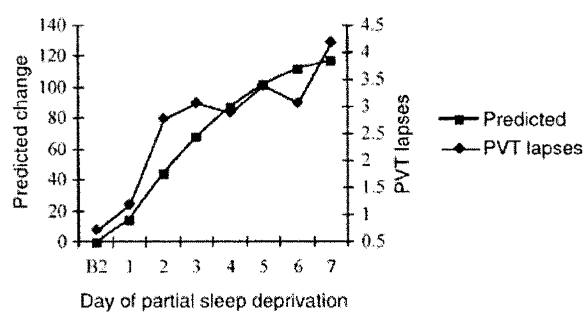


Figure 1. Mean (for testing at 10:00, 16:00 and 22:00 hours) relative performance on a 10-min visual psychomotor vigilance task (PVT) for 16 participants across the final baseline day (B2) and 7 days of partial sleep deprivation (mean sleep 5 h) against predicted relative change.

Figure 4. Comparison of FAID Model to predicted data. (permission requested.)

Dawson and Fletcher (2001) describe several other validation studies in which they compared the predications of the model and concluded, "Model predictions were correlated against psychomotor vigilance task lapses (r = 0.92) and reaction time responses (slowest 10%, r = 0.91) as well as sleep latency (r = -0.97). Further correlations were performed on four measures from a 64 h continuous sleep deprivation study; that is objective vigilance (r = -0.75) as well as subjective performance (r = -0.75), sleepiness (r = 0.82) and tiredness (r = 0.79). ...The results indicate that model predictions correlate well across a range of objective and subjective measures." (pg. 475).

In developing the FAID model, the authors have provided a description of the procedure that they used to validate the cut-off values of their modeling software. Based on previous research comparing the neuropsychological performance of sleep deprived individuals with that of persons with various blood alcohol levels it was possible to calibrate the FAID scores to reflect "high fatigue" levels associated with real world behaviors. In others words, high FAID scores could be associated with scores on other measures which had been produced by persons with continuous sleep deprivation and with neuropsychological performance similar to high blood alcohol content levels. Accordingly, a FAID score of 80 is likely produced after 21-22 hrs of wakefulness. Similarly, a score of 80 points reflects the neuropsychological performance produced when an individual has a blood alcohol level over 0.05%. Thus, "performance impairment at 80 fatigue points is at a level that would not legally be permitted in a motor vehicle operator if it were due to alcohol intoxication in most countries." (Dawson & Fletcher, 2001, pg. 481)

In the modeling workshop, according to Roach, Fletcher & Dawson (2004), the FAID model ranked as high as first and as low as sixth in its ability to predictions of the neurobehavioral data provided in the scenarios to be tested. Roach, Fletcher & Dawson (2004) concluded that:

> The differences in predictive power between models *were relatively small* (italics added) compared with the difference between model prediction and experimental data. (pg. A68)

Akerstedt

Folkard & Akerstedt proposed a “"three process model of sleep and alertness" (TPMA) (Folkard & Akerstedt, 1987). Their work from the Modeling workshop is described in Akerstedt, Folkard, and Portin (2004). The three process model uses subjective sleepiness data obtained from several studies. The three processes postulated include: sleepiness (c), time awake (s), and the wakeup or sleep inertia component (w). Alertness then is predicted to be the sum of S + C.

Attempts to validate the model have been based on both real world and laboratory studies using ratings of subjective alertness and EEG analyses as criterion variables. Data has also been gathered on operational performance using driving simulators and performance on psychomotor vigilance tests (Akerstedt, Folkard, & Kecklund, 1993 as cited in Akerstedt, Folkard, & Portin, 2004)).

Circadian Technologies

The Circadian Alertness Simulator (CAS) was also evaluated at the modeling workshop (Mallis, Mejdal, Nguyen, & Dinges, 2004). The CAS model includes both a circadian component and different factors for different types of work related activity. The model provides users with a plot of activity level and alertness level as well as a fatigue index. Validation efforts have been conducted "in sleep and alertness studies in workers with irregular, regular, and or rotating work schedules, comparisons of simulated and actual see and alertness, and correlations between a fatigue index and accident rates in transportation.... The model was developed for use in 24 hour transportation and shift work operations and is currently tailored for irregular work schedules in the transportation industry." (pg. A7)

At a recent congressional hearing Dr. Martin Moore-Ede, CEO of CTI, described the model and its uses in the transportation industry. He explained that CTI has developed the CAS model which is now used as the basis of their fatigue management plan. The process started with the development and validation of a Circadian Alertness Simulator (CAS) model which predicts not only levels of fatigue risk (as a fatigue Risk Score) but also the rate of DOT recordable accidents. The model produces a fatigue-risk score between 1 (low risk) and 100 (high risk) which is calculated from an employees work-rest pattern over the preceding seven day period. According to CTI, the average fatigue risk score of US truck drivers is approximately 40. Given these scores, the probability of a DOT recordable accident is strongly associated with the risk of fatigue scores reaching 60-70 and above. When a person obtains a score of 90 on the CAS there is a 50% probability of having a DOT recordable accident in the near future.

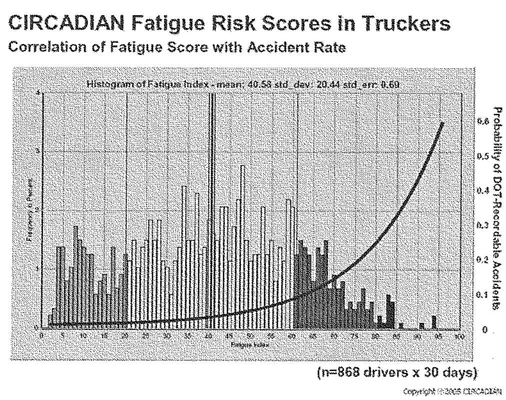


Figure 5. Use of the CAS in transportation. (permission pending.)

According to Dr. Moore-Ede, in real world applications actual truck-driver work rest histories are obtained from various sources such as driver logs or on-board monitoring devices. These data are then used to produce a Fatigue Score that provides an estimate of the degree of fatigue risk that an individual driver is exposed to at the time of measurement. The Fatigue Score is then provided to drivers, dispatchers, safety managers and operations managers for use in decisions about how to meet operational expectations while managing the risk associated with fatigue.

This modeling tool forms the basis of the **Fatigue Risk-Informed Performance-Based Safety** management approach that has been utilized by CTI consultants in their work throughout the transportation industry. The approach has also been used successfully with other industries such as fire prevention and nuclear power plants. The principle is that if railroads measure and monitor the specific risks, then government regulators can require the operators of the regulated industries to focus their attention and creative energy on ways to reduce those specific risks, without prescribing cumbersome rules on the exact interventions by which the safety goal should be met. Because of the variety of conditions and agreements across the railroad industry and the different terrain and length of time needed to complete various runs the one size fits all approach does make sense in the railroad industry. Recent findings from the San Antonio study (Sherry, 2005) for example, revealed that a majority of the employees were working at an optimal level of alertness with a low risk of fatigue.

Results of the modeling workshop showed that the CAS model was the best in terms of predicting the hourly alertness levels for a sample of locomotive engineers. On other data sets the CAS model faired about as well as the other models tested. As Van Dongen (2004) states "not one model clearly stood out as the overall best or worst....The models were capable of predicting the data of scenarios 1 [88 hours of wakefulness in a laboratory setting] and 3 [extraboard locomotive engineers] fairly well." (pg. A35)

Hursh et al.

Hursh et al. (2004) described the SAFTE model used in the Fatigue Modeling workshop. The authors postulate several processes that determine the performance effectiveness at a given point in time. The homeostatic process is a linear mathematical function in which a person's ability to perform basic cognitive tasks declines at a steady rate over time. The rate at which cognitive performance declines has been derived from other studies and estimated to be about 1% per hour. Differences in the rate of decay may vary according to the type of task that is being performed such as simple reaction time or basic arithmetic. The sleep restoration function varies according to the time of day but is estimated to be fully restored after a little more than 6 hours of sleep. The sleep inertia process is also estimated in the model and, based on the findings of Dinges, Orne, and Orne (1985) and Balkin et al. (2002) is thought to affect performance for as much as two hours after waking up. The circadian process is also included in the SAFTE model and is hypothesized to affect both sleep and performance. The authors state that the circadian process influences cognitive performance such that there is a "gradual rise during the day with a plateau in the afternoon and a rapid decline at night that closely parallels published studies of body temperature." And further, "Circadian rhythm combines with a gradually depleting reservoir process resulting in a bimodal variation in cognitive effectiveness" based on the data obtained from other published studies. (Hursh et al, 2004). The SAFTE model is particularly strong in that it combines an estimate for a phase shift that might occur if the individual were to end up performing cognitive tasks in a different time zone following air travel. The model includes parameters that estimate "jet lag" that describes the degree of performance or impairment that would obtain in different time zones.

The SAFTE Model has been described in some detail by the authors as a "three-process quantitative model" (pg. a44) (Hursh et al., 2004). The model was developed for use with military personnel to estimate performance in the military field setting. The most recent version of the model was developed based on data obtained from the Sleep Dose Response Study (Balkin et al., 2000) which has also been used in the construction of the Fatigue Avoidance Scheduling Tool (FAST) (Eddy & Hursh, 2001). The model is conceptualized as a sleep reservoir which influences processes which influence the capacity of an individual to perform cognitive processes and complete tasks. With each unit of time that a person is awake the components and capacity of the sleep reservoir is decreased over time. The reservoir is restored in accordance with the intensity and quality of sleep obtained over time. Sleep intensity is directly affected by the time of day and sleep quality is affected by various real-world demands. The model output, level of effectiveness, is modulated by the circadian effects of time of day, and the depletion or accumulation of the sleep reservoir. Thus, the SAFTE model is similar to that suggested by Folkard and Akerstedt (1987).

The SAFTE model has been validated by fitting a mathematical model to the observed data obtained from laboratory sleep deprivations studies that have tested the sleep dose response effect with impressive results. Model predictions against data published by Angus and Heslegrave (1985) showed a high level of accuracy and a good fit with the data (R^2=0.98). Similarly, using the dose-response data of Balkin et al. (2000) the predictions of the SAFTE model again show a very good fit with the data (R^2=0.94).

Results of the modeling workshop showed that none of the models did very well overall. All of the models predicted the subjective ratings and the performance data for the scenario with extended wakefulness. However none of them, "could predict the sleep dose-dependent build-up of impairment over the multiple days of sleep restriction" (Van Dongen (2004) page A32). The SAFTE model was the most accurate in predicting sleepiness for scenario 2 partial sleep deprivations, and third best for predicting alertness in locomotive engineers. However, differences between the models were small and do not support the superiority of one over another at this time.

The SAFTE model is a very sophisticated and powerful tool with which to examine cognitive performance and reaction time as a function of sleep and wake periods. The model fits the best experimental data available quite well and has been tried in several different operational settings. As Hursh and his colleges note however, the usefulness of the models depends on the how to "bridge this gap between laboratory metrics of performance and performance in the natural environment of work and war."

(page A52). The Federal Railroad Administration is currently sponsoring a validation effort using work schedule data supplied by several railroads. As stated in a May 16, 2005 announcement:

> "FRA is accelerating its ongoing research aimed at validating and calibrating a fatigue model (which has already been proven in the laboratory by the Department of Defense) that can be used to (I) more precisely determine the role of fatigue in human factors accidents and (ii) improve crew scheduling by evaluating the potential for fatigue given actual crew management practices. When the model is properly validated, it will be made available to railroads and their employees as foundation for developing crew scheduling practices based on the best current science. The work plan for model validation will also provide a much more precise accounting of the role of fatigue (including acute fatigue, cumulative fatigue, and "circadian" or time-of-day effects) in train accidents.[11]

General Comments

The various papers and critiques of the results of the modeling workshop produced a number of different responses. Criticisms of the models and their results resulted in a number of important comments related to general model development and continued work. A summary of these comments is included below produced the following:

1) *Individual predictions.* Typically the models are validated by estimating the extent to which they account for overall group performance or group means. Using the models to attempt to explain or evaluate individual behavior will carry some degree of error. Thus, there will be a need to specify the extent to which the predictors are accurate.

2) *Predication accuracy.* How accurate are the model predications? Most psychological tests provide a standard error of measurement or a confidence interval so that users may evaluate the accuracy of the numerical predictions and the confidence within which those predictions can be assumed to be accurate. Typically, with other psychological tests a stand error of measurement is included that permits the user to assess the confidence with which the scores can be viewed. For example, IQ scores are typically reported with a range of plus or minus 3 points. Similarly, in large scale survey studies results are typically reported with an accuracy level of 3 – 5 percentage points. Model estimations need to provide such information as well.

2) *The outcome scales.* Some of the models have been developed to predict subjective ratings of sleepiness using the Karolinska Sleepiness Scale, others

[11] FRA Safety Action Plan:
http://www.fra.dot.gov/downloads/Safety/action_plan_final_051605.pdf

using performance on the PVT. The parameters used to model the pattern of subjective sleepiness may not be exactly the same, they are probably similar, but, Modeling subjective sleepiness Validation of the output from the models is generally geared towards the prediction of group not individual behavior.

4) *Real world accuracy.* Dinges (2004) called for additional research to validate these models in the real world.

Attempt at Model Validation

Dinges (2004) and others (Raslear and Coplen, 2004; Friedl, Mallis, Ahlers, Popkin, and Larkin, 2004) recommended that models be evaluated according to real world criteria and along with similar calls for validation by. These authors identified the need to develop models that will be useful in the operational environment. According to Friedl et al. (2004) in order to be useful in the operational environment such models must be "validated in specific field settings and be proven useful and useful for prediction of some important aspect of performance" (pg. A193).

A study conducted by the Sherry (2005), with the support of the railroad industry, sought to provide some initial data on the validity of the SAFTE Model in an operational setting. The SAFTE model has been of particular interest to individuals in the rail industry that is characterized by work schedules that have irregular start times and varying lengths of duration. Under current law, a train employee must have at least eight consecutive hours off duty following the completion of a work period. An employee who has been on duty for 12 consecutive hours may not return for duty until that employee has had at least 10 consecutive hours off duty. It is common practice in the rail industry at away from home terminals to transport road crews by cab from a train or terminal to a motel. If the crew is at a remote location, it may take an hour or more for the crew to reach its rest location. Thus, a twelve hour shift can become 13 or even 14 if the crew has to wait for its relief to arrive before being transported to the terminal. Upon arrival at their home terminal the employee usually has to drive home. Because crews are called at least two hours before they are to report for duty, a crew member may actually have only five hours or less of uninterrupted rest.

In the rail industry, locomotive engineers are required to undergo a certification exam every two years. This is equivalent to renewing one's driver's license to operate a motor vehicle on the highways. The purpose of this exam is to ensure that engineers continue to be proficient at knowledge of the rules as well as basic train handling techniques. Individuals are assigned a specific date and time at which they are expected to complete the 3 hour recertification exam. Successful completion of the exam results in continuation of a license to operate a locomotive in the railroad.

Locomotive engineers typically work various irregular work schedules. In advance of the required test of demonstration of proficiency it is common for a locomotive engineer to work in their normal fashion up to the day preceding the recertification exam or simulation. Thus, these recertification exams provide a naturally occurring opportunity to assess the impact of sleep and rest on human performance. Also, they present the opportunity to assess the adequacy of existing models to predict actual real work performance on a task that is extremely critical to continued employment.

The validation study sought to provide some initial field study data on the validity of the SAFTE Model in an operational setting by obtaining predictions of performance effectiveness from the SAFTE model and comparing them to the scores on the engineer recertification exam as required by law.

Participants for the current study were 176 individuals who reported for test on whom work schedule data were also available. Anonymous data were obtained from the archival records of a large rail transportation company. Accordingly, due to the anonymous nature of the study based on archival data held on file by the company we were unable to obtain additional data. Thus, little demographic information was available on these individuals as these data were obtained after the individuals had completed the testing.

To determine the degree of operational proficiency needed to operate a locomotive the railroad company used a simulation and assessment program called NetSim. These are computer administered software simulations that assess the individual's ability to operate a locomotive over a predefined section of railroad terminology. Successful completion of the simulation is required to maintain certification as a locomotive engineer. Simulations consist of a monitored 90 minute episode in which the locomotive engineer operates controls to respond to real life situations such as crossings, speed restrictions, hazards, etc. which are presented to them via a video tape administration that is synchronized with the time clock of a locomotive control panel. The individuals completed the NetSims at their assigned time and receive a pass-fail, a total score, and scores on specific aspects of performance such as speed control, use of breaks, etc.

The archival data for a major Midwestern rail transportation company were investigated. A random sample of individuals who completed the NetSims during a predetermined time were captured. The archival data were matched with other information on the work rest history of the same individual. The average efficiency score, as well as the lowest efficiency score, for the 10 work periods (not ten days) prior to the simulation run were identified. Statistical analyses were then conducted to determine the existence of relationships, if any, between scores generated from the FAST model and performance on simulators.

The analysis of the SAFTE model was conducted using a simple univariate correlation approach. This method compared the relative change in one variable to the unit change in another variable. Due to the fact that the data were archival no manipulation of the actual conditions (e.g. hours of sleep, etc) was performed. Thus, the causal relationship between the two variables can not be inferred due to the *non-experimental* nature of the investigation.

The archived scores of individuals who completed the NetSim simulation test, the recertification test, were obtained from the company. These results obtained the pass/fail scores, total number of items correct, break wear, fuel consumption, draft forces and general information on train handling. Next, these scores were matched with the work/rest schedules also obtained for the individual engineers who completed the simulator performance tests. Data were obtained during the period 2/12/2002 and 9/11/2002. These data were analyzed to determine the relationship between hours of rest available and various performance indicators from simulation scores. In all, information was available on 175 simulator runs.

Data from the work schedule history was entered into the FAST/SAFETE software. The resulting output provided the estimates of the individual's likely cognitive effectiveness or "efficiency" on a particular task, in this case reaction time. These efficiency scores were then paired with the *actual* output obtained as a result of completing. Average daily efficiency scores obtained for the work schedule on the days preceding and on the day of the actual simulator run were calculated. These average efficiency scores were taken as indicators of the average level of readiness to perform a given task. In addition, the efficiency score obtained on the actual day of the simulation, estimated on the basis of the work schedule provided, was used as well.

Results of the correlational analysis of the NetSim scores and work rest schedule data used to generate the FAST/SAFETE scores revealed a non-significant relationship between the FAST Efficiency scores and the scores on the NetSims.

As the Efficiency Score increased, number of items correct remainder decreased. The *remaining score* is the number of points on the test that *remain* after the penalty points are deducted. So, the higher the remaining scores, the higher the score on the test. Results indicate that as the efficiency score approaches 100 the test score decreases slightly. In other words, the higher the FAST score the *poorer* the score on the simulation. This is not in the expected direction and points to problems with the model. This is a very interesting counterintuitive finding. Essentially, as FAST efficiency scores increased we would hope that remaining score or test score would also increase, which did not occur with this data set. Actual pass/fail scores on the test did appear to correlate at a non-significant level ($r = -.130$, $p \leq .103$) on the actual date of testing. This result means that as the efficiency scores increase, the likelihood of passing decreases (on the graph a fail is scored as a 0 and a pass is scored as a 1). A counterintuitive result was produced. (Sherry, 2005)

These results demonstrate the lack of relationship between a model validated on laboratory data obtained under controlled conditions. The model was certainly accurate and had a good fit with the control data. These findings suggest that there is a lack of relationship between scores on the FASTSAFTE model and real work activities such as those found in the NetSim engineer recertification test. While the initial models appear to be promising based on the laboratory data on which they were derived, there is little evidence to suggest that the model actually corresponds to real life performance.

Additional research examining the validity of sleep models relative to real life measures of performance are clearly needed and, as discussed earlier, is currently underway.

Current Status and Implementation of Modeling Approaches

The US railroad industry is piloting the use of modeling and a risk based approach on one of the Class I railroads. Since 2003 the Union Pacific Railroad has been implementing the use of the FAID model in reviewing its operations to manage fatigue. In 2003 the UPRR contracted with the University of South Australia and Professor Drew Dawson to review their operations and crew scheduling approaches and to assist in the identification of scientifically based fatigue countermeasures for the railroad.

The first major step in applying a scientifically based model to the railroad operational environment is to gather the relevant data on the work schedules that make up the various pools and extraboards throughout a system. The UPRR has in excess 400 different agreements governing work assignments in various locations throughout the system. Each of these agreements defines a work territory and group of people dedicated to performing the work and the terms of that agreement.

In the railroad industry, many of the work agreements are characterized by a rate that individuals will earn per mile. Consequently, the number of miles that are available in a run will generate more earnings. In addition, in many cases the work agreements or contracts include a range – including a minimum and maximum number of miles that are deemed targets in the contracts. These mileage targets are monitored by both labor and management on a regular basis. The numbers of employees assigned to a pool or extraboard are adjusted to enable the employees who have made the agreement to be able to ensure that they are achieving their mileage goals. Person working those agreements then are working to obtain their mileage goals and the company is also trying to maximize these arrangements.

When persons work the jobs in the pool then they are expected to sign up for a particular work assignment and to work as the trains arrive in their location. Accordingly, as the traffic ebbs and flows there is a demand on the individuals in the location to be able to work the traffic. If the traffic increases individuals may be expected to work more frequently as the amount of traffic consumes the available labor. As traffic slows then individuals will work less frequently. Again, since annual earnings are based on the number of miles worked and the number of miles worked was related to the number of trips worked, then there is a cycle of work and rest that becomes optimal that is needed to ensure earnings. Thus, the business demands of the operation, the number of crews, and the amount of traffic, all interact to create a work environment.

It is possible then to examine the work history of employees at any railroad to examine the amount of time worked and the amount of time off. At UPRR a commitment was made to use the FAID model to assess the fatigue levels of the various work schedules on the system. The time and effort to apply the model to the data was considerable and required the efforts of crew management specialists, computer programmers, payroll and accounting, and safety and health psychology experts. Work histories of individuals throughout the UPRR system needed to be obtained and reformatted. Once the data was properly formatted it was then analyzed using the FAID model. These work histories were entered into the FAID model and analyses of the work histories, in comparison to the threshold values of the FAID model were examined.

A summary of the results of these analyses, computed for the interval between Jan 2003 and December 2005, is presented in Figure 4 and reveals that the majority of the employee work schedules are found in the Good range as measured by the model. In fact, for the 20 months included in the study only the Southern region falls into the Fair region for two months.

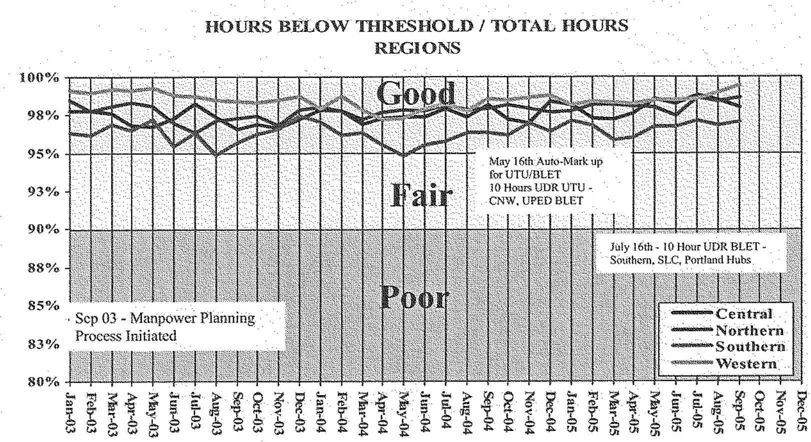
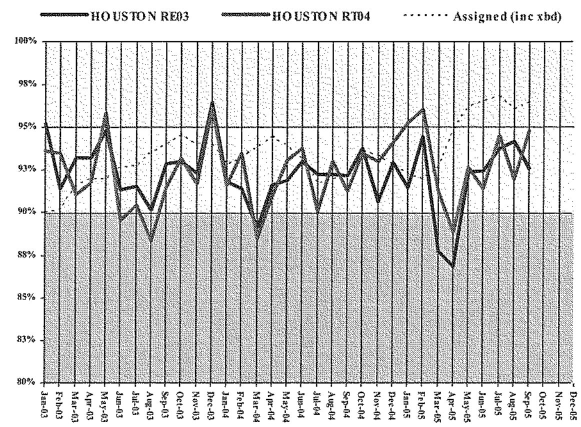


Figure 6. Percentage of boards over threshold.

These data and recommendations were presented by the UPRR at a meeting of federal, labor, and other key industry representatives and recognized experts in fatigue in November of 2005. The purpose of the meeting was to inform the railroad community of the UPRR activities and to request their input and reactions.

HOURS BELOW THRESHOLD / TOTAL HOURS



Following the initiation of these analyses using the FAID model additional countermeasures were put in place that were able to improve the overall functioning of the system. For example, in May of 2005 the automatic 8 am markup for UTU employees was initiated. Traditionally employees returning from a vacation or other absence would return to work at 12:01 am on their appointed day. Under this new provision, their first assignment after the absence would not begin before 8 am allowing a full night of sleep before work. A mandatory 10 hours rest requirement for some employees. was also instituted. This was followed in July with the addition of the BLE to the agreement. Improvements in the FAID scores for the system are noticed following the addition of these countermeasures.

It should be noted that the lines in Figure 6 and 7 represent averages which mean that some scores will be above and some below the average. As can be seen in Figure7 they are reflected with corresponding drops in the Houston area in the Southern Region during the same time periods (Aug – 03 and Apr-04 and Apr - May - 05) in which the scores fell below 90%. Note that there has been steady improvement since those months in 2005.

On the basis of these and other data provided it can be seen that for the most part there are only a small number of work schedules that are at risk for fatigue according to the FAID model. More importantly, the FAID model identifies that there are may be fatigue risk, however, all of these schedules are currently functioning within the existing hours of service and do not mean that persons are working in such a way as to be a safety risk. The safety risk has yet to be established scientifically and most scientific data suggest that while there is a reduction in effectiveness after 20-21 hours of wakefulness this reduced performance is likely less than 10% of optimal efficiency.

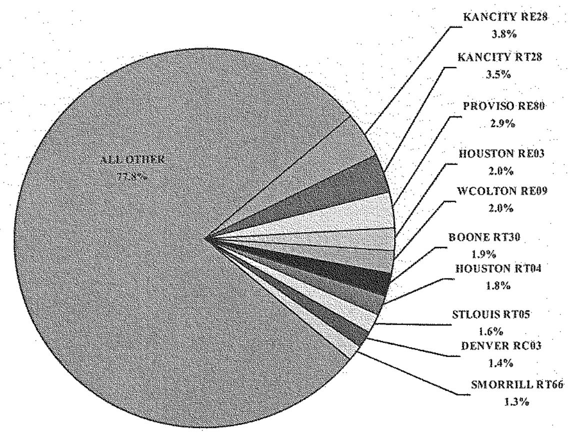


Figure 8. Percent of boards below threshold during 2005.

Figure 8 shows that 78% of the boards did not exceed FAID threshold levels during 2005. In fact it appears that in one location Kansas City boards exceeded threshold only about 3.7% of the time.

Since initiating this analysis UPRR has developed a series of action steps that it uses to manage fatigue. Specifically, all workgroups in the UP network are *risk-ranked* nationally and regionally as well as by service unit and board. These data are monitored by the General Director of Crew Resources and discussed with appropriate operational and safety groups as needed.

A standard report, that includes the graphs presented in Figures xx and xx, can be generated in a few as 24 hours by Crew Management, and reviewed for the identification of fatigue. This standardized report then provides a key mechanism for conducting a fatigue risk assessment.

Where a workgroup exceeds the allowable time over threshold [FAID > 90] there is a clearly specified 'corrective action' process that is undertaken by the crew scheduling team and other relevant groups where necessary [e.g. Labor Relations, Dispatch, etc]. In general, this process is designed to be risk-based, such that attempts to reduce Fatigue Related Risk (FRR) where it poses the greatest hazard.

In general, workgroups with the highest percentage of time below the threshold are considered 'at greatest risk'. However, risk is a relative term and based on the FAID model those with the least sleep opportunity. Furthermore, it is important to note that this analysis does not take into account the contribution of non-work related factors (i.e. an individuals' behavior during the sleep opportunity).

It is also important to be aware that this ranking process occurs within the constraints of current HOS regulations. There is no suggestion that the ranking process identifies unsafe working practices, but rather, those where employees have the least degree of sleep opportunity.

When an 'at risk' location has been identified it will be modeled using a second piece of software developed by UPRR [The Boardgame]. This software can then be used to analyze possible schedule data, identify hypothetical causes of the possible problems and then model the impact of various schedule changes or countermeasures on of any proposed solutions. The proposed solutions can be further studied using the FAID model.

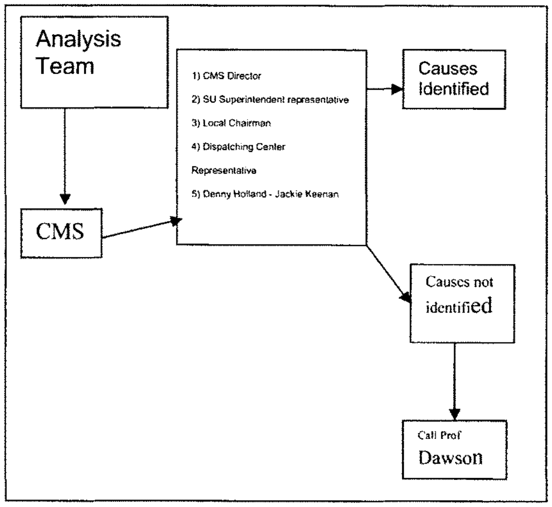
This software program (Boardgame) uses historical data on train movements to simulate the effect of different fatigue countermeasures strategies on average

Some common strategies that can be modeled include:

- varying the number of staff/turns on the pool,
- changing the number of staff/turns on the extra-board,
- altering minimum break times,
- introducing work-rest cycles,
- introducing fixed start windows, etc.

The crew-scheduling department in with safety, labor relations, and operations can use this tool to assist in identifying solutions that will be mutually acceptable and also have a high probability of reducing fatigue risk.

The software program ("Boardgame") is just one tool to be used in dealing with fatigue risk reduction efforts. The UPRR Crew Management staff has developed a flow chart and decision tool to be used when they identify a board or roster that may have a higher fatigue risk. The crew management staff has determined that they will bring together an analysis team consisting of various on-site experts. These individuals will consult the crew management data and then begin a step by step process of determining what might be contributing to the occurrence of a schedule that could lead to FAID scores occurring below threshold. The team gathers relevant information and discusses various possibilities. If the team is able to identify the relevant causes then they make a recommendation to crew management who in turn make recommendations to operations and personnel. If the team is unable to come to a conclusion then they will likely bring in outside experts.



Summary

The development of a scientifically based method for accurately assessing and quantifying the extent to which an employee might be at risk for operating equipment in a fatigued state has been undertaken by a number of different investigators around the world. The seven mathematical models that have received the most attention were studied together in a conference sponsored by the Department of Defense and the Department of Transportation in 2004. The results of the so-called modeling workshop have led to further research and development as well as attempts at model validation. The models are clearly in need of additional empirical validation and support. Nevertheless, the UPRR has taken the lead in applying one of the models to its work schedules and attempting to manage the fatigue risk associated with the schedule in a particular location. As has been mentioned before, the results of the analyses conducted by the UPRR demonstrates that fatigue risk affects a small portion of the entire railroad operation. Consequently, a prescriptive "one size fits all approach" is likely to do more harm than good.

The UPRR has broken new ground with the utilization of a sophisticated modeling tool as a key component of a risk based approach to the management of fatigue. This approach is consistent with current thinking regarding a risk-based approach to fatigue management and other safety issues in the work place The establishment of a accountable process for assessing the existence of fatigue related risk and acting on the fatigue risk assessment data that they have collected is commendable. Initial efforts have also been underway to development an industry wide approach to utilization of this technology.

Chapter 5. Scheduling Efforts

The use of work schedules is another way that the railroad industry has attempted to address the effects of fatigue on the railroad industry. These efforts are designed to stabilize schedules to enable employees to have the maximum amount of time available to work and the maximum amount of time to be able to obtain rest at the a desired location.

Typically, in the freight railroad industry a person is required to be available for work on an as needed or on call basis. The employee is usually able to bid onto a particular work assignment that will operate from a home to an away terminal. The individual signs up for a work assignment, typically called a pool assignment. In a pool assignment the individual is assigned a train on a first in first out basis. As trains arrive at a terminal a crew is assigned to the train and expected to report for duty to operate a particular train to a particular destination. Most of the pools operate on a continuous basis, and in large terminals trains are typically called every 30-60 minutes. This is due primarily to the operational constraints of the physical facilities of the yard etc.

Given that crews are called on a 24-hour basis, start times and end times for duty periods vary considerably over the course of a 24-hour seven day a week period. In other words, generally speaking, for freight pools in most parts of the country, there will be no consistent work schedule for the individual. These types of continuous operations then will necessitate that an individual will likely have a work schedule that will be variable. Railroads have typically dealt with this aspect of the work by ensuring that sufficient time off between trips exists for people to be able to obtain needed rest to recover from work assignments and to then be able to successfully return to work.

In the most extreme cases a person might experience the minimum least 8 hours off between work assignments, as required by law. This means that the person will have at least 8 hours between the time that they are relieved of duty and "tie-up" at the terminal and then return to active duty at the terminal for the next shift. However, this 8-hour rest period could include the typical 2-hour call prior to the next assignment and other activities such as travel between the work location and home or lodging, when away from home.

In most cases however, individual employees have a longtime period between work shifts or trips. For example, data provided by the Canadian Pacific Railway indicates that the average length of time on duty is about 9.93 hours.

By agreement several different situations have occurred. For example, in many locations a person who has worked more than 10 hours is eligible for additional time off duty if they wish. If an employee has worked almost 12 hours then they are entitled to more time off. Under current law, a train employee must have at least eight consecutive hours off duty following the completion of a work period and during the prior 24 hours before the employee may go on duty. An employee who has been on duty for more than

12 consecutive hours may not return for duty until that employee has had at least 10 consecutive hours off duty.

The following Figure 9 demonstrates the various scenarios that are possible. The table shows that if the individual has worked a specified number of hours then they are entitled to a certain amount of time off.

Time On Duty	Time Off – Undisturbed
Less than 12 hours	8 hours
> 12 hours	10 hours off

Figure 9. Hours of Duty and Time Off.

In practice, individual railroad companies have adopted a variety of approaches that deal with the amount of time off that a person has had. Recently, the Union Pacific Railroad adopted a 10 hrs undisturbed rest policy for all road work assignments. Coupled with the calling times this means crews have at least 11 and one-half or 12 hours off between assignments. This appears to acknowledge the need for longer rest periods. However, it should also be noted that the length of time off between trips is often much longer than 8, 10 or even 12 hours. In some locations the time off between trips can be at least 24-36 hours. This is due to the fact that the employees are working in locations that have large distances between terminals and crews can accumulate their requisite monthly mileages in fewer trips. So, they are able to work the maximum and obtain a decent income with decent time off. In other locations, the distance of a run is short and thus individuals must work more trips in order to be able to obtain a good salary for their lifestyle.

The other issue that occurs in the railroad work environment is the number of days off between trips. The period is not predictable in many locations where there is no specific assigned amount of time (beyond the minimum). In other words, no days off. While much of the general population has a work schedule of five days on and two days off, the freight railroad industry has not adopted this type of work-rest schedule. The reasons are many and include the unpredictable nature of traffic as discussed earlier as well as the structures of labor agreements that have evolved over time. This means that there are no regular weekends.

The amount of time off that is available to individuals is a matter of contractual agreement. Labor organizations and their management counterparts have developed agreements that do not include scheduled days off. This ensures that individuals will be able to work a maximum amount of time and generate the maximum amount of earnings for their efforts. Unfortunately, this comes at a price for leisure time.

Scheduling crew starts and time off is one way of managing fatigue. Over the past decade a number of different approaches have been tired. Starting with the CANALERT project and later the BNSF Spokane Project, significant efforts were made to develop work rest schedules that would minimize the risk of fatigue. These scheduling efforts were investigated thoroughly and evidence was reported in earlier versions of this monograph. However, due to the importance of these projects in demonstrating the effectiveness of the scheduling approaches in minimizing fatigue and improving alertness they are summarized here again.

CANALERT

Through the combined efforts of Canadian National, Canadian Pacific and VIA Rail, in conjunction with The Brotherhood of Locomotive Engineers a task force was formed and Circadian Technologies[12] was hired to provide assistance to address fatigue issues and charged the various railroads to develop policies and procedures to deal with the crew rest and fatigue problems. As a result a pilot project in Calgary and Jasper was initiated in 1995 called CANALERT. The following are the major components of the project.

Timepools

Effective April 27, 1997 the East (Brooks) and West (Laggan) districts began assigning crews within time pools that represented three specific time windows of operation. Please note that the agreements for Engineers and Conductors are almost identical. Employees who bid into these pools were required to specify their preferred Timepool within the specific pool and assignments were made according to seniority. Within each timepool crew assignments were made on a first out basis. To provide some flexibility, each timepool overlapped the next one by an hour. During this overlap period crews could continue to be called from the prior timepool until it was exhausted. Crews would then be called from the next timepool during the overlap period.

Pool	Overlap	Duty Period	Total Duty Cycle	
Lark	0500 –0600	0600 – 1500	1 hr + 9 hr	10 hr Window
Owl	1400 – 1501	1501 – 2359	1 hr + 9 hr	10 hr Window
Cat	2300 – 0001	0001 – 0559	1 hr + 6 hr	7 hr Window

Figure 10. Canalert Time Pool Duty cycle

The timepools were designed to minimize the likelihood that a person would be working in a time period that interrupts their natural circadian rhythm. Included in the scheduling process was the concept of a Protected Zone, the time within a timepool when, according to a person's circadian clock, they would be most likely to fall asleep (and also the time when a person would most likely be sleeping and therefore, the most likely time for a person to receive recuperative sleep.) To prevent and protect employees from being on duty at a time during which they would usually be sleeping, employees who have not had at least 3 hours of Circadian Rest (rest during their Recuperative period) were scheduled to complete their trip prior to the time of the Protected Zone. The

[12] Dr. Martin Moore-Ede was a key member of the planning team for CTI in collaboration with Transport Canada..

Protected Zone is that time that was established as being the most likely recuperative period for the employee. The recuperative zones for the various pools were as follows:

	Overlap	Duty	Recuperative Zone	Protected Zone	Special
Lark	0500 – 0600	0600 –1500	1700 –0900	0300 – 0700	0100 – 0300
Owl	1400 –1501	1501 – 2359	2000 – 1200	0700 – 1100	0400 – 0700
Cat	2300 – 0001	0001 – 0559	0800 – 2100	1800 – 2200	0400 – 0800

Figure 11. Protected Time Zones

In addition to establishing these recuperative zones and protected zones, labor and management agreed that the normal running times of certain classes of trains (expedited vs. general freight) should be considered when calling a person for duty. For example, an employee in the Lark Time Pool at their away from home terminal is called at 2130 hours to handle a lower speed train. Under normal circumstances the employee might wish to accept to call in order to get home promptly. However, the CANALERT '97 agreement precludes the employee accepting the assignment, as the person would require at least 6 hours to complete the trip as this would cause the employee to be on duty during the Protected Zone.

CANALERT '97 -Off Duty to Order Requirement

All Other Trains	400 Series Trains	Combination DH Service
Larks	Larks	Larks
0500 – 2100 1.5 hr call	0500 – 2200 1.5 hr call	0500 – 2300 1.5 hr call
0030 – 0659 Max 1.5 hr call Plus 3 hrs rest	0030 – 0659 Max 1.5 hr call Plus 3 hrs rest	0030 – 0659 Max 1.5 hr call Plus 3 hrs rest
2330 – 0659 Min of 30 min call plus 3 hrs rest	2330 – 0659 Min of 30 min call plus 3 hrs rest	2330 – 0659 Min of 30 min call plus 3 hrs rest
0700 – 1.5 hr call	0700 – 1.5 hr call	0700 – 1.5 hr call

Figure 12. Time Zone Service Periods

Minimum hours of rest rules were also established. The existing provision of 10 hours rest plus call was changed to a mandatory six hours of rest plus call at the home terminal.

Improved Rest Facilities Existing bunkhouses had been stationed next to the train yards. The bunkhouses at the Blue River, B.C. bunkhouse were given specific improvements including added soundproofing to interior walls, blackout curtains, and white-noise generators to mask disruptive noises.

Enroute Napping Policy An innovative napping policy was established at this time. Whenever a train arrived at a siding where a delay was expected, the engineer could notify rail traffic control and request a 20-minute opportunity nap. Engineers were provided with mattresses and blindfolds to aid in "napping." If the engineer was continuing to operate during a timepool's protected zone, a negotiated nap was permitted.

Terminal Napping Facilities Rest facilities with comfortable chairs in a quiet location were established in the Calgary and Jasper terminals. These were available for engineers to rest as they waited for their trains or for recuperative rest at the end of a trip prior to driving home.

Locomotive Cab Audio System Just as motorists listen to the radio to increase alertness, it was felt that special headsets might reduce fatigue by decreasing noise, improving communication and by providing stimulating music. Music was provided through a cassette tape (automatically preempted by the locomotive's communication radio.)

Lifestyle Training and Individual Counseling A four-hour training program called "Managing a Road Lifestyle" was developed for employees and their families.

Evidence

Volunteers were recruited to participate in the study. To volunteer for the project an engineer simply bid the chosen subdivision for a 6-month commitment. Of the forty engineers who volunteered, 16 were assigned to the "lark" pool", and 12 each to the "cat" and "owl" pools.

Volunteers agreed to keep a daily sleep log and to be wired to a portable EEG for three randomly selected round trips during baseline and post-testing.

A separate set of 10 volunteers were also recruited in the Montreal area as part of the VIA Rail project.

Time Pools.

Time pools were popular with 80% of the volunteers indicating that they were reasonably or extremely effective at increasing alertness and decreasing fatigue. Approximately 85% reported that they found that the time pools improved their family and social life.

Spokane Time Pool Project

A project was initiated in April 1997 on the BNSF Railroad that was designed to give employees the opportunity to start work at fixed pre-determined time windows. (Sherry, 2003) These Time Windows were available by bid primarily to members of the Pasco Pool and enabled the employee not only to protect only the time period specified but also to have specified assigned days off. In addition, the extra board was also given an opportunity to work an 8-3 format (work 8 days and then have three (3) assigned days off.) Individual engineers and conductors participated in this project for a period of 90 days. After the completion of the initial 90 days the union members voted to extend the agreement another 30 days however, the project was eventually cancelled by mutual agreement of labor and management

A variety of measures were employed to assist in evaluating the effectiveness of the project. The majority of the findings indicated an overall positive effect for the project. For example, significant differences pre and post for the Time Widows sample were found for the Stanford Sleepiness Scale –LW ($F(1,34)=7.501$, $p<.010$), and Hours of Sleep in the Last 24 hours ($F(1,36)=5.472$, $p<.025$).

There were significant improvements in measures of fatigue. For example, at post testing respondents described themselves as less fatigued, less sleepy over the prior week's trips, and as getting more sleep in the last 24 hours. No differences were found on number of naps or average daily hours of sleep in the last 72 hours or week.

Comparing the Time Windows participants with those on the Extra board significantly lower levels of sleepiness were found for the Time Widows participants on the Stanford Sleepiness Scale –LT ($F(1,32)=3.798$, $p<.032$), and the overall rating of Improved Fatigue Levels ($F(1, 32)=4.335$, $p<.021$). No differences on the other scales were noted.

After the experimental phase it was decided that a comparison between employee fatigue levels before the project began and thirty (30) days after its completion would enable a more accurate comparison between employees. This would allow a comparison of the employee's ratings of fatigue when they were under a countermeasures program and when there were no countermeasures in place.

In order to achieve this comparison an additional survey was administered to employees in the Pasco Pool and the Extra board thirty days following the completion of the TWP. These results were then compared with those obtained at the end of the TWP project alone.

There were a number of significant differences between employee's ratings at the end of the TWP and thirty days following its completion. Most interesting was that employees reports of amount of sleep obtained in the last 24 and 72 hours was significantly different ($p<.05$) with the extra board reporting 8.47 hours and the Pasco Pool reporting only 7.34. Further, for the Stanford Sleepiness Scale – LW there in a non-significant trend suggesting that the Pasco Pool was slightly sleepier than the Extra board.

Interestingly, there was also an increase in the number of countermeasures used reported by the members of the Extra board. For example, the Extra board reported using slightly more stretching than the Pasco Pool ($p<. 052$) and slightly more Relaxation techniques to help sleep off duty ($p<. 042$).

In terms of satisfaction, the Extra board appeared to be more satisfied with their jobs and with the BNSF than the Pasco Pool employees. This suggests that the Time

Windows Project participants did in fact feel that they lost something. At the end of the follow-up period the members of the Pasco Pool without the TWP were working more hours, getting less sleep, and feeling more fatigued than they were during the TWP. A graphic display of sleepiness levels as measured by the Stanford Sleepiness scale measured is displayed in Figure 12. Similarly, hours of sleep at pre, post, and follow-up is also displayed in Figure 13.

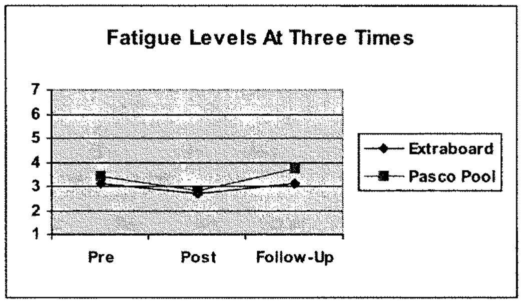


Figure 13. Fatigue Levels at Pre – Post and Follow-Up

In addition to measuring fatigue levels, hours of sleep also changed over the course of the project. During the TWP hours of sleep was greatest for both the TWP and the Extra board. However, thirty days after the cessation of the project hours of sleep had decreased and almost returned to pre project levels.

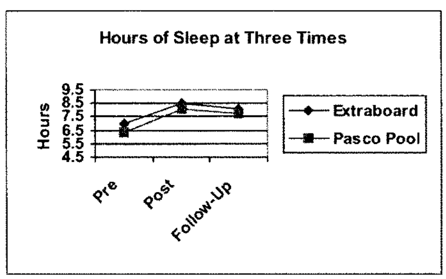


Figure 14. Hours of Sleep at Pre Post and Follow-up (Sherry, 2003).

Fatigue levels for study participants in comparison to the control group are shown in Figure 14. These results indicate that during the period of the study fatigue levels improved in comparison to those of a similar location on the BNSF system. The data show that the two locations were not significantly different in fatigue levels, as measured by the Stanford Sleepiness Scale, at the beginning of the study and at the follow-up. However, there were significant differences (* indicates $P<.05$) between the two locations at the end of the experimental period (post). In other words, when the scheduling arrangements returned to their pre-experimental condition (at the three month three-month follow-up) the fatigue levels also returned to the pretest levels. Thus, the fatigue countermeasures employed produced the desired results by reducing fatigue at the Spokane location.

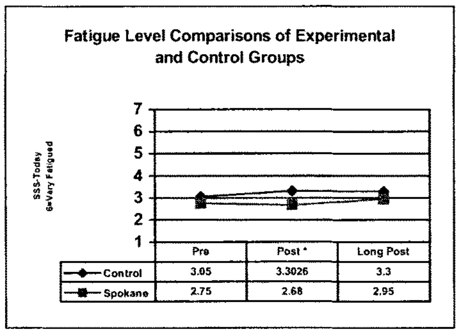


Figure 15. Comparison of Fatigue between TWP and Control (Sherry, 2003).

Comments

This was the first example of a project that included all employees, pool crews and extra board, working between two points. It was also the first example of a Time Windows project that uses Time Windows to control the start time variability. The Buffalo-Toledo project on Conrail had a 10-hour window, which can still lead to persons having a disruption of the circadian cycle. In this project participants knew exactly when they were going to work, regardless of train arrival or departure times. In addition, having assigned days off allowed participants the opportunity to recoup sleep debts. Finally, the inclusion of the napping policy makes this program one of the most comprehensive and thorough implemented to date.

Two criticisms have been leveled at the Spokane Time Windows project. First, time away from home was not controlled in this project. Unfortunately, for persons in this pool it is not uncommon to have long time away periods (in excess of 14 hours). Thus, the satisfaction with the program suffered because of this. A second criticism was that the program costs were too high. This was due in part to the fact that participants were guaranteed a wage consistent with their previous year's performance during the same time period. Unfortunately, there was a 14% reduction in traffic during this time period as compared to the previous year resulting in lowered revenue for the subdivision.

BNSF began a large number of fatigue countermeasure initiatives underway that involve scheduling, napping, and education. The Time Windows Project was noteworthy in its attempt to address start time variability, hours of rest, and assigned days off. The improvement in assigned days off resulted in employees having a greater likelihood of recouping any sleep debts they may have incurred.

UPRR San Antonio

Sherry (2005) conducted a study, sponsored by the FRA and the UPRR, on the work schedules of UPRR employees in the San Antonio area was sponsored by the FRA. This study was conducted with Union Pacific Railroad Train and Engine employees reporting for duty to the San Antonio Kirby Yard from November 3rd through November 8th 2004. During that time, questionnaire assessment of 283 Train and Engine employees occurred (out of a possible 356 who reported for duty), yielding a response rate of 79.5%. The sample consisted of 137 Engineers and 128 Conductors, 18 did not indicate their craft. In addition, in consultation with labor and management, a total of 40 Engineers and Conductors were identified from several Pools and Extraboards to wear Actigraphs during a 30 day period.

Results of the Epworth Sleepiness Scale (Johns, 1991), a self-report measure of sleepiness, indicated that a substantial portion of the respondents scored in the high to very high range for sleepiness (50.5%), while 49.5% of respondents scored in the normal range. Scores on this instrument were significantly higher than scores obtained by two other, previously studied, railroad locations.

POOLS[13]	N	Mean	Std. Deviation
Laredo-Eng (RE35)	5	6.9520	1.40981
Houston-Eng (RE42)	2	7.1850	.71418
Hearn-Eng (RE46)	1	3.7100	.
DelRio-Cond (RT30)	1	7.0300	.
Laredo-Cond (RT32)	3	6.1600	1.05702
Houston-Cond (RT41)	2	6.5450	1.74655
Hearn-Cond (RT45)	1	5.4900	.
EXTRABOARDS[14]			
Engineer-EB (XE40)	4	7.0825	.59673
Engineer-EB (XE-30)	4	7.3975	2.08031
Conductor-EB (XT30)	5	5.4483	.83741
Conductor-EB (XT40)	2	5.0950	1.18087
Total	30	6.4094	1.40447

Figure 16. Average amount of sleep for pools and extraboards.

Actigraph measurements were obtained for 30 study participants, and are summarized in Figures 15 and 16. Measurements for individuals on the results of the actigraph assessment indicate that the average amount of sleep per 24 hour period for the entire

[13] Note: The terms in the table refer to engineer and conductor pools and extraboards. For example, Houston-ENG is the designation for the Houston locomotive engineer freight pool. Similarly, the DelRio-Cond (RT30) refers tot eh Conductor's freight pool and its corresponding identification number.

[14] Note: Engineer-EB (XE40)refers to one of two Engineer extraboards and its corresponding identification number. Similarly, Conductor-EB (XT40) refers to the Conductors Extraboard.

duration of the study, was 6.40 (±1.40) ranging from a low of 3.71 average hours of sleep to a high of 10.02. This is consistent with other published statistics such as those reported in the 2002 "Sleep in America Poll" shift workers average 6.5 hours of sleep in a 24-hour work day period (NSF, 2002).

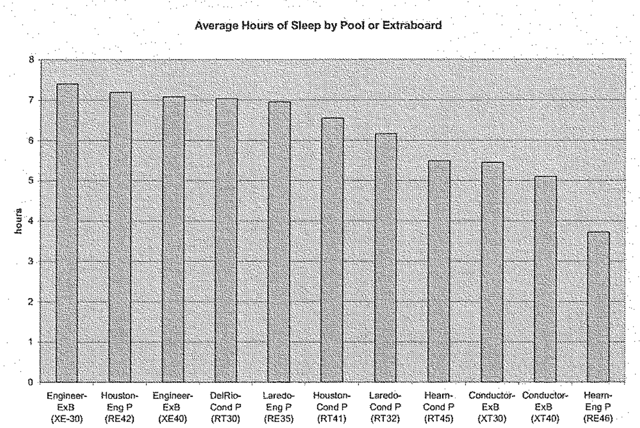


Figure 17. Average hours of sleep for selected pools and extraboards.

Figure 16 represents the results of the actigraph analysis of the work schedules for railroad employees in the San Antonio Kirby Yard area. As can be seen most of the work groups receive on the average, 6 hours of sleep or more. The conductor extraboards in this study appeared to have the lowest average amount of sleep. Thus, eight out of eleven work groups were found to obtain amounts of sleep about equal to or less than shift workers in other industries (NSF, 2002).

There are several conclusions that can be drawn from these findings. On the average, employees working railroad work schedules are able to obtain about the same amount of sleep as US shift workers in general. There are some schedules for which railroad employees are able to obtain more sleep that average US shift workers and some for which they receive less. These results suggest that not all work schedules in the railroad industry are problematic. In fact, many work schedules provide more opportunities to obtain rest than that obtained by typical shift workers. The results obtained appear to be the result of a number of factors including local agreements, traffic patterns, and workforce availability.

Coal Fields

The situation with respect to the average length of time on duty appears to be about the same since the previous reports were filed (GAO, 1992, 1993). Data was obtained from the AAR for 150 employees that worked over a 10 month period in the Wyoming-Nebraska coal fields. As can be seen from Figure 9 there is a range of hours worked peaking at 12 hours. The average length of time that railroad operating employees are on duty ranges from less than 1 hour to 12 hours. Railroad employees of course are required by law to go off duty after the hours of service expire. The data indicate that the average

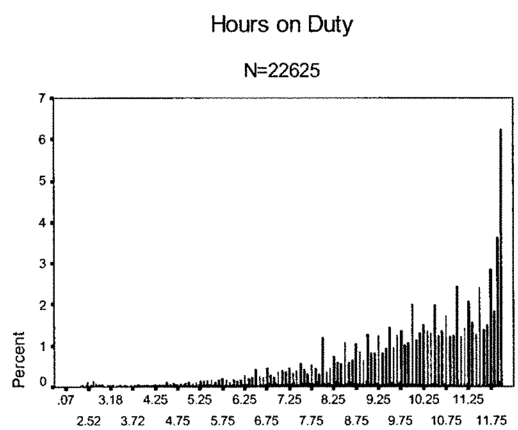


Figure 18. Hours off Duty Prior to a trip and Hours on Duty.

	Time Off Duty	Time on Duty
# Trip Starts	11143	22625
Mean	25.1636	9.6091
Median	15.5000	10.0800
Mode	8.00	12.00
Std. Deviation	17.97512	2.09523
Minimum	8.00	.07
Maximum	72.92	12.00

Figure 19. Statistics for Coal Fields

Amount of time on duty for this sample of employees was 9.6 hours with a median of 10.08 and a standard deviation of 2.1. Just under 50% of the sample works 10 hours or less with an equal number working between 10 and 12 hours. This standard deviation indicates that employees worked 9.6+- 2.1 about 66% of the time. In fact, examining the distribution of shift lengths we can see that a little more than half of the sample worked less than 10 hours.

Hours off between trips averaged 25.07+-17.92 with a minimum of 8 and a maximum of 72. The data show that 75.9% of the sample received 12 hours or more time off before beginning a trip. To prevent skewing the data, time off that most likely included vacations (time off exceeding 73 hours) was excluded from the analysis. The distribution of the data is bi-modal reflecting the fact that a substantial portion of the sample receives nearly 48 hours or two days off between trips.

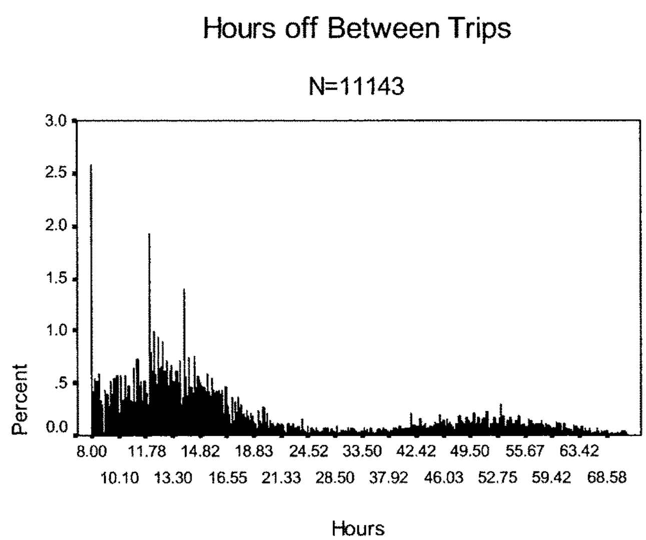


Figure 20. Hours off between trips.

While this data is limited to a particular region of the country and one major Class I railroad it does reflect the practices on one major railroad and the fact that this area operates effectively with such a work schedule. While accident statistics by individual were not available, the data reflect the prevailing approach that railroads are using to address the demands of the work schedules on employees. This is providing time off between trips for rest and sleep.

Overlays - BNSF

Some of the railroad carriers have developed a set of countermeasures that offer railroad employees predetermined voluntary opportunities to take time off. The BNSF has developed a voluntary system known as an "overlay." Under this system, a person will agree to be available for work 7 consecutive days followed by three days off. BNSF reports that as many as 100+ locations have adopted the overlay system. An important component of this approach is reducing unexpected vacancies by providing an incentive for employees to remain available for work during their assignment periods. The provisions usually include a penalty for laying off during this time period. Employees are not paid curing their assigned times off but their overall earnings are about the same as they would have been under the traditional "first in first out" approach.

A possible concern is that employees may choose to voluntarily continue working during their "off" period. This means that an individual will be able to work "as much as they want" and if they choose they can work additional extra hours or trips to maximize their income. While this is good from a productivity standpoint (and may have made the program more acceptable to employees) it does mean that individuals may not fully utilize their recovery periods to rest and prepare for additional work assignments.

While we have not studied any of the locations that have implemented an overlay policy, the concept shows considerable promise. From a fatigue perspective, it mirrors the common knowledge that at least two nights off between trips are needed to be able to fully recover from the effects of sleep deprivation. For all practical purposes the overlay seems like a good arrangement. There is time off to recover from extended work shifts, there is time off to address family and leisure time.

Scheduled Railroad - NS

Many of the carriers believe that the ultimate solution to addressing fatigue on the railroad has to do with the development of a so-called scheduled railroad. In this scenario, the various railroads are designed to operate trains at specific times. There are varying degrees of what this means. For example, a scheduled assignment might be developed to deal with mining operations. Here, a crew would likely report to work at a specific time work a specific number of hours and then return to their terminal. Other similar circumstances include yard jobs, industry switch jobs or work trains. All of these assignments have a specific start time and ends time typically associated with their activity. These types of jobs begin to approach the traditional industry shift schedule and are more manageable and have less serious impact on fatigue issues.

The Norfolk Southern railroad has indicated that it has approximately 85% of its employees on "scheduled" assignments. This means that the employees are scheduled to "show-up" at a specific time. In addition, along with these assignments the majority of individuals also have a minimum 10 hours of undisturbed rest after a duty period. This approach was agreed to by labor and management under a verbal agreement entered in to in 1997. This approach is very beneficial in that it provides a both predictability and opportunity for recovery. The CSX has also been moving in the direction of becoming a scheduled railroad.

Mid-route switching – CN

CN central has developed an approach to managing crew fatigue that is unique in the railroad industry. Currently, crews that work on the CN are able to return to their home terminal at the end of a work shift because of the fact that crews switch trains midway between the home and away-from-home terminal. The train crews then return to their home terminal on a train traveling in the opposite direction that they began. Such a scenario is effective in that it improves quality of life and likely also improves sleep quality due to the fact that employees are able to sleep in their own home.

At this point approximately 65% of the workforce is covered by this type of a work schedule.

CSX

Several railroads have adopted what is called the "assigned time off" approach. Under this approach employees are scheduled to have a specific day off. For instance, at CSX, the employees have been given a specified two days off after every 8 days on duty. This means that a person knows well in advance what their days off will be and can plan accordingly.

The assigned days off does not address the issues with respect to the circadian issues. In other words, persons who are on these schedules are working variable starts and end times and have little ability to know when or how long they might be on duty. However, assigned days off does present an important improvement by allowing a regular predictable period for recovery sleep.

Union Pacific Railroad

As discussed in Chapter 4, UPRR has utilized software designed to evaluate a particular work schedule and estimate the overall level of fatigue that might be associated with the particular schedule. Then, by providing the feedback and information to the railroad employees who would be working such a schedule railroad employees are able to evaluate the extent to which this schedule would be likely to result in fatigue or not.

In several locations on the UPRR system railroad employees have been provided with the software necessary to evaluate various work schedules. The existing work schedules are entered into the software and then evaluated by the software. Next, the railroad employees are asked to consider alternative work schedules. In the program that the UPRR has developed the railroad employees are asked to consider whether or not they would like to utilize a particular work schedule. Following the evaluation of the schedule from both a fatigue perspective and other lifestyle and financial perspectives the local work force is able to decide if a new schedule should be adopted.

Several locations have utilized this approach to evaluate their work schedules from a fatigue standpoint. The software is made available to the workforce upon request. The approach can then be used effectively by both management and labor in evaluating proposed changes to work schedules. In addition, the FADE model has been applied to entire systems and focused on how the entire UPRR system is able to be evaluated using the software.

This approach has considerable promise in that it utilizes a scientifically validated model to address the specific work schedules that employees utilize. In addition, due to the fact that temporary employees are able to utilize the data from the work schedules to address potential changes they can anticipate and investigate changes that might be made from a fatigue standpoint beforehand.

A further advantage of this approach is that it utilizes a fatigue model to address the likely effects of work schedule changes and is then capable of utilizing and

The model was evaluated along with a number of other models at the Seattle Modeling Workshop (Van Dongen et al., 2004). The FADE Model faired about as well as any of the models that were presented.

UPRR North Platte/Marysville Scheduling Project

UPRR has initiated a pilot scheduling project that utilizes scheduled start times. This agreement between the UPRR and the BLE-T is a very unique effort to manage fatigue, provide predictability and improve quality of life.

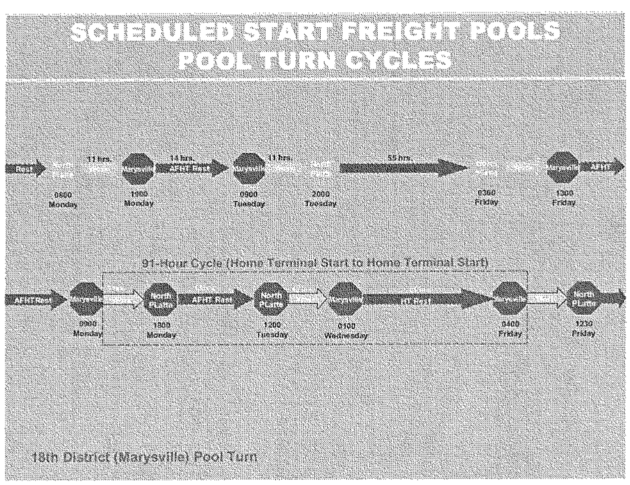


Figure 21. UPRR Scheduled Start Time Freight Pool.

The project began as an "employee engagement" process that allowed employees and local management to develop schedules that considered both employee needs and organizational operating requirements. The initial efforts were supported by software developed in Australia (FAID & "Boardgame") that offered local employees and managers the opportunity to develop and test potential solutions based on retrospective data.

The scheduling team developed a structured scheduling program that built on the traditional rhythm of the work pools. For example, it was determined that a properly functioning pool rotated (employee called from the home terminal) approximately every 91 hours. Therefore, as a solution, it was fixed that employees would report at the home terminal for duty every 91 hours.

This eliminated the need for calling at the respective home terminals, created predictable schedules and rest periods and ultimately reduced unscheduled absences. Attached is a schematic drawing depicting the basic operation of the North Platte/Marysville project. The employees have been very positive about this program. Crew resources management has also been very supportive as well.

Chapter 6. Technological Countermeasures

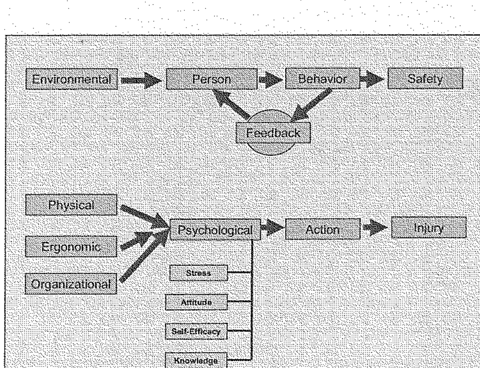
During the past few years there have been several attempts to investigate the effectiveness of some technological countermeasures as a means of assisting railroad employees to deal more effectively with fatigue. These efforts have been evident in the study of the effects of performance actigraphs on the sleep and rest schedules of railroad employees.

One of the first studies involving actigraphs was reported by Sherry (2004). Actigraphs were used to obtain readings on the extent to which the employees at a particular location were obtaining the required rest. Next, the information was fed back to the employees that they were able to utilize these data to make decisions.

Galesburg-BNSF

This project was designed to obtain individual participation in the monitoring of fatigue through the use of individual fatigue monitors (Sherry, 2004). Research has suggested that a combination of factors work together to affect performance. To understand which factors have the ability to alter behavior, further study of performance feedback was needed. The goal of this study then was to determine whether individual feedback devices, such as actigraphs (which are essentially motion detectors that are able to keep track of the amount of body movement that occurs), could be useful for helping railroad employees better plan their sleep and wake activity.

Figure 22. Factors affecting safety.



As can be seen from the Figure 22 Sherry (1992) argued that the effects of person and organizational behavior on the behaviors that lead to safe work performance are significant. However, there are several other factors that in turn influence behavior. Behavior is influenced by the effects of antecedents, consequences, and actions that precede a specific behavior and is paramount to understanding and eventually controlling the behavior that is deemed to be risky or even unsafe. Thus, the person is influenced by feedback from the environment and the consequences of their behavior. Again, Sherry, using a behavioral approach to safety, attempted to identify the antecedents (A), behaviors (B), and the consequences (C) of those behaviors. This ABC approach to understanding the effect of feedback on work performance was useful in changing the behavior of the employees of a railroad car repair facility.

Several investigators have continued to elaborate on the behavioral based models. Krause, Hidley and Hodson (1990) promoted the idea that a safety focused corporate environment needed to be created so as to sustain the behaviors that needed to be changed. Knipling and Olsgard (2000) identified a cluster of 16 behaviors common to drivers history of vehicle-related accidents and injuries. Geller (1998) evaluated *behavior*-based feedback interventions (BBIs) designed to increase the safe-driving practices of nineteen 44 year-old pizza deliverers. He focused on goal-setting and feedback techniques, including: (a) non-numerical goals in an awareness and promise card intervention; (b) non-numerical goals mandated as company policy; (c) participative and assigned group goal setting and feedback; (d) group goal setting and feedback with added public individualized feedback; (e) individualized feedback and competition; and (f) private individualized feedback paired with dynamic, static, or dynamic and static goals.

Measuring fatigue in the workplace is a complex process. It is common to use both subjective and objective measures of fatigue and alertness to evaluate the impact of a countermeasure, as multiple measures allow the investigator to triangulate the truth and produce a more convincing conclusion. There are four kinds of measures that are typically used in measuring fatigue; physiological, behavioral, subjective self-report and performance measures.

The current project was designed to obtain individual participation in the monitoring of fatigue through the use of individual fatigue monitors. The goal of this study was to determine whether individual feedback devices, such as actigraphs, could be useful for helping railroad employees better plan their sleep and wake activity. Project participation consisted of the completion of a consent-form, several survey questionnaires, a daily sleep log, and wearing an actigraph, which measured sleep and work during the course of the project.

A total of 29 individuals originally agreed to wear an actigraph sleep watch, 24 hours a day, for two consecutive thirty-day periods. Actigraphs are devices that detect motion. They are able to keep track of the amount of body movement that occurs. They are mechanical and do not harm the individual wearing them. They do not keep track of pulse or electrical activity. They must be worn continuously but should be taken off for showering or bathing or vigorous exercise. Various studies over the years have demonstrated a very strong relationship between body movement and sleep.

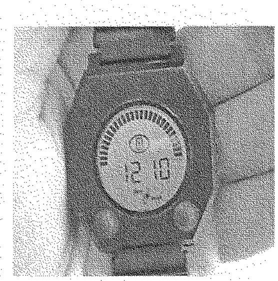


Figure 23. Image of an actigraph.

In addition to wearing the sleep watch, participants were asked to complete a daily sleep log that cataloged their activities for each of the thirty days. This was a simple task, whereby a participant would account for their actions according to a legend (e.g., "s" = sleep/ "w" = work/ etc.). Age of survey respondents ranged from 22 to 65 years, with a mean of 41 years of age. The average number of years of education reported was 13.29, indicating that the average Galesburg survey respondent had a high school degree as well as one additional year of post high school education. Number of years as a railroad employee ranged from 1 to 46, with the average tenure as an employee being 13.97 years. Eight, or 28%, of these 29 participants discontinued participation in the study during the first month. Thus, a total of 21 participants completed this study in its entirety.

During the first month of the study all participants wore the same type of non-performance actigraph to gather baseline activity data on each participant. At the end of the first thirty-day period Time 1 sleep logs were collected, the Time 2 survey was administered, and the battery in each actigraph was changed to ensure continual motion recording. During the second meeting with each participant the performance monitoring actigraphs were randomly distributed to half of the sample. A total of ten participants received the performance watches and eleven participants received the non-performance watches. Each of the individual's who received the performance watch were given instruction on how to interpret the performance reading as well as instruction on various fatigue countermeasures. For example, if an individual saw that his or her performance reading was in the 70's and knew that he or she was likely to be called to work in the evening, the merit of napping instead of completing domestic chores was discussed and emphasized. Finally, approximately two weeks after the performance watches were distributed, a researcher called each individual to inquire about how the watch was working and to address any questions and/or concerns that were presented.

At the end of the first month of the study, each participant received a $25.00 gift certificate to a local restaurant. Similarly, at the end of the second month each participant received an additional $25.00 gift certificate, for a combined total of $50.00 for wearing an actigraph for two months.

The assessment instruments that were administered at each phase consisted of a survey that included a number of questionnaires: Stanford Sleepiness Scale; Epworth Sleepiness Scale; Denver Job Satisfaction Scale; Denver Fatigue Adjective Checklist; Denver Sleepiness Scale; Denver Depression Scale; Denver Anxiety Scale; Denver Stress Scale; Denver Quality of Life Scale; Shift Work Index – Exhaustion; Shift Work Index – Depression; Shift Work Index - Quality of Life; Actigraph Monitoring; Sleep and Activity Logs. A complete description of these measures can be obtained from the authors. Detailed explanations of the methods are available in Sherry (2004).

To understand the effects of individualized actigraph feedback on fatigue management in railroad engineers, comparisons on the study measures were conducted between the performance feedback and the non-performance actigraph wearers. Results of repeated measures analysis of variance revealed that statistically significant differences in subjective levels of alertness were found between the participants wearing the performance feedback actigraphs and those who did not wear the devices. On the Shift

Work Index alertness measure a significant main effect over time was found for study participants (F (1, 5) = 7.912, p<.037).

Comparison of Feedback vs Non-Feedback Groups

		N	Mean	Std. Deviation	p<
Has Performance Reading on the Sleep Watch Helped You	Feedback	10	2.6000	1.0750	.679
	NoFeedback	8	2.3750	1.1877	
	Total	18	2.5000	1.0981	
Has Sleep Watch Helped You Manage Your Fatigue	Feedback	9	3.5556	1.6667	.038
	NoFeedback	7	1.7143	1.4960	
	Total	16	2.7500	1.8074	
Has Sleep Watch Helped You Monitor Your Fatigue	Feedback	9	4.4444	1.1304	.002
	NoFeedback	7	1.7143	1.7043	
	Total	16	3.2500	1.9494	
Recommend the Performance Sleep Watch	Feedback	10	3.9000	1.1972	.125
	NoFeedback	7	3.0000	1.0000	
	Total	17	3.5294	1.1789	
More Aware of Fatigue Due to Sleep Watch	Feedback	10	3.9000	1.2867	.019
	NoFeedback	8	2.2500	1.3887	
	Total	18	3.1667	1.5435	
Sleep Watch Use if Available at Low Cost	Feedback	10	2.9000	1.5239	.168
	NoFeedback	8	1.8750	1.4577	
	Total	18	2.4444	1.5424	
If Under $100 Would You Purchase Sleep Watch	Feedback	10	2.6000	1.5776	.332
	NoFeedback	8	1.8750	1.4577	
	Total	18	2.2778	1.5265	
If Improvements Were Made Would You Use Sleep Watch	Feedback	10	3.5000	1.2693	.146
	NoFeedback	8	2.5000	1.5119	
	Total	18	3.0556	1.4337	
Increased Naps Due to Performance Readings	Feedback	9	2.4444	1.9437	.225
	NoFeedback	6	1.3333	1.0328	
	Total	15	2.0000	1.6903	
More Prepared to Deal with Fatigue Because of Watch	Feedback	9	3.3333	2.0000	.121
	NoFeedback	6	1.6667	1.7512	
	Total	15	2.6667	2.0237	

Figure 24. Results of ANOVA on Feedback vs. Non-feedback groups.

For those engineers that wore the performance actigraph, the most robust finding indicated that the performance sleep watch helped those individuals monitor their fatigue levels (F(10, 18)= p<.038), and seven out of nine respondents indicated that the watch helped them to monitor their fatigue to a "Very Great Degree" – the highest rating available. Similar findings were also noted for whether the performance actigraph helped one "manage fatigue" as well as be "more aware of fatigue" in comparison to the non-feedback condition.

When the participants in the experimental group were asked to rate the degree to which they would recommend the performance sleep watch to others, the mean response was 3.90. Thus, 80% of participants would recommend the sleep watch to others to a "Considerable or Very Great Degree". This suggests that for these participants the performance readings were useful and could be helpful to other railroad employees.

Similarly, when asked to what degree the watch made the users more aware of their need for rest and sleep, the mean response was 3.90, thus indicating that the watch made them more aware of their need for rest/sleep to a "Considerable Degree". In fact, 70% of engineers in the experimental group indicated that the performance readings made them more aware of their fatigue levels to a "Considerable or Very Great Degree". Again, this suggests that for this group, the performance readings increased their awareness of the need for rest. Finally, approximately 56% of participants felt more prepared to "deal with fatigue" as a result of the performance readings on the actigraph.

Conclusion

Overall, study participants in the experimental group found the performance actigraph to be a useful tool for fatigue management. In addition, there were statistically significant improvements in subjective alertness for persons wearing the performance feedback actigraphs in comparison to those individuals who did not wear them. In general, participants wearing the performance actigraphs indicated that the watch helped participants in the experimental group monitor their fatigue levels. Small sample size is a limitation of this study. Interestingly, however, the trends were in the predicted direction suggesting that if the sample size had been large, a significant effect may have been detected.

These studies of performance actigraphs were designed to increase an individual's ability to control their own behavior by providing additional information regarding their sleep and activity patterns. Hopefully, by giving the individual greater information they would be able to improve their sleep hygiene behavior and ultimately improve their functioning and safety in the workplace.

Chapter 7. Sleep Disorders

As noted in Chapter 1 the FRA issued a safety advisory following the NTSB investigation of the Clarkson, MI accident. This advisory raised concerns regarding the need to identify those individuals possibly suffering from a sleep disorder such as sleep apnea. The FRA also called for the identification of best practices in the diagnosis and treatment of sleep disorders and related medical conditions and the need for treatment of those disorders as a precaution in the prevention of fatigue related accidents.

Sleep disorders, and sleep apnea in particular have been studied over the last thirty years as possible contributors to the occurrence of fatigue and consequently as a contributing factor to the occurrence of motor vehicle accidents.

As early as the late 80's researchers (George et al., 1987; Findley, 1988), according to Pakola, Dinges, & Pack (1995), identified the fact that persons suffering from sleep apnea were anywhere from two to seven times as likely to report an accident as controls. Phillip et al. (2005) noted that drivers that involved in traffic accidents had a higher rate of sleep disorders than controls. Patients admitted to hospital for emergency treatment following an accident were 6.5 times more likely report an accident if they were suffering from sleep apnea than not.

Teran-Santos, Jimenez-Gomez &v Cordero-Guevara (1999) found that patients with a high apnea-hypopnea ratio were 6.3 times more likely to be involved in a motor vehicle accident than those with a lower ratio. Howard et al. (2004) in a study of 2432 commercial truck drivers in Australia found that sleepiness as measured by the Epworth Sleepiness Scale (Johns, 1991) was associated with a greater risk of accidents.

Pack et al. (2006) studied 1391 individuals with commercial vehicle driver's licenses (CDL) living within a 50 mile radius of the University of Pennsylvania. Study participants completed a number subjective as well as cognitive performance measures including reaction time, lane changes, and symbol substitution. Results indicated that 17.6 percent of the CDL holders had mild sleep apnea, 5.8% had moderate and 4. 7 percent had severe sleep apnea. These prevalence rates are consistent with those of the general population. The study also showed that the occurrence of sleep apnea was significantly associated with both increased age and degree of obesity.

The importance of accurate diagnosis and treatment of Obstructive Sleep Apnea Syndrome (OSAS) was highlighted by Phillip et al.(2005) who reported that "more than 800,000 drivers were involved in OSAS-related motor vehicle collisions in the year 2000. These collisions cost approximately 15 billion dollars and 1400 lives in the year 2000. In the United States, treating all drivers suffering from OSAS with Continuous Positive Air Pressure treatment (CPAP) would cost 3.18 billion dollars, save 11.1 billion dollars in collision costs and also save 980 lives annually." (pg. 32)

The report by Pakola, Dinges, and Pack (1995) documented the existence of regulations and practices guiding the granting of drivers licenses in the US and several other countries including Canada, Australia, Sweden, and the Netherlands. The report noted that in the US the Federal Motor Carrier regulations specifically state that conditions that are likely to cause loss of consciousness or blackouts are considered sufficient for cancellation of or denial of a license to operate motor vehicles. At the time the report was written seven states were identified that had regulations or guidelines that specifically mentioned sleep apnea and narcolepsy as conditions that could be prohibitive of driving. The Federal Highway Administration produced a report in 1991 (FHWA, 1991) that specifically identified a number of pulmonary diseases that could lead to suspension or denial of drivers licenses.

The FRA recommendations were designed to promote the fitness of employees in safety-sensitive positions by doing the following:

1 Establishing training and educational programs designed to inform employees of the potential for performance impairment as a result of fatigue, sleep loss, and sleep deprivation.
2 Ensure that employees' medical examinations include assessment and screening for possible sleep disorders and other associated medical conditions and:
   a) Develop standardized screening tools
   b) Develop a good practices guide for the diagnosis and treatment of sleep disorders
   c) Develop an appropriate list of certified sleep disorder treatment centers.
3 Request that employees in safety-sensitive positions voluntarily report sleep disorders.
4 Develop policies that prohibit employees with sleep disorders from performing any safety-sensitive duties until properly treated.
5 Implement policies and procedures to:
   a) Promote self-reporting of sleep-related medical conditions by protecting the medical confidentiality of that information
   b) Encourage employees with diagnosed sleep disorders to participate in recommended evaluation and treatment; and
   c) Establish dispute resolution mechanisms that resolve current fitness of employees who have reported sleep-related medical conditions.

From a fatigue perspective, the NTSB recommendations and the subsequent FRA safety advisory have contributed to an increase in awareness on the part of the industry, the labor organizations and management of the importance of sleep disorder screening. The railroads have made a concerted effort to increase their efforts to educate the workforce and to screen and identify those persons with sleep disorders. The proper identification of sleep disorders has been seen as an important precautionary measure to prevent the occurrence of events similar to those that occurred at Clarkson.

As noted above (see page 18) a 1998 study of a sample of railroad employees also indicated that the prevalence of sleep disorders was about the same as that of the general population. A variety of sleep disorders have been identified. These disorders have been found to affect fatigue, sleepiness and alertness in persons identified with these conditions.

Disturbances in sleep and wakefulness associated with working irregular hours are not considered biological or clinical disturbances of sleep. These pathological disturbances in sleep and wakefulness must meet various diagnostic criteria in order to qualify as clinical conditions.

There are several different types of sleep disturbance: insomnia, which refers to too little sleep; hypersomnia, which refers to too much sleep; and parasomnia, which refers to deviation from normal sleep patterns. Some authorities estimate that about one third of the population suffers from disturbed sleep (Bixler, Kales, Soldatos, Kales, & Healy, 1979; Liljenberg, Almquist, Hetta, Roos, Agren, 1988).

According to these specialists, in order to meet the criteria of chronically disturbed sleep a person must suffer some form of sleep disturbance at least every other day for a period of three weeks. These disturbances must involve either taking to much time to fall asleep (more than 45 minutes), repeated waking (more than 5 times per night), waking up too early (more than 60 minutes) or getting one and a half hours less than the required 8 hours of sleep. Moreover, any of these symptoms must also be accompanied by disturbances in performance or daytime functioning. Insomnia is present in about 5 to 6 percent population. In most cases insomnia is thought to be the result of learned psychological responses. Persons suffering from insomnia often report high levels of anxiety associated with worries, traumatic events, or prolonged stress from work or other sources. Depression is another common source of disturbed sleep. Depressed patients often report obtaining less sleep, have difficulty falling asleep, intermittent awakening, and early morning waking. Treatment usually involves some form of psychological intervention including cognitive restructuring and relaxation training.

Hypersomnia, the desire for more sleep, usually manifests itself as a difficulty in staying awake. Criteria for diagnosing this condition are a consistent inability to remain awake in typical everyday situations such as traveling as a passenger in a car, watching TV, listening to a lecture, or reading a newspaper. Common causes of hypersomnia that have received increased attention recently are snoring and sleep apnea which both have excessive sleepiness as associated symptoms. Approximately 30 percent of men and 20 percent of women experience snoring. Recent studies have demonstrated that snoring reduces both the quality and duration of sleep as a result of short periods of waking. Snoring has also been connected to the occurrence of high blood pressure. It is hypothesized that sleep apnea is the result of temporary blockage of the respiratory pathway due to excess fatty tissue in the throat or a relaxation muscles of the throat. When the person has difficulty breathing, a startle response occurs causing the person to momentarily wake up in order to restore breathing. Interestingly, the person is unaware of the recurrent awakening that occurs throughout the sleep period. Unfortunately, the repeated awakenings reduce deep sleep and REM sleep. REM sleep (Rapid Eye Movement) is a recurring portion of a normal sleep pattern associated with dreaming and believed to restore brain function. A person suffering from sleep apnea experiences extreme tiredness during the day. Recent research has begun to look at the relationship between sleep apnea and accidents.

There are several treatments for sleep apnea and excessive snoring. Sleeping on one's side can help and surgery can be used to remove obstructions. Weight loss may aid in decreasing the amount of fatty tissue in the throat. Another treatment is the wearing of an appliance in the mouth to keep the airway open. Known as CPAP, continuous airway pressure, the procedure has been shown to be successful.

Parasominas are disturbances during sleep, which disrupt but do not prevent sleep. The most common are nightmares, sleep walking, restless legs and bruxism or gnashing of teeth. While these disorders are not the result of working in a railroad environment, the co-occurrence of these disorders in conjunction with an irregular working schedule found in railroad settings may perhaps lead to increased risk for performance decrements. Consequently, railroad companies have sought to engage in identification of persons with sleep disorders to minimize the likelihood of problems arising.

The screening program initiated by Conrail in 1998 was one of the first of its kind. Subsequently other railroads also undertook to educate their employees regarding the nature of sleep disorders. Several railroads also used the same screening procedures adopted by the former Conrail.

In 2005 the Work/Rest Task Force drafted the following statement that was agreed to by senior railroad officials as well as the leadership of the BLET and UTU. Several websites now include discussions of these issues and other communications have been prepared to broadcast the information throughout the industry.

> *Sleep disorders, like any other medical condition potentially affecting the safe performance of essential job functions or the safety of co-workers or the general public, require an individual assessment of the employee diagnosed with the condition to determine medical fitness for service and the necessity of any appropriate reasonable accommodations. The carrier s medical policy for assessment of sleep disorders is intended to neither diminish in any way the employee s responsibility for failure to comply with operating and safety rules, nor infringe upon an employee s rights under an existing collective bargaining provision.*

This statement represents a progressive and thoughtful response to the identification of medical conditions that might lead to a person being unable to safely operate a locomotive. In addition, the industry has also undertaken to develop a pilot program designed to screen individuals for the presence of sleep disorders such as sleep apnea. In particular, this program which is being conducted in conjunction with the Union Pacific Railroad and the University of Pennsylvania is noteworthy in that it offers study participants the opportunity to utilize a self-administered home assessment device designed to screen for the presence of sleep disorders. The study began on July1 2006 and is designed to obtain 400 volunteers over a ten month period. Employees are invited to participate in the study when they are notified of their upcoming engineer recertification exam. The goals of the study are to: determine the prevalence of sleep disorders in the population, develop a process of screening that is acceptable to all the stakeholders, assess follow-up compliance with recommendations, and finally to determine future research needs. A particularly note-worthy aspect of this program is the fact that study participants will be able to use an in-home sleep data detection device. This is being developed in response to the concern of many participants that the sleep study needed to diagnose the presence of a sleep disorder requires one to check in to a hospital overnight. Many patients find this procedure unusually intrusive and are unwilling to participate. In addition, the nature of the procedure may have a negative impact on earnings. Consequently, this study is being watched very closely to determine the effectiveness of this new and innovative approach.

At it's September 21 meeting, FRA's Rail Safety Advisory Committee, which includes railroads, labor organizations FRA and NTSB is expected to form a Working Group to explore new medical fitness for duty issues for safety sensitive employees.

Chapter 8. Napping in Railroad Settings

The most effective counter measure to reduce fatigue and improve alertness remains getting sufficient sleep. Unfortunately, it is not always possible to obtain sufficient sleep when working in the 24/7 operating environment of the railroad. One countermeasure that has been adopted by some of the railroads has been to permit controlled napping under special circumstances. Napping was first instituted as a counter measure as part of the CANALERT project in 1995 and later adopted several other railroads in 1998. It is not universally applied however, because of different operating practices on different railroads.

The scientific evidence supporting the positive benefits of napping in operational settings is quite impressive. Dinges and Broughton (1989) first summarized the available literature on naps in their volume on the characteristic behavioral and medical aspects of napping. They argued that naps may be beneficial and have positive effects if a person's sleep needs are not being adequately met. In fact they wrote that Trichopoulos et al found that there was a reduction in Coronary Heart Disease in populations where a 30 minute siesta was occurred. (pg. 306) They also wrote that "To the extent that naps facilitate functioning in situations involving limited sleep opportunities during circadian phases of increased sleep pressure, they have a potentially important role to play in sleep scheduling to optimize alertness. (pg. 304)

Most studies of short on-duty naps may not be directly applicable to operational environments and to shift work. An exception is the NASA Ames Research Center study on planned cockpit napping. (Rosekind et al., 1994). The study demonstrated that on-duty naps, averaging 25 minutes in length, improved performance and alertness in aircrews on long-haul flights. The Ames study appears to be well designed and does support on-duty napping as a promising intervention in a controlled operational setting. Dinges (1995) commented however, that the Rosekind et al. (1994) report demonstrated five "fundamentally important points about using planned napping as a fatigue countermeasure strategy":

(1) It was possible to safely and effectively plan ahead of time for when a nap would be taken
(2) It was possible for every operator to fall asleep in a reasonable period of time
(3) Sleep inertia did not pose a serious problem because 20 minutes was allowed for its dissipation prior to assuming duties
(4) As in laboratory studies the nap improved objective measures of alertness ... but did not eliminate feelings of fatigue
(5) The beneficial effects of a single nap were most evident on night flights, when control crews showed increasing fatigue relative to crews allowed a nap. (p. 51)

In general, napping, after sleep inertia has been overcome, has positive effects on performance that can be seen as long as 10 hours after a nap has been taken. However, it appears that napping research that utilizes a methodology readily generalizable to the on-duty activity of railroad employees is scarce. Thus, definitive conclusions about the effects of napping on the actual day-to-day performance for railroad employees are premature. Further study of the duration and timing of naps in the work/rest cycle, and sleep inertia is needed to clarify the best utilization of this technique.

Dinges, Whitehouse, Orne, and Orne (2000) studied the effects of a two hour nap on 41 volunteers during a period of 56 hours of wakefulness. The naps were strategically placed near the circadian peak or trough and following 6, 18, 30, 42, or 54 hrs of wakefulness. Tests every few hours consisted of psychomotor and cognitive tasks, as well as mood scales completed at the beginning, middle, and end of each bout. Eight performance and 24 mood parameters were compared between groups and after the naps. Despite continued deterioration over time consistent with the circadian peak or trough the naps appeared to slow or mitigate the decline in cognitive performance but not mood. The timing of the nap also appeared to have no relationship to subsequent performance. Thus, naps were seen to have a beneficial effect on the cumulative effect of sleep deprivation.

Macci, Boulos, Ziad, Simmon, & Campbell, (2003) examined the effects of an afternoon nap on subjective alertness and cognitive performance in 8 truck drivers in after partial sleep deprivation on a simulated night shift. Naps were obtained during a 3 hour period in an afternoon setting. Persons in the no-nap condition remained awake. Both conditions were followed by a simulated driving session. Participants completed a pre-nap testing session followed by post nap testing at midnight, 2:30 am, 5am, and 7:30 am. In the nap condition, the subjects showed lower subjective sleepiness and fatigue, as measured by visual analog scales, and faster reaction times and less variability on cognitive performance tasks. Thus, a 3-hour after noon nap resulted in significant performance improvements in the subsequent midnight shift worked 7 to 14 hours after the nap.

Tietzel and Lack (2001) examined the effects of napping following a night of restricted sleep. During a 3-wk period, 12 individuals participated in a repeated measures design comparing the effects of no naps, 10-min, and 30-min afternoon naps following 4.7 hrs night sleep. Both cognitive measures of performance and subjective measures of alertness were obtained before naps and 5, 35, and 60 min after napping. Results show there was significant improvement in subjective alertness and cognitive performance immediately following the 10 minute naps over the no nap condition. Interestingly however, alertness and performance measures failed to show improvements immediately following the30 nap but did improve one hour after the nap occurred. The authors suggest that the decreases in performance and alertness may have been the result of so-called sleep inertia.

Brooks and Lack (2006) studied the effects of naps of different lengths in a sample of participants who slept at home and then completed laboratory assessments following naps later in the afternoon. Five-minute naps had little effect compared to the non-nap conditions. However, 10-minute naps produced immediate improvements in subjective sleepiness and cognitive performance and these benefits lasted for as long as 155 minutes. Next, 20-minute naps produced performance improvements approximately 30 minutes after the nap was completed that lasted for slightly over two hours. Finally, the 30-minute naps were followed by reduced alertness and performance immediately following the nap but improvements lasting up to 155 minutes after the nap. Overall, a 10-minute nap was most effective. The results of sleep inertia were present in this study.

Song, Fuen; Danmin; Chen, Zuhuai (2003) studied the effect of naps during a 40-hour sleep deprivation experiment. Eight male medical students volunteered and during the study did simple typing and short-term memory tasks in different time periods for 8 hours. The participants took 3 30 min/ naps at 1:00 PM in the afternoon of the 1st day and 2nd day and at 1:00 in the morning when they were monitored by computer. The results of the effect of sleep deprivation on short-term memory improved the students' RT in short-term memory tasks.

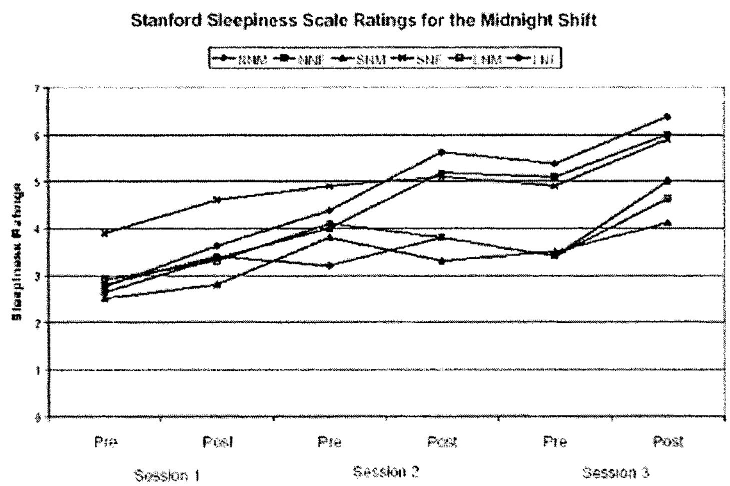


Figure 25. Sleepiness by Nap Condition – Rocca et al. (2000) - permission pending.

In 2000 Rocco, Compretore, Caldwell, and Cruz studied the effects of short and long naps on night shifts. Sixty air traffic controllers were randomly assigned to either a long nap (two hours) a short nap (45 minutes) or a no-nap condition. Study participants completed three early morning shifts followed by a rapid rotation to a midnight shift on the fourth day. Using repeated measures analysis of variance on both objective measures of cognitive performance and subjective ratings of sleepiness results indicted that the naps were beneficial to person on the midnight shifts. The longer nap resulted in better performance than the shorter naps. As can be seen from the accompanying figure, the results indicate that subjective ratings of sleepiness were significantly higher for persons in the no-nap condition than either the long or the short nap conditions.

Arora et al. (2006) studied 40 medical interns assigned to a nap scheduled for 2 weeks of every month over a one year period. During the other two weeks of the month they were on a regular no-nap schedule. Results of the study that used actigraphs to measure sleep and wake minutes revealed that interns in the napping condition obtained significantly more sleep, about 41 minutes, on the average, than those in the non napping condition. Moreover, they also reported less overall fatigue as well.

Driskell and Mullen (2005) conducted a meta-analysis of the effects of napping on work place behavior that results in several recommendations on the utilization of naps for improved performance. Taken together with other findings in this section we can draw several conclusions. In conclusion, several summary points about napping can be made:

- A "nap" may be defined as any sleep that is less than 50% of an individual's average nocturnal sleep length (Dinges et al., 1989)
- Napping can be either voluntary or involuntary
- Planned napping may be an effective fatigue countermeasure in certain controlled settings (Rosekind et al., , 1994)
- Sleep loss increases the likelihood of napping at any time
- The napping environment should be conducive to sleep
- Napping can be followed by sleep inertia depending upon how fatigued/sleepy the person is prior to a nap
- Many studies show that naps can improve alertness and performance under specific controlled conditions
- Shorter naps (5-10 minutes) may be less likely to result in sleep inertia but still improve performance (Brooks & Lack, 2006).

Most of the major railroads have adopted a napping policy that permits employees operating rail equipment to avail themselves of short naps (30 – 45 minutes in length) under controlled circumstances if the opportunity permits. Other industries have begun to follow suit, for example, an article in the August 26 2006 edition of USA today by noted that "Employers, such as Southington, Conn.-based manufacturer Yarde Metals, which has a Nap Room, are waking up to the fact that sleep deprivation can have a bottom-line impact. At 10e20, a New York-based global search marketing and Web solutions company, President Chris Winfield makes sure employees are supplied with free Starbucks coffee and Red Bull energy drinks. "It's coffee in the morning and Red Bull in the afternoon," he says. "We have a lot of legs shaking, but the work gets done." (Armour, 2006). The article goes further noting BNSF Railway policy defining conditions under which naps on the job may occur, including the fact that they are not to exceed 45 minutes and that one employee on the crew must remain awake during the other person's nap.

According to Baxter and Kroll-Smith (2005, pg. 43) "The NASA-sponsored research on airline pilots has undoubtedly done the most to … helped spread the workplace nap among shift workers (pg. 43)" and they note further that in a study of human relations professionals 15.4 percent of companies surveyed either permit or openly encourage breaktime naps, 32.4 percent permit naps if they are taken discreetly, 20.7 percent forbid naps but do not discipline employees who nap at work, and 31.5 percent forbid naps and discipline employees caught napping on the job (Mardon, 2000).

After interviewing key informants from several major industries, including Union Pacific Railroad , the Baxter and Kroll-Smith (2005) concluded that

> *"Once a tactical, jerry-rigged private rebellion against the discipline of work, the workplace nap is an increasingly normalized activity that is integrated into the work role and the work day. Napping is tolerated or introduced at work to increase mental acuity and amplify efficiency in ever-demanding work environments. ...The nap and larger alertness management movement is designed to improve safety and performance.... Normalizing the workplace nap begins with the burgeoning world of sleep research. (pg 50-51)"*

Thus, these noted sociologists have documented the changing workplace attitudes towards the work place nap. In an effort to improve performance and safety whilst accommodating the need for 24/7 continuous operations the scientifically determined value of a short daytime nap is seeing increased utilization in the modern work setting.

Summary

Napping is accepted as a fatigue counter measure in most major US railroads. Several of the roads have detailed written polices outlining the steps and procedures that need to be followed in order to ensure both employee safety. This has followed documentation in the scientific literature that clearly supports the value of short naps as a means of restoring alertness and effective cognitive performance. While there are some instances of performance decline following a nap, (sleep inertia) these appear to be short-lived and related to the length of the nap. The long-term benefits of napping would appear to outweigh the brief effects of sleep inertia. Moreover, with proper management of the nap and limiting the duration to no more than 15-20 minutes the effects of sleep inertia seem minimal.

Chapter 9. Summary and Conclusions

Over the past five years a number of new developments have occurred in the transportation industry relative to fatigue. We have seen developments in the regulatory arena for commercial motor vehicle drivers, increased awareness of the role of sleep disorders in transportation safety, educational efforts, new efforts at scheduling, development of scientific models, technological counter measures, and an increase in the popularity of a risk-based approach to fatigue management.

Regulation

In the area of regulation, the Federal Motor Carriers legislation was very significant. The implications for the rail industry are unclear. A recent review of the Railroad Hours of Service regulations by Sherry, Belenky, and Folkard (2006) concluded that significant change to the actual regulation were likely not necessary. However, the adoption of a risk-based approach to managing fatigue, similar to the Canadian approach, that has been adopted by the Union Pacific and that is being considered by other railroads is extremely promising. The essence of this approach is the identification of work schedules or working conditions that may have a greater fatigue related risk to then make recommendations regarding operating practices or crew scheduling matters. This approach was presented to a scientific panel and representatives of both the Federal Railroad Administration and the labor organizations and received a very positive response.

In addition, also consistent with the recommendations of Sherry, Belenky, and Folkard (2006) the railroad organizations have adopted a 10 hour undisturbed rest policy in many locations as well as 7:00 AM markups.

Changes in the regulation that are prescriptive are probably impractical and would likely have significant unintended negative consequences that would outweigh the desired benefits. Furthermore, the application of the scientific principles varies from situation to situation. Consequently, continued efforts to develop a fatigue related risk management approach and the establishment of fatigue counter measures plans than can be successfully audited and reviewed would likely be a more practical solution that would allow for the flexible application of scientific principles.

My recommendation is to encourage the railroad industry to adopt a risk-based approach and to develop fatigue counter measures plans that can be reviewed by external groups on a regular basis. This could be done voluntarily, be more in line with scientific principles and more effectively than with a piece of legislation.

Education

Great progress has been made in the railroad industry as a result of the efforts made to educate the work force. Providing individuals with needed information, delivered though a variety of media and methods, the industry has made great strides. Additional work is needed however, as the focus has been on the education of the rank and file. Continued efforts to educate management of both the railroad companies and the labor organizations, on the identification of fatigue related risk, and appropriate counter measures needs to be undertaken.

The development of the Educational Web Site will be an important resource, but, continued efforts to identify best practices and techniques are also needed. A course specifically designed for executives, a set of recommended practices, perhaps vetted by a scientific panel would add provide much needed guidelines to an unfortunately rather subjective and individualized approach. Utilization of the recommended coaching techniques developed for the *Actigraph Individualized Feedback Study* (Sherry, 2004) would be a first step.

Sleep Disorder Screening

In the last three to five years considerable progress has been made in educating the railroad industry and its employees regarding the risks associated with sleep disorders. Screening programs and educational programs have been put in place. In addition, efforts to identify medical conditions that might influence fitness-for-duty have also been improved. In short, there has been a great deal of progress in this area, that is likely to improve as studies currently being conducted of self-report screening tools, in – home assessment devices , and additional educational efforts get underway.

Technology

Technological developments have been largely experimental. The actigraphs studies that provide feedback on effectiveness conducted by the author are promising but unfortunately dependent upon models that are still under development.

Nevertheless, technological aids that can assist individuals in monitoring and planning their own alertness and sleep hygiene will continue to be of interest. If nothing else these studies have shown that there is a desire on the part of railroad employees to have good information coupled with knowledge of effective counter measures to deal effectively with the demands of railroad work schedules.

Scheduling

Scheduling programs have been challenging to implement due to the relationship between scheduling, earnings, costs and profit. Several years ago the labor unions and the railroad companies experimented with different types of schedules, time windows, 7-3's, 8-3's, 10-5, 11-3, etc. Very few of those programs remain.

Some railroads have attempted to increase the proportion of scheduled time trains; one railroad in particular has had considerable success with this approach. However, there are still the unscheduled extraboard crews that make up a much smaller percentage of the work forces and day to day activity of railroad operations. It is this small percentage that requires some attention. Efforts to target interventions to manage fatigue related risk are more efficient uses of limited resources.

The overlay program, the meet and return programs and the assigned days off programs have been in place for several years. They have been well received and appear to be cost effective as well thus ensuring their continued operation. The scheduled start time program also appears to show promise as well.

Existing pool schedules and extraboards may also operate well, with little fatigue risk, as was shown in some of the data reported. The utilization of fatigue models to evaluate schedules is also a technique that has been used on one railroad and is being considered by others. Consequently, progress is being made in this area.

Conclusion

Following the investigation of a number of pilot activities in the late 90's the railroad industry has seen a consolidation of its efforts in the use of overlay, assigned time off, and meet and return scheduling programs. These are becoming standard approaches to managing fatigue related risk. An increase in the amount of scheduled train traffic has also been noted. Increased awareness of the sources signs and effects of fatigue related to sleep disorders and sleep habits has also been seen. The railroad industry has seen consolidated utilization of these fatigue counter measures along with napping programs. Sleep disorder screening, and educational programs. Finally, a very promising move towards the adoption of a fatigue risk management program has been initiated with considerable interest shown by several key industry organizations.

References

Åkerstedt, T.; Kecklund, G. (2001). Age, gender and early morning highway accidents. *Journal of Sleep Research, 10, 105-110.*

Akerstedt, T., Folkard, S., & Kecklund, G. (1993). *The prediction of intentional and unintentional sleep onset.* In Harsh J, Ogilvie, R, Eds. Sleep onset. Washington, DC: American Psychological Association.

Akerstedt, T., Folkard, S., & Portin, C. (2004). Predictions from the Three Process Model of Alertness. *Aviation, Space, and Environmental Medicine*, 75, A75.

Åkerstedt, T., Kecklund, G., & Knutsson, A. (1991). Manifest sleepiness and the spectral content of the EEG during shift work . *Sleep: Journal of Sleep Research & Sleep Medicine*, 14, 221-225.

Angus, R.G., and Heslegrave, R.J. (1985). Effects of sleep loss on sustained cognitive performance during a command and control simulations. *Behavior Research Methods, Instruments, and Computers*, 17, 55-67.

Arora, V, Dunphy, C, Chang, VY, Ahmad, F., Humphrey, HJ, Meltzer, D. (2006) The effects of on duty napping on interns sleep tim*e and fatigue. Annals of Internal Medicine*, 144, 11, 856-7.

Armour, S. (2006, August 21**).** Companies try to help workers sleep more. USA TODAY.

Arnedt, J. T.; Wilde, G. J. S.; Munt, P. W.; MacLean, A. W. (2001). How do prolonged wakefulness and alcohol compare in the decrements they produce on a simulated driving task? *Accident Analysis & Prevention*, 33, 337-344.

Baldwin, D. C. Jr.; Daugherty, S. R. (2004). Sleep Deprivation and Fatigue in Residency Training: Results of a National Survey of First- and Second-Year Residents. *Sleep: Journal of Sleep and Sleep Disorders Research*, 27, 217-223.

Baldwin, D. C. Jr.; Daugherty, S. R. (2004). Sleep Deprivation and Fatigue in Residency Training: Results of a National Survey of First- and Second-Year Residents. *Sleep: Journal of Sleep and Sleep Disorders Research*, 27, 217-223.

Baldwin, D. C. Jr.; Daugherty, S. R.; Tsai, R.; Scotti, M. J. Jr. (2003). A National Survey of Residents' Self-Reported Work Hours: Thinking Beyond Specialty. *Academic Medicine*, 78, 1154-1163.

Balkin, T., Braun, A.R., Wesensten, N., Jeffries, K, Varqa, M., Baldwin, P., Belenky, G., and Herscovitch, P. (2002). The process of awakening a PET study of regional brain activity patterns mediating the reestablishment of alertness and consciousness. *Brain*, 125, 2308-2319.

Balkin, T., Thome, D., Sing, H., Thomas, M., Redmond, D., Wesensten, N., Williams, J., Hall, S., and Belenky, G. (2000). *Effects of sleep schedules on commercial motor vehicle driver performance. U.S. Department of Transportation, Federal Motor Carrier Safety Administration.* Study Objective I: Field Study – Actigraphic assessment of the sleep of CMV drivers over 20 consecutive days; Study Objective II: Laboratory Study – The sleep dose/response (SDR) study.

Barger, L. K.; Cade, B. E.; Ayas, N. T.; Cronin, J. W.; Rosner, B.; Speizer, F. E.; Czeisler, C. A.; Harvard Work Hours, Health, and Safety Group (2005). Extended Work Shifts and the Risk of Motor Vehicle Crashes among Interns. *New England Journal of Medicine*, 352, 125-134.

Baxter, V. and Kroll-Smith, S. (2005). Normalizing the Workplace Nap: Blurring the Boundaries between Public and Private Space and Time Current *Sociology*, January 2005, Vol. 53(1): 33–55 SAGE.

Beck, A. T. (1993). Cognitive therapy: Past, present, and future. *Journal of Consulting and Clinical Psychology*, 61, 194-198.

Belenky, G., Wesensten, N. J., Thorne, D. R., Thomas, M. L., Sing, H. C., Redmond, D. P., Russo, M. B., & Balkin, T. J. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. *Journal of Sleep Research*, 12, 1-12.

Bixler, E., Kales, A., Soldatos, C., Kales, J., & Healy, S. (1979). Prevalence of sleep disorders in the Los Angeles metropolitan area. American *Journal of Psychiatry*, 136, 1257-62

Bonnefond, A.; Muzet, A.; Winter-Dill, A.; Bailloeuil, C.; Bitouze, F.; Bonneau, A. (2001). Innovative working schedule: Introducing one short nap during the night shift. *Ergonomics*, 44, 937-945.

Bonnet, M.H. (1985). Effect of Sleep Disruption on Sleep Performance and Mood. *Sleep*, 8, 11-1.

Bonnet, M.H. (1986). Performance and Sleepiness as a function of frequency and of Sleep Disruption, *Psychophysiology*, 23, 263-271.

Borbely, A. (1982). A two process model of sleep regulation. *Human Neurobiology*, 1, 195-204.

Borbely, A., & Achermann, P. (1999). Sleep homeostasis and models of sleep regulation. *Journal of Biological Rhythms*, 14, 557-568.

Box, G.E.P., & Draper, N. R. *Empirical model building and responses surfaces*. Wiley: NY.

Brooks A; Lack L. A brief afternoon nap following nocturnal sleep restriction: which nap duration is most recuperative? *Sleep,* 29(6):831-840.

Cole, R.J., Kripke, D.F., Gruen, W.F., Mullaney, D.J., and Gillin, J.C. Automatic sleep/wake identification from wrist activity. *Sleep,* Vol. 15, 1992, pp. 461-469.

Connor, J.; Whitlock, G.; Norton, R.; Jackson, R. (2001). The role of driver sleepiness in car crashes: A systematic review of epidemiological studies. *Accident Analysis & Prevention*, 33, 31-41.

Cooper, C. L. *Safety and Human Organizations*. John Wiley: New York, 1998.

Czeisler, C. A. (2004). Work Hours and Sleep in Residency Training. *Sleep: Journal of Sleep and Sleep Disorders Research*, 27, 371-372.

Daugherty, S. R.; Baldwin, D. C. Jr. (1996). Sleep deprivation in senior medical students and first-year residents. *Academic Medicine*, 71, S93-S95.

Dawson, D., & Fletcher, A. (2001). A quantitative model of work-related fatigue: Background and definition. *Ergonomics*, 44, 144-163.

Dawson, D. & Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature*, 388, 235.

Dinges, D., & Broughton, R. (Eds.). (1989). *Sleep and Alertness: Chronobiological, Behavioral, and Medical Aspects of Napping*. New York: Raven Press.

Dinges, D. F. (1995). *The performance effects of fatigue*. In Proceedings of the Fatigue Symposium. National Transportation Safety board/NASA Ames Research Center, November 1-2.

Dinges, D. (2004). Critical issues in development of bio-mathematical models of fatigue and performance. *Aviation, Space, and Environmental Medicine*, 75, A181-191.

Dinges, D., & Graeber, R.C. (1989). Crew fatigue monitoring. Flight Safety Foundation: *Flight Safety Digest*, 65-75.

Dinges, D. F., & Kribbs, N. B. (1991). Performing while sleepy: Effects of experimentally induced sleepiness. In T. H. Monk (Ed.) *Sleep, Sleepiness, and Performance.* New York: Wiley.

Dinges, D. F.; Orne, M. T.; and Orne, E.C. (1985). Assessing Performance upon Abrupt Awakening from Naps during Quasi – Continuous Operations. *Behavior Research Methods, Instruments, & Computers*, 17(1), 37-45.

Dinges, D. F.; Orne M. T.; Whitehouse, W. G.; Orne, E. C. (1987). Temporal Placement of a Nap for Alertness: Contributions of Circadian Phase and Prior Wakefulness. *Sleep,* 10 (4), 313-329.

Dinges, D., Pack, F., Williams, K, Gillen, K., Powell, J., Ott, G., Aptowicz, C., and Pack, A. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep,* 20 (4), 267-277.

Dinges, D. F.; Whitehouse, W. G.; Orne, E C.; Orne, M T. (1988). The benefits of a nap during prolonged work and wakefulness. *Work & Stress.* 2(2) 139-153.

Doghramji, P. P. (2004). Recognizing Sleep Disorders in a Primary Care Setting. *Journal of Clinical Psychiatry*, 65, 23-26.

Drake, C. L., Roehrs, T. A., Burduvali, E., Bonahoom, A., Rosekind, M., & Roth, T. (2001). Effects of rapid versus slow accumulation of eight hours of sleep loss. *Psychophysiology,* 38, 979-987.

Driskell, J. & Mullen, B. (2005). The efficacy of naps as a fatigue countermeasure: a meta-analytic integration. *Human Factors*, 47 (2), 360-377.

Eddy, DR; & Hursh, SR. (2001). *Fatigue Avoidance e Scheduling Tool (FAST).* Brooks, AFB, TX: Human Effectiveness Directorate, Biodynamic and Protection Division, Flight Motion Effects Branch, 2001. AFRL-HE-BR-TR-2001-0140, SBIR Phase 1 Final Report.

Fairclough, S. H.; Graham, R. (1999). Impairment of driving performance caused by sleep deprivation or alcohol: A comparative study. *Human Factors*, 41, 118-128.

Falleti, M. G.; Maruff, P.; Collie, A.; Darby, D. G.; McStephen, M. (2003). Qualitative similarities in cognitive impairment associated with 24 h of sustained wakefulness and a blood alcohol concentration of 0.05%. *Journal of Sleep Research*, 12, 265-274.

FHWA (1991). Conference on Pulmonary/Respiratory Disorders and Commercial Drivers. Federal Highway Administration, FHWA-MC-91-004.

FMCSA , (2003)_http://www.fmcsa.dot.gov/rules-regulations/topics/hos/HOS-2005.htm. Federal Motor Carriers Safety Administration.

Findley, L.J., Unverzagt, M.E., & Suratt, P.M. (1998). Automobile accidents involving patients with obstructive sleep apnea, American Review of Respiratory Disorders, 138, 337-340.

Fletcher, A., & Dawson, D. (2001). A quantitative model of work-related fatigue: Empirical evaluations . *Ergonomics*, 44, 475-488

Fletcher, A., & Dawson, D. (2001). Field based validations of a work-related fatigue model based on hours of work . Transportation Research Part F: Traffic Psychology and Behaviour, 4, 75-88.

Fletcher, A., Dawson, D. (2001). A quantitative model of work-related fatigue: Empirical evaluations. *Ergonomics*, 44, (5), 475-488.

Fletcher, Lamond, den Heuvel, & Dawson (2003). Prediction of performance during sleep deprivation And alcohol intoxication using a quantitative model of work-related fatigue. Sleep Research Online, 5(2)67-75,

Folkard, S., Åkerstedt. T. (1987). Towards a model for the prediction of alertness and or fatigue on different sleep/wake schedules. In Oginski, A, Pokorski, J., Rutenfranz, (eds.) Contemporary advances in Shiftwork research, Krakow.: Medical Academy, 1987: 231-240.

Friedl KE, Mallis MM, Ahlers ST, Popkin SM, Larkin W. (2004). Research requirements for operational decision-making using models of fatigue and performance. *Aviation, Space, and Environmental Medicine*;75(3 Suppl):A192-9.

Gander A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury?

Geller, E.S. The psychology of safety. CRC Press, New York, 1998.

George CF (2001) Reduction in motor vehicle collisions following treatment of sleep apnea with nasal CPAP. Thorax , 56, 508–12.

George, C.F., Nickersn, P.W., Hanly, P.J., Millar, T.W., Kryger, M. H. (1987) Sleep apnea patients have more automobile accidents. Lancet, 8556, 447.

Glenville, M., Broughton, R., Wing, A., & Wilkinson, R.T. (1978). Effects of Sleep Deprivation on Short Duration Performance Compared to the Wilkinson Auditory Vigilance Task, *Sleep,* 1, 169-176.

Government Accounting Office (1992a). Railroad Safety: Engineer Work Shift Length and Schedule Variability. GAO/T-RCED-92-68.

Government Accounting Office (1992b). Railroad Safety: Engineer Work Shift Length and Schedule Variability. GAO/RCED-92-133.

Government Accounting Office (1993). Railroad Safety: Human Factors Accidents and Issues Affecting Engineer Work Schedules. GAO-/RCED-93-160BR.

Grant, J. S. Concepts of fatigue and vigilance in relation to railway operations. *Ergonomics*, Vol. 14, No. 1, 1971, pp. 111-118.

Guzzo, Jette, & Katzell. The effects of psychologically based intervention programs on worker productivity: A meta-analysis. *Personnel Psychology*, Vol. 38, No.2, 1985, pp. 275-291.

Härmä, M.; Sallinen, M.; Ranta, R.; Mutanen, P.; Müller, K. (2002). The effect of an irregular shift system on sleepiness at work in train drivers and railway traffic controllers. *Journal of Sleep Research*, 11, 141-151.

Herscovitch, J. & Broughton, R. (1981). Performance deficits following short-term partial sleep deprivation and subsequent recovery oversleeping, *Canadian Journal of Psychology*, 35, 309-322.

Horstmann, S.; Hess, C. W.; Bassetti, C.; Gugger, M.; Mathis, J. (2000). Sleepiness-related accidents in sleep apnea patients. *Sleep: Journal of Sleep Research & Sleep Medicine*, 23, 383-389.

Howard ME, Desai AV, Grunstein RR, Hukins C, Armstrong JG, Joffe D, Swann P, Campbell DA, Pierce RJ (2004) Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. *American Journal of Respiratory and Critical Care Medicine*, 170, 1014–21.

Hursh SR ; Redmond DP ; Johnson ML ; Thorne DR ; Belenky G ; Balkin TJ ; Storm WF ; Miller JC ; Eddy DR. (2004). Fatigue models for applied research in warfighting. *Aviation, Space, and Environmental Medicine*; 75(3) Suppl: A44-53;

Jewett, M. E.; Dijk, D.; Kronauer, R. E.; Dinges, D. F. (1999). Dose-response relationship between sleep duration and human psychomotor vigilance and subjective alertness. *Sleep: Journal of Sleep Research & Sleep Medicine*, 22, 171-179.

Jewett, M. E.; Dijk, D.; Kronauer, R. E.; Dinges, D. F. (1999). Dose-response relationship between sleep duration and human psychomotor vigilance and subjective alertness. *Sleep*, 22(2) 171-179.

Johns, M. (1991). Anew method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep,* 14(6), 540-545.

Kandelaars, K. J., Fletcher, A., Eitzen, G. E., Roach, G. D., & Dawson, D. (2006). Layover Sleep Prediction for Cockpit Crews During Transmeridian Flight Patterns . *Aviation, Space, and Environmental Medicine*, 77, 145-150.

Kinicki, A. J., Prussia, G. E., Wu, B., & McKee-Ryan, F. M. (2004). A Covariance Structure Analysis of Employees' Response to Performance Feedback . *Journal of Applied Psychology*, 89, 1057-1069.

Knipling, R.R., & Olsgard, P. J. *The behavioral power of on-board safety monitoring feedback.* Paper presented at the 10th Annual Meeting of the Intelligent Transportation Society of America (ITS America), Boston, May 1-4, 2000.

Krause, T. R., Hidley, J. H., & Hodson, S. J. (1990). *The behavior based safety process: Managing involvement for an injury free culture.* Van Nostrand-Reinhold, New York.

Lamond, N.; Dorrian, J.; Burgess, H. J.; Holmes, A. L.; Roach, G. D.; McCulloch, K.; Fletcher, A.; Dawson, D. (2004). Adaptation of performance during a week of simulated night work. *Ergonomics*, 47, 154-165.

Lamond, N.; Dorrian, J.; Burgess, H. J.; Holmes, A. L.; Roach, G. D.; McCulloch, K.; Fletcher, A.; Dawson, D. (2004). Adaptation of performance during a week of simulated night work. *Ergonomics*, 47, 154-165.

Laux, P. M. (2004). Hours of Service: Revisiting the Rule. Driving Force Magazine, http://www.drivingforcemag.com/index.php?id=385.

Liljenberg, B., Almquist, M., Hetta, J., Roos, B., & Agren, H. (1988). The prevalence of insomnia: The importance of operationally defined criteria. *Annals of Clinical Research*, 20 (6), 393-398.

Lilley, R.; Feyer, A.; Kirk, P.; Gander, P. (2002). A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury? *Journal of Safety Research*, 33, 53-71.

Lisper, H., & Kjellberg, A. (1972). Effects of 24-hour sleep deprivation on rate of decrement in a 10-minute auditory reaction time task. *Journal of Experimental Psychology*, 96, 287-290.

Luna, T. D. (1997). Air Traffic controller shiftwork: What are the implications for aviation safety? A Review. *Aviation, Space, and Environmental Medicine*, 68, p. 69-79.

Luna, T., French, J., & Mitchal, J. (1997). A study of USAF air traffic controller Shiftwork: sleep, fatigue, activity and mood analyses. *Aviation, Space, and Environmental Medicine*, 68, p. 18-23.

Macchi, M. Mila; Boulos, Ziad; Ranney, Thomas; Simmons, Lucinda; Campbell, Scott S. (2002). Effects of an afternoon nap on nighttime alertness and performance in long-haul drivers. *Accident Analysis & Prevention*, 34, 825-834.

Mallis, M.M, Mejdal, S., Nguyen, T.T., & Dinges, D. (2004). Summary of the key features of seven bio-mathematical models of human fatigue performance. *Aviation, Space, and Environmental Medicine*, 75, 3, A4-A14.

Mardon, S. (2000). *Shiftwork Practices, 2000*. Cambridge, MA: CTI.

Melamed, S.; Oksenberg, A. (2002). Excessive Daytime Sleepiness and Risk of Occupational Injuries in Non-Shift Daytime Workers: An addendum. *Sleep: Journal of Sleep and Sleep Disorders Research*, 25, 48.

Melamed, S.; Oksenberg, A. (2002). Excessive Daytime Sleepiness and Risk of Occupational Injuries in Non-Shift Daytime Workers. *Sleep: Journal of Sleep and Sleep Disorders Research*, 25, 315-321.

Munsterberg, H. (1913). *Industrial Efficiency*. New York: Houghton Mifflin.

NSF (2002). *2002: Sleep in America Poll*. National Sleep Foundation, www.sleepfoundation.org.

NTSB, (2002). Collision of Two Canadian National/Illinois Central Railway Trains near Clarkston, Michigan, November 15, 2001. NTSB: RAR-02-04

Pack, A., Maislin, G., Staley, B., Pack, F., Rogers, W., George, C., Dinges, D. (2006). Impaired Performance in Commercial Drivers Role of Sleep Apnea and Short Sleep Duration. *American Journal of Respiratory and Critical Care Medicine*, 174. pp. 446-454.

Pakola, S., Dinges, D. & Pack, A. (1995). Review of regulations and guidelines for commercial and noncommercial drivers with sleep apnea and narcolepsy. *Sleep,* 18 (9), 787-796.

Petersen, D. *Human error reduction and safety management.* Aloray Press, New York, 1984.

Philip, P.; Sagaspe, P.; Moore, N.; Taillard, J.; Charles, A.; Guilleminault, C.; Bioulac, B. (2005). Fatigue, sleep restriction and driving performance. *Accident Analysis & Prevention*, 37, 473-478.

Phillip, P., Sagaspe, P., Taillard, J., Moore, N., Guilleminault, C., Sanchez-Ortuno, M., Akerstedt, T., & Bioulac, B. (2003). Fatigue, sleep restriction, and performance in automobile drivers: A controlled study in a natural environment. *Sleep: Journal of Sleep and Sleep Disorders Research*, 26, 277-280.

Phillips, R. (2000). Sleep, watchkeeping and accidents: A content analysis of incident at sea reports. *Transportation Research Part F: Traffic Psychology and Behaviour*, 3, 229-240.

Pilcher, J, & Hufcutt, A. (1996). Effects of sleep deprivation on performance: A meta-analysis. *Sleep,* 19 (4), 318-326.

Pollard, J. K. *Issues in Locomotive Crew Management and Scheduling.* USDOT Report # DOT/FRA/RRP-91-06, 1991.

Radun, I.; Summala, H. (2004). Sleep-related Fatal Vehicle Accidents: Characteristics of Decisions Made by Multidisciplinary Investigation Teams. *Sleep: Journal of Sleep and Sleep Disorders Research*, 27, 224-227.

Raslear TG, Coplen M. (2004). Fatigue models as practical tools: diagnostic accuracy and decision thresholds. *Aviation, Space, & Environmental Medicine.* 2004 Mar;75(3 Suppl):A168-72.

Reason, J. Managing the management risk: New approaches to organizational safety. In B. Wilpert and T. Quale (Eds.), *Reliability and safety in hazardous work systems.* Psychology Press, Ltd., Hove, UK, 1990.

Rhodes, W., Heslegrave, R., Ujimoto, K.V., et al. (1996). *Impact of shift work and overtime on air traffic controllers – Phase II: Analysis of shift schedule effects on sleep, performance, physiology and social issues.* Final report TP12816E, Transportation Development Centre, Transport Canada.

Roach, G., Fletcher, A., & Dawson, D. (2004). A model to predict work-related fatigue based on hours of work. *Aviation, Space, & Environmental Medicine.* 2004 Mar;75(3 Suppl):A61-69.

Rocco, D., Compretore, C, Caldwell, L., Cruz, C. (2000). *The effects of napping on night shift performance.* DOT/FAA/AM-00/10.

Roehrs, T., Merlotti, L., Petrucelli, N., Stepanski, E., & et al. (1994). Experimental sleep fragmentation . *Sleep: Journal of Sleep Research & Sleep Medicine*, 17, 438-443.

Roehrs, T.; Burduvali, E.; Bonahoom, A.; Drake, C.; Roth, T. (2003). Ethanol and Sleep Loss: A "Dose" Comparison of Impairing Effects. *Sleep: Journal of Sleep & Sleep Disorders Research*, 26, 981-985.

Rosa, R. R.; Bonnet, M. H. (1993). Performance and alertness on 8 h and 12 h rotating shifts at a natural gas utility. *Ergonomics*, 36, 1177-1193.

Rosekind, M. R.; Gander, P. H.; Miller, D. L.; Gregory, K. B.; Smith, R. M.;Weldon, K. J.; Co., E. L.; McNally, K. L.; Lebacqe, J. V. (1994). Fatigue Operational Settings; Examples from the Aviation Environment. *Human Factors*, 36(2) 327-338.

Sassani A, Findley LJ, Kryger M, Goldlust E, George C, Davidson TM (2004) Reducing motor-vehicle collisions, costs, and fatalities by treating obstructive sleep apnea syndrome. *Sleep*, 27, 453–8.

Sherry, P. (1992). *Peer involvement and behavioral safety: A case study.* Paper presented at the annual meeting of the American Association of Railroads Safety Conference, Little Rock.

Sherry, P. (1991). Person environment fit and accident prediction. *Journal of Business and Psychology*, 2, 123-132.

Sherry, P. (2003). Fatigue in Transportation. *Clinics in Occupational and Environmental Medicine*, 3, 131-148.

Sherry, P (2004). Individualized Feedback on Fatigue Related Performance Effectiveness Using Ambulatory Wrist Monitoring Actigraphy. *Sleep*, 27, A407.

Sherry, P. (2005). *Final Report On the Assessment of Fatigue in Train and Engine Employees of the Union Pacific Railroad in the San Antonio Area.* National Center for Intermodal Transportation, University of Denver.

Sherry, P. (2005). A Fatigue Model and Job Performance: Testing the validity of model predictions for locomotive engineers. A paper presented at the Annual Meeting of the 2005 International Conference on Fatigue Management in Transportation Operations, Seattle, Washington , September 2005.

Sherry, P., Bart, S., & Atwater, J. Distractibility, fatigue, job stress, and accidents in long haul truck drivers. Paper presented at the annual meeting of the Rocky Mountain Psychological Association, Reno, Nevada, 1997.

Sherry, P., Belenky, G., & Folkard, S. (2006). Hours of Service Regulations in the US Railroad Industry: Time for a Change. *Transportation Law Journal*, (in press).

Skinner, B. F. (1953). Some contributions of an experimental analysis of behavior to psychology as a whole. *American Psychologist*, 8, 69-78.

Song, G., Huang, F., Miao, D., Li, Q., & Chen, Z. (2002). [The effect of naps during a 40-hour, sleep-deprivation period on short-term memory]. *Psychological Science (China)*, 25, 603-604.

Stein, A. C.; Allen, R. W.; Cook, M. L. (1985). The interaction of alcohol and fatigue on driver simulator performance. Proceedings of the American Association for Automotive Medicine, 29, 91-104.

Stutts, J. C.; Wilkins, J. W.; Osberg, J. S.; Vaughn, B. V. (2003). Driver risk factors for sleep-related crashes. *Accident Analysis & Prevention*, 35, 321-331.

Teran-Santos J, Jimenez-Gomez A, Cordero-Guevara J (1999) The association between sleep apnea and the risk of traffic accidents. Cooperative Group Burgos-Santander. *New England Journal of Medicine*, 340, 847–51.

Tietzel, Amber J. & Lack, L. (2001). The short-term benefits of brief and long naps following nocturnal sleep restriction. *Sleep*, 24, 293-300.

Tilley, A., & Wilkerson, R. (1984). The effects of a restricted sleep regime on the composition of sleep on performance. *Psychophysiology*, 21, 406-412.

Todd, C.; Reid, N.; Robinson, G. (1989). The quality of nursing care on wards working eight and twelve hour shifts: A repeated measures study using the MONITOR index of quality of care. *International Journal of Nursing Studies*, 26, 359-368.

Trichopoulos, D; Tzonou, A; Christopoulos, C; Havatzoglou, S; Trichopoulou, A. (1987). Does a siesta protect from coronary heart disease? *Lancet*, 2 (8553) : 269-70.

Van Dongen, H. (2004) Comparison of Mathematical model predictions to experimental data of fatigue and performance. *Aviation, Space, and Environmental Medicine*, 75(3), A15-A36.

Van Dongen, H. P. A.; Maislin, G.; Mullington, J. M.; Dinges, D. F. (2003). The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep*, 26, 117-126.

Vineet, A, Dunphy, C., Chang, V, Ahmad, F., Humphrey, H. , and Meltzer, D. (2006). The effects of on-duty napping on intern sleep time and fatigue. *Annals of Internal Medicine*,144.11 (June 6, 2006): 792(7).

Weller, D., & Sherry, P. (1992). Role of supervisor support in buffering the stress-strain relationship. A paper presented at the APA/NIOSH Conference. Washington, D.C.

Wilkinson, R., & Houghton, D. (1982). Field test of arousal: A portable reaction timer with data. *Human Factors*, 24, 487-493.

Williamson, A. M.; Feyer, A.; Mattick, R. P.; Friswell, R.; Finlay-Brown, S. (2001). Developing measures of fatigue using an alcohol comparison to validate the effects of fatigue on performance. *Accident Analysis & Prevention*, 33, 313-326.

Wylie, C. D. (2005). Sleep, Science, and Policy Change. *New England Journal of Medicine*, 352, 196-197.