Fatigue Risk Mitigation[*]

1. Introduction

Pursuant to 49 CFR, part 228, subpart F, railroads must identify the fatigue implications of the schedules worked by their train employees engaged in commuter or intercity rail passenger transportation by using an FRA-approved, scientifically valid biomathematical model of human performance and fatigue. Currently two models have been validated and calibrated by FRA: Fatigue Avoidance Scheduling Tool ("FAST") (Hursh, Raslear, Kaye, & Fanzone, 2006)[1] and Fatigue Audit InterDyne ("FAID") (Tabak & Raslear, 2010)[2]. FRA established threshold values of 70 for FAST and 72 for FAID by analyzing accident data. FAST scores below and FAID scores above these established fatigue thresholds for more than 20% of the scheduled work time demonstrate an increased risk for a fatigue-related human factors accident, and therefore fatigue must be mitigated for schedules with such fatigue scores.

2. Modeling

2.1 Purpose of Modeling

Fatigue is a multifaceted issue that has no tests or biomarkers that indicate its presence. In the absence of such a method to determine fatigue, biomathematical models of fatigue are useful as an objective method to determine the fatigue potential of a given schedule. Fatigue models use a variety of factors that have been shown to impact fatigue to determine fatigue risk. Different fatigue models may use slightly different factors and may assign these factors different weights in their algorithms. It is because of these differences that there is not a perfect one-to-one relationship between the models. A given schedule may appear more fatiguing using one model than it would using another. The underlying risk of fatigue has not changed; the differences are due to the different factors and calculations in the models. Fatigue modeling should be thought of as a useful tool to help determine if a given schedule has an increased risk for fatigue. However, modeling should not be the only tool used to identify fatigue risk.

2.2 Development of new Fatigue Models

As stated above, currently only FAST and FAID have been validated and calibrated by FRA. However, FRA understands that new biomathematical models of fatigue may become available in the future. The Tabak and Raslear (2010) report "Procedures for Validation and Calibration of Human Fatigue Models: The Fatigue Audit InterDyne Tool" includes information as to how a

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[*] This document provides informal answers to frequently asked questions and examples of how a fatigue mitigation plan might be submitted to FRA. For formal interpretations of 49 CFR, part 228, subpart F, please contact Colleen A. Brennan, Trial Attorney (202–493–6028); Matthew T. Prince, Trial Attorney (202–493–6146); Rich Connor, Operating Practices Specialist (202-493-1351); or Dr. Amanda K. Emo, Fatigue Program Manager (202-493-6413).

[1] Hursh, S.R., Raslear, T.G., Kaye, A.S., & Fanzone, J.F. (2006). *Validation and calibration of a fatigue assessment tool for railroad work schedules, summary report* (Report No. DOT/FRA/ORD-06/21). Washington, DC: U.S. Department of Transportation. (http://www.fra.dot.gov/downloads/Research/ord0621.pdf)

[2] Tabak & Raslear, T.G. (2010). *Procedures for Validation and Calibration of Human Fatigue Models: The Fatigue Audit InterDyne Tool* (Report No. DOT/FRA/ORD-10/14). Washington, DC: U.S. Department of Transportation (http://www.fra.dot.gov/rpd/downloads/TR_Procedures_or_Validation_and_Calibration_final.pdf).

new biomathematical fatigue model may be validated and calibrated. Additionally, the T.G. Raslear report "Criteria and Procedures for Validating Biomathematical Models of Human Performance and Fatigue; Procedures for Analysis of Work Schedules"[3] provides detailed instruction regarding the processes involved in validating and calibrating a new model of fatigue. Once validated and calibrated using this methodology, the model can be sent to FRA for approval to use in lieu of or in addition to the currently approved biomathematical fatigue models.

2.3 Requirements

Covered railroads must use a validated and calibrated biomathematical model of fatigue to model all schedules that fall outside the categorical Type I scheduled assignment hours of 4 a.m. to 8 p.m. (scheduled assignments outside these hours are generally referred to as Type II assignments). The only exception is an assignment that is nested completely within a previously modeled schedule; such assignments are not required to be modeled. For example, if a 9 p.m. to 6 a.m. schedule is modeled a 10 p.m. to 6 a.m. schedule does not have to be modeled, as the hours fall entirely within the previously modeled schedule.

2.4 Modeling Results

Any schedule that violates the established fatigue threshold for 20% or more of the scheduled assignment must be submitted to FRA along with a fatigue mitigation plan for that schedule. If the fatigue risk of a particular schedule can not be mitigated to an acceptable level, a declaration of the operational necessity of the schedule must also be submitted, along with the plans to mitigate fatigue in the schedule as much as possible. Schedules that violate the established fatigue threshold for less than 20% of the scheduled assignment do not have to be submitted and do not require a fatigue mitigation plan. Furthermore, Type II scheduled assignments (which are those assignments including any period of time not between the hours of 4 a.m. and 8 p.m.) that when modeled do not violate the established fatigue threshold, and whose hours do not extend into the hours between 12 a.m. (midnight) and 4 a.m. may be treated as Type I schedules. These schedules do not require fatigue mitigation and are not required to be submitted to FRA. It should be noted that any schedule that extends past 12 a.m. (midnight) must be treated as a Type II scheduled assignment regardless of the results from modeling that schedule.

3. Reporting to FRA

Railroads with only Type I scheduled assignments need only submit a letter to the Associate Administrator for Railroad Safety indicating that no analyses were required. Other covered railroads are required to submit a letter to the Associate Administrator for Railroad Safety declaring that the railroad performed required analyses using an approved biomathematical fatigue model and indicate the results of those analyses. If any of the results of a railroad's schedule analyses indicate a violation of the established fatigue threshold, railroads are also required to submit the results of their analyses, copies of affected schedules, and fatigue mitigation plans for these schedules. Schedules that violate the established fatigue threshold which are unable to be fully mitigated must also be accompanied by a statement of operational necessity.

[3] Available at http://www.regulations.gov/#!documentDetail;D=FRA-2009-0043-0003.

Employees, or labor organizations representing employees, may also submit information regarding their support or opposition to FRA regarding a railroad's fatigue mitigation plans and the operational necessity of a railroad's schedules that violate the established fatigue threshold. However, this is not required.

FRA will review submissions and notify railroads of their acceptance within 120 days of receipt. If a fatigue mitigation plan is rejected, FRA will provide a time frame for resubmitting the required information.

4. Fatigue Risk Mitigation

4.1 Defining Fatigue Risk Mitigation

A fatigue mitigation is any intervention or strategy which lessens the severity of fatigue experienced by an individual. A fatigue mitigation plan should supplement the minimum time off and maximum time on duty requirements established by the Hours of Service regulation. Since it is impossible to completely eliminate fatigue, the goal with any fatigue mitigation plan should be to maximize those factors that positively influence alertness (e.g., allowing adequate opportunities for rest) while minimizing those factors that negatively influence alertness and are associated with an increased risk for fatigue (e.g., avoid schedules that occur during circadian lows).

When discussing fatigue and fatigue risk mitigation, it is important to note that fatigue itself is not a hazard. Rather, fatigue increases the likelihood of occurrence of certain negative events. Simply stated, fatigue increases the risk of certain events occurring. Reducing fatigue reduces the fatigue-related risk. However, there are situations where reducing fatigue is not possible, or at least not practical. In these situations reducing the demands of a particular job (e.g. eliminating tasks, making tasks less demanding) is an acceptable method of reducing fatigue-related risk.

When looking at fatigue risk as a whole, it is important to look at the hazards (risks) associated with a particular job, identify those hazards that may be particularly sensitive to fatigue, and determine a fatigue risk tolerance. When looking at job tasks, a Haddon matrix can be helpful in determining risk tolerance.

	SEVERITY		
PROBABILITY	**LOW**	**MEDIUM**	**HIGH**
HIGH			
MEDIUM			
LOW			

RISK KEY	
HIGH	
MEDIUM	
LOW	

Figure 1. Haddon Risk Matrix

The Haddon risk matrix, as shown in figure one, provides a visual representation of risks. As shown in the matrix, when the probability of a fatigue-related incident is low and severity is low

the risk is also low. Conversely, when probability of a fatigue-related incident is high and severity is high the risk is also high. Using a risk matrix, a railroad can determine its risk tolerance, identify those tasks that exceed that risk tolerance, and take steps to mitigate those risks that exceed the established risk tolerance.

For example, an analysis of a scheduled assignment might reveal 20 hazards. Of those hazards, the railroad may indentify 5 which are above its risk tolerance. The railroad can then focus its efforts on mitigating those risks which are above the established fatigue risk tolerance.

4.1.2 Understanding the Established Fatigue Threshold

For the purposes of the regulation, threshold values for two biomathematical models (i.e., FAST, FAID) have been established, as discussed above. When a scheduled assignment violates one of these values, a fatigue mitigation plan is required. A scheduled assignment is considered to be fully mitigated if the scheduled assignment no longer violates the established fatigue threshold when the mitigation interventions or strategies are applied. A scheduled assignment is considered to be partially mitigated if the scheduled assignment still violates the established fatigue threshold after the application of the selected mitigation interventions or strategies.

It should be noted that there is still a risk for fatigue in a scheduled assignment that no longer violates the established fatigue threshold. Also of note, there are many qualitative fatigue mitigation strategies, such as education about fatigue, non-punitive mark off policies, and avoidance of fatigue-sensitive tasks that may reduce fatigue risk. However, because these strategies are qualitative in nature, they most likely will not result in a change in the fatigue value produced by a biomathematical model when that scheduled assignment (or assignments) is analyzed. This by no means indicates that qualitative mitigation strategies should not be pursued nor does it indicate that these qualitative strategies are less effective than quantitative strategies. Fatigue mitigation should not be thought of as an attempt to achieve a certain score but rather as a tool to reduce fatigue and improve safety. Fatigue is an issue that affects all employees and as such, ways to reduce fatigue for all employees should be sought.

4.2 Developing a Plan

As previously stated, a fatigue mitigation plan provides additional protection from fatigue beyond the minimum off duty and maximum on duty requirements established by the Hours of Service regulation (which must also be complied with, in addition to any established fatigue mitigation plans). Fatigue mitigation plans will vary from organization to organization and may even vary from job to job or even schedule to schedule. Management and labor must work together to identify system risks, and then develop strategies to reduce those risks. A successful fatigue mitigation plan is one that looks at all of the elements that contribute to fatigue, and all possible solutions, and selects those strategies that will work best. Even if two railroads operate identical schedules, the mitigation solution that will work best will vary from railroad to railroad, given the constraints of railroad size, staffing requirements, economic concerns, the number of affected schedules, and the operational necessity of schedules.

To assist in the development of fatigue mitigation plans, a task force of the RSAC working group that assisted FRA in the development of the regulation created a “toolbox” of suggested methods

of mitigating fatigue[4]. This toolbox includes information on various fatigue mitigation strategies that a railroad may choose to employ. The toolbox is by no means exhaustive and does not constitute a list of the only acceptable fatigue mitigation strategies and methods.

4.3 Role of Employees and Labor Organizations

When a railroad is creating a fatigue mitigation plan, the affected employees and/or associated labor organizations should be included in the process. This is required by the regulation, but is, even more importantly, essential to the development of the most effective fatigue mitigation policies and strategies. Management and labor should work together to identify areas of concern and discuss potential solutions. Ideally, this should lead to a fatigue mitigation plan that has achieved consensus from both management and labor. Although consensus may not be reached, railroads should still put forth their best effort to develop a fatigue mitigation plan that is sensitive to the concerns of employees.

Employees and associated labor organizations also have the opportunity to contact FRA to convey their support or opposition regarding the railroads' schedules, fatigue mitigation plans, and statements of the operational necessity of those assignments where full fatigue mitigation is not possible.

4.3 Fatigue Education

Railroads are required to provide their train employees engaged in commuter or intercity rail passenger transportation with initial fatigue awareness training, and to provide refresher fatigue awareness training every three (3) years thereafter. Some railroads may use fatigue education as part of their fatigue mitigation plans. Fatigue education is a requirement for all employees, however, not just those currently working schedules that require a fatigue mitigation plan. Having a fatigue education plan in place does not eliminate the requirement for the development and submission of fatigue mitigation plans for specific schedules for which they may be required – even when education is deemed to be a vital component of that plan.

5. Examples for Reporting to FRA

There are several possible scenarios regarding scheduling, the results of fatigue modeling, and fatigue mitigation. It is possible for a combination of scenarios to apply to a given railroad. Below is a list of possible scenarios and reporting requirements for those scenarios. These samples are provided as examples only; reports to FRA are not required to be made in this format. Schedules that do not violate the fatigue threshold are not required to be submitted, though doing so will assist FRA in minimizing the burden of modeling schedules in the future.

5.1 Type I Schedules Only

Schedules: Type I (Start 4 a.m. or Later and End 8 p.m. or Earlier)
Model results: No modeling required
Reporting requirements: If all schedules are Type I, notice should be sent to the Federal Railroad Administration's Associate Administrator for Railroad Safety indicating that all schedules are Type I schedules.

[4] Available at http://www.regulations.gov/#!documentDetail;D=FRA-2009-0043-0002.

Example text: I certify that all schedules for Railroad X are Type I scheduled assignments falling within the hours of 4 a.m. and 8 p.m.

5.2 Type II Schedules that may be Treated as Type I

Schedules: Start 4 a.m. or Later

End after 8 p.m. but before 12 a.m. (midnight)

Modeling results: Schedule does not violate fatigue threshold

Reporting requirements: Notice sent to FRA indicating that schedule extends past 8 p.m. but not past 12 a.m. and does not violate established fatigue threshold.

Example text: Railroad X has (number) schedules that begin no earlier than 4 a.m. and extend past 8 p.m. but not past 12 a.m. These schedules have been modeled using an approved biomathematical fatigue model and do not violate the established fatigue threshold. Therefore, in accordance with 49 CFR part 228, these schedules will be treated as Type I scheduled assignments. A list of these schedules and modeling results has been provided.

5.3 Type II Schedules that do not Violate the Established Fatigue Threshold

Schedules: Type II scheduled assignments extending past 12 a.m.

Modeling result: Schedule does not violate fatigue threshold.

Reporting requirements: Notice sent to FRA indicating that schedules are Type II scheduled assignments but do not violate the established fatigue model threshold.

Example text: Railroad X has (number) Type II scheduled assignments. These schedules have been modeled and do not violate the established fatigue threshold. A list of these schedules and modeling results has been provided.

5.4 Type II Schedules that Violate the Established Fatigue Threshold and are Fully Mitigated

Schedules: Type II scheduled assignments

Modeling results: Schedule violates established fatigue threshold

Reporting requirements: Notice sent to FRA indicating that schedules are Type II scheduled assignments and violate the established fatigue model threshold. A copy of the affected schedules, results of the model analysis, and a Fatigue Mitigation Plan (FMP) for these schedules must also be provided.

Example text: Railroad X has (number) Type II scheduled assignments that when modeled violated the established fatigue threshold. Therefore, in accordance with 49 CFR part 228, a fatigue mitigation plan (FMP) has been developed and is included. Fatigue was able to be fully mitigated in these schedules by following this FMP. The FMP was developed with input from affected employees and associated labor organizations. A list of the schedules and modeling results before and after these mitigations were applied has been included.

5.5 Type II Schedules that Violate the Established Fatigue Threshold and are Partially Mitigated

Schedules: Type II scheduled assignments

Modeling results: Schedule violates established fatigue threshold

Reporting requirements: Notice sent to FRA indicating that schedules are Type II scheduled assignments and violate the established fatigue model threshold. A copy of the affected schedules, results of the model analysis, and FMP for these schedules must also be provided.

Example text for some measurable reduction: Railroad X has (number) Type II scheduled assignments that when modeled violate the established fatigue threshold. Therefore, in accordance with 49 CFR part 228, a fatigue mitigation plan (FMP) has been developed and is included. The FMP was developed with input from affected employees and associated labor organizations. Fatigue was not able to be fully mitigated in these schedules. By applying the mitigations outlined in the FMP, fatigue risk in these schedules was reduced from [number] to [number] but this still violates the established fatigue threshold.

Example text for no measureable reduction: Railroad X has (number) Type II scheduled assignments that when modeled violate the established fatigue threshold. Therefore, in accordance with 49 CFR part 228, a fatigue mitigation plan (FMP) has been developed and is included. The FMP was developed with input from affected employees and associated labor organizations. Fatigue was not able to be fully mitigated in these schedules. After applying the mitigations outlined in the FMP, the fatigue risk in these schedules was not able to be measurably reduced.

5.5.1 Operational Necessity

If scheduled assignments still exceed the established fatigue threshold after the execution of a FMP, a statement of operational necessity is required for those schedules. The statement of operational necessity should clearly indicate why that scheduled assignment is necessary for operations.

Example text: The attached schedules are operationally necessary for Railroad X. Without these schedules Railroad X would be unable to (insert operational necessity; e.g. meet customer service demands, accommodate the volume of passengers that use the system, maintain the system and meet scheduled daily service).

6. Fatigue Mitigation Plan Reporting

As discussed in section four above, FMPs may vary from railroad to railroad, job to job, or even schedule to schedule. Furthermore, a railroad may have some schedules that fit one example in section 5, and other schedules for which a different example will apply. It is therefore possible for one railroad to submit multiple FMPs to FRA for review. Having multiple FMPs gives a railroad the flexibility to meet the unique needs of a particular job or schedule. The prospect of having more than one FMP need not be daunting, as individual components unique to specific jobs or schedules can be included as part of a larger fatigue management plan. Some abbreviated examples are provided in the following sections for reference. These examples follow a template which railroads may choose to use for their fatigue mitigation plans, but are under no obligation to do so.

6.1 Fatigue Mitigation Plan Example One

Fatigue Mitigation Plan for Railroad X

Submitted to FRA: March 1, 2012

Affected Schedules: All schedules of Railroad X that violate the established fatigue threshold

Description of specific intervention or strategy:

Education

1. Railroad X has developed an educational awareness program for affected employees. Employees will complete three self-paced courses on fatigue, delivered via the company intranet. The first module details the importance of sleep, the second module details how fatigue can affect safety and performance in the railroad industry, and the third provides information on sleep disorders and how they impact fatigue.
    a. Additionally train and engine employees will complete a fourth module that details performance and safety consequences of fatigue that are related to their specific job duties.
2. All employees will be provided with 3x5 reminder cards that list alertness strategies. Prior to receiving the cards, covered employees will attend a 20 minute in person briefing that outlines how individuals can sometimes be poor judges of how fatigued they have become, and that individuals tend to overestimate the efficacy of alertness strategies while underestimating the effects of fatigue on their performance.

Policy

1. Railroad X has developed a fatigue reporting policy. Unscheduled employees are now permitted to mark off "fatigued" without fear of adverse consequences. The railroad has also developed a policy whereby an employee who is experiencing excessive fatigue during a shift may report this to a supervisor and be transferred to a job duty that is not safety-critical, where practical, or allowed to mark off early and not complete the employee's scheduled duty tour.

Scheduling

1. A scheduling pool system has been developed for all unscheduled extra board employees. These employees have the same 16 hours when they may be called for duty and 8 hours when they will never be called for duty.
2. Employees who typically work six consecutive days with two days off will now have the option of working three days, having one day off, and then working three additional days with one day off.

Peer to Peer

1. Railroad X has developed a peer to peer program for fatigue. One aspect of the program involves the creation of "fatigue buddies". Fatigue buddies will discuss the impact of fatigue on job performance. Additionally, they will share alertness strategies with each other, encourage each other to report for duty fully rested, and discuss events and issues that may lead to fewer opportunities for rest, or for inadequate rest.

6.2 Fatigue Mitigation Plan Example Two

Fatigue Mitigation Plan for Railroad X

Submitted to FRA: March 1, 2012

Affected Schedules: Schedules covering the hours of 11 p.m. to 8 a.m. for conductors and engineers.

Description of specific intervention or strategy: A biomathematical model of fatigue has identified the greatest fatigue risk to be between the hours of midnight and 3 a.m. Railroad X has identified, with collaboration from affected employees, tasks that are particularly sensitive to fatigue. These tasks pose an increased risk of fatigue-related performance impairment. In an effort to reduce these risks, the tasks listed below will be avoided between the hours of midnight and 3 a.m.

The fatigue sensitive tasks that will be avoided between the hours of midnight and 3 a.m. are:

1. Example task 1
2. Example task 2
3. Example task 3

6.3 Fatigue Mitigation Plan Example Three

Fatigue Mitigation Plan for Railroad X

Submitted to FRA: March 1, 2012

Affected Schedules: Schedules covering the hours of 9 p.m. to 7 a.m. for yard jobs.

Description of specific intervention or strategy: Affected employees will now work a three days on duty one day off duty schedule rather than the previous six days on duty two days off duty schedule. Fatigue was able to be fully mitigated using this 3-1 scheduling.