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Report to Congressional Requesters

September 2011

FREIGHT RAILROAD SAFETY

Hours of Service Changes Have Increased Rest Time, but More Can Be Done to Address Fatigue Risks

GAO-11-853

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GAO Accountability * Integrity * Reliability

Highlights

Highlights of GAO-11-853, a report to congressional requesters

Why GAO Did This Study

The Rail Safety Improvement Act of 2008 (RSIA) overhauled requirements for how much time certain freight railroad workers can spend on the job (called "hours of service"). Changes included limiting the number of consecutive days on duty before rest is required, increasing minimum rest time from 8 to 10 hours, and requiring rest time to be undisturbed. RSIA also provided for pilot projects and waivers. RSIA's changes became effective for freight railroads in July 2009. GAO was asked to assess (1) the impact of these changes on covered train and engine (T&E) employees, including implications for fatigue, (2) the impact of the changes on the rail industry, and (3) actions the Federal Railroad Administration (FRA) has taken to oversee compliance with hours of service requirements and implement RSIA provisions for pilot projects and waivers. To perform this work, GAO analyzed covered employee work schedules and used models to assess fatigue, surveyed the railroad industry, analyzed FRA inspection and enforcement data, and interviewed federal and railroad officials as well as fatigue and sleep experts.

What GAO Recommends

FRA should, among other things, assess the fatigue risk of work performed during night hours and develop data from pilot projects and waivers to help assess fatigue issues. The Department of Transportation raised concerns about findings related to the oversight process and provided additional clarifying information. Based in part on this additional information, GAO withdrew part of a recommendation. GAO also made other clarifications in the report.

View GAO-11-853 or key components. To view the e-supplement online, click GAO-11-894SP. For more information, contact Susan Fleming at (202) 512-2834 or flemings@gao.gov.

What GAO Found

According to GAO's analysis of covered employee work schedules, RSIA's requirements led to changed work schedules, increased rest time, and reduced risk of fatigue for covered T&E employees. RSIA's consecutive work day limits and rest requirements contributed to work schedule changes and increases in rest time. Increased rest time also led to equivalent decreases in the hours that covered employees worked. Overall, GAO found, using an FRA-validated fatigue model, that the time covered employees spent working at a high risk of fatigue—a level associated with reduced alertness and an increased risk of errors and accidents—decreased by about 29 percent for employees of class I railroads (those with the largest revenues) and by about 36 percent for employees of selected class II railroads (those with smaller revenues). GAO's analysis also shows that there are further opportunities to reduce fatigue risk. Specifically, RSIA's changes did not result in material decreases in night work, yet scientific literature and GAO's analysis show night work represents a major factor in fatigue risk.

As might be expected from changes aimed at improving safety by reducing covered employee fatigue, the railroad industry reported that RSIA's hours of service changes had operational and administrative effects on it, some of which increased some railroads' one-time or ongoing costs. GAO did not determine how RSIA's changes affected railroads' earnings; but the act took effect as the economy was starting to recover from the recession that began in late 2008. Through its industry survey and interviews, GAO found that RSIA's changes affected railroad operations, including changes to crew and train schedules and increases in staffing levels. Railroad officials GAO spoke with attributed these changes to RSIA's consecutive work day limits and rest requirements, both of which acted to reduce people's availability to work. To maintain operations while complying with the law, railroad officials told GAO they, among other things, hired new employees or brought employees back from furlough. GAO estimated that adding people—120 to 500 each by some class I railroads—increased these railroads' annual costs by $11 million to $50 million. Administrative effects reported by railroads included a need for railroads to revise their hours of service timekeeping systems.

FRA uses a risk-based approach to oversee compliance with hours of service and other safety requirements, analyzing inspection and accident data to help target inspections to activities where noncompliance is associated with a greater risk of accidents. GAO's analysis of inspection and enforcement data for the years before RSIA took effect and for the following year show it is too early to determine if FRA has changed the priority it assigns to overseeing hours of service requirements or if a change in priority is warranted. FRA has not been able to implement RSIA-required pilot projects because no railroads have chosen to participate. Nor has it approved voluntary pilot projects designed to test the fatigue-reduction potential of alternatives to RSIA requirements. FRA has approved petitions for waivers of compliance with hours of service requirements for some railroads, but is not required by RSIA to collect data on the safety effects of the approved alternatives. Data from pilot projects—if implemented—and waivers could be used to improve FRA's assessment of fatigue issues.

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Freight Railroad Safety: Results of Rail Industry Survey about Hours of Service Issues (GAO-11-894SP, September 2011), an E-supplement to GAO-11-853

Abbreviations List

ASLRRA	American Short Line and Regional Railroad Association
DOT	Department of Transportation
FAID	Fatigue Audit InterDyne™
FAST	Fatigue Avoidance Scheduling Tool™
FRA	Federal Railroad Administration
NIP	National Inspection Plan
RSIA	Rail Safety Improvement Act of 2008
T&E	train and engine

GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

September 28, 2011

The Honorable John D. Rockefeller, IV
Chairman
The Honorable Kay Bailey Hutchison
Ranking Member
Committee on Commerce, Science,
and Transportation
United States Senate

The Honorable Frank R. Lautenberg
Chairman
Subcommittee on Surface Transportation
and Merchant Marine Infrastructure,
Safety, and Security
Committee on Commerce, Science,
and Transportation
United States Senate

The Honorable John Thune
United States Senate

Railroads make important contributions to the nation's economy. Currently, they account for about 40 percent of all freight carried (as measured by ton-miles[1]), and, according to the Department of Transportation (DOT), the demand for freight rail service is expected to increase 88 percent by 2035. Although railroad safety has improved in recent years—as evidenced by a nearly 40-percent decline in accidents from 2001 to 2010—accidents can have significant consequences, causing deaths, injuries, and property damage. Fatigue can be a factor in accidents, as in July 2005, when two freight trains collided head-on in Mississippi, resulting in the deaths of 4 crew members and over $9.5 million in property damages.

To improve railroad safety by reducing the potential for fatigue, laws dating as far back as 1907 have limited the amount of time that railroads may require or allow certain railroad employees to remain on duty (called

[1]A ton-mile is the transportation of 1 ton of freight 1 mile.

"hours of service") and have established minimum rest times between work shifts.[2] In October 2008, Congress passed the Rail Safety Improvement Act of 2008 (RSIA), which called for an extensive overhaul of railroad safety requirements, including hours of service requirements.[3] RSIA generally retained the maximum time train and signal employees may remain on duty (12 hours), but increased the minimum rest time between work shifts from 8 hours to 10 hours and limited the number of consecutive days that train employees may work before having to take a minimum rest period, among other requirements.[4] RSIA also required the Secretary of Transportation (the Secretary) to conduct pilot projects to analyze practices that may be used to reduce fatigue for train and engine (T&E) employees and allowed for the approval of waivers of one of the new hours of service requirements, or for other requirements as part of an approved pilot project. This authority has been delegated to the Federal Railroad Administrator (FRA).[5] The new hours of service requirements became effective for freight railroads in July 2009.

You asked us to review the safety and other impacts of the new hours of service requirements that were established in RSIA and the federal government's role in monitoring and enforcing the new rules. This report discusses the (1) impacts of the hours of service changes on the covered T&E workforce, including potential impacts on fatigue, (2) operational and administrative impacts of the hours of service changes on the railroad industry, and (3) actions taken by FRA to oversee compliance with hours of service requirements and implement RSIA provisions related to hours of service pilot projects and waivers. At the time of our work, hours of

[2]For purposes of this report, we define "shift" as a duty tour as described in 49 C.F.R. § 228.5: (1) The total of all periods of covered service and commingled service for a train employee or a signal employee occurring between two statutory off-duty periods (i.e., off-duty periods of a minimum of 8 or 10 hours); or (2) The total of all periods of covered service and commingled service for a dispatching service employee occurring in any 24-hour period.

[3]Pub. L. No. 110-432, Div. A, title I, 122 Stat. 4848 (Oct. 16, 2008).

[4]Train employees include those engaged in or connected with the movement of trains and signal employees are those that install, maintain, or repair signal systems. Dispatching service employees (those that dispatch orders relating to train movement) are also covered by hours of service laws. See 49 U.S.C. § 21101. RSIA did not increase the statutory minimum off duty period for dispatching service employees. For purposes of this report we use the terms train employees and train and engine employees interchangeably.

[5]49 C.F.R §1.49(oo).

service requirements were still being developed for train employees in the commuter and intercity passenger rail industry, which DOT issued in August 2011.[6] Consequently, this report focuses on freight railroad hours of service issues.

To address the impacts of the hours of service changes on the covered T&E workforce, including potential impacts on fatigue, we reviewed literature related to work and rest schedules and their relationship to fatigue and interviewed experts who had conducted research on fatigue and work. We then analyzed work schedule data for covered T&E employees for May 2008 and May 2010. We selected these months to represent time periods before and after RSIA's implementation and to avoid the time period during which the economic recession that began in late 2008 was causing a rapid contraction in the rail industry. We discussed the time frames for our analysis with railroad officials, and they generally agreed with our selection. Our analysis covered work schedules for T&E employees at all 7 class I railroads and 6 class II railroads that use electronic hours of service recordkeeping systems.[7] To assist in this analysis, we acquired two models that FRA has validated for use in assessing potential fatigue levels of covered railroad workers—the

[6]RSIA also maintained the prior hours of service requirements for the passenger rail industry for three years from the date of its enactment or until the effective date of new regulations covering the industry. The Secretary of Transportation was authorized to develop hours of service requirements for train employees engaged in the commuter and intercity passenger rail industry that differed from the freight railroad requirements. If these requirements were not in effect by October 2011, then RSIA provided that the freight railroad requirements would apply to these train employees at that time. FRA issued a Notice of Proposed Rulemaking on these requirements in March 2011. 76 Fed. Reg. 16200 (Mar. 22, 2011). The final rule was issued in August 2011, to be effective October 15, 2011. 76 Fed. Reg. 50360 (Aug. 12, 2011).

[7]For economic regulatory purposes, the Surface Transportation Board (STB) divides the railroad industry into three classes based primarily on annual operating revenues. For 2009, this revenue threshold was at least $378.8 million for class I, at least $30.3 million for class II, and less than $30.3 million for class III. For accident and incident reporting, FRA divides the railroad industry into three groups based on the total work hours reported annually. Group 1 railroads are the same as class I railroads. Group 2 railroads report 400,000 total work hours or more annually but are not class I railroads, and group 3 railroads report less than 400,000 total work hours. According to FRA officials, groups 2 and 3 are roughly equivalent to class II and III railroads. In this report, we generally refer to railroads by class rather than by group—even though our selection of railroads for work schedule and survey purposes was based on FRA's groups, not classes—since class is a more common identifier. The six class II railroads were Belt Railway of Chicago, Consolidated Rail Corporation, Indiana Harbor Belt Railroad, Paducah & Louisville Railroad, Port Terminal Railroad, and Wheeling & Lake Erie Railroad.

Fatigue Audit InterDyne™ (FAID) model and the Fatigue Avoidance Scheduling Tool™ (FAST). To help analyze RSIA's effects on the covered workforce at class III railroads, we conducted focused interviews with 69 class III railroads. To address the operational and administrative impacts of RSIA's hours of service changes on the railroad industry, we surveyed all class I and class II railroads and 232 class III railroads. We received responses from all 7 class I railroads, 14 of 15 class II railroads, and 163 of 232 class III railroads, for an overall response rate of 72 percent. We also interviewed federal, railroad, and railroad trade association officials, as well as rail labor representatives. Unless otherwise specified, all statistics or coefficient estimates mentioned throughout this report are significantly different from zero with probability of error less than 0.05.[8] To address actions taken by FRA to oversee hours of service compliance and to implement RSIA provisions related to pilot projects and waivers, we reviewed legislation, regulations, and policy documents and analyzed FRA data on hours of service inspection and enforcement actions. We also reviewed information on FRA's actions to implement pilot projects related to hours of service issues and analyzed data on petitions for waivers of hours of service requirements and their status. Finally, we discussed inspection and enforcement issues with officials in FRA headquarters and regional offices, and with railroad officials from class I, II, and III railroads. (For more information on our objectives, scope, and methodology, see app. I, and for the results of our railroad industry survey, see GAO-11-894SP.)

We conducted this performance audit from April 2010 to September 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Freight railroads are an important component of the nation's transportation system, operating over 700 million train-miles in 2010.[9] The freight railroad industry is primarily composed of 7 large railroads (called

[8]This is the same as a p-value < 0.05.

[9]A train-mile is the movement of a train a distance of 1 mile.

class I railroads) and about 570 smaller class II and III railroads. Within the industry, class I railroads predominate, representing about 93 percent of total freight revenue and about 68 percent of total rail mileage operated in the United States in 2009. Class II and III railroads include regional and short line railroads. Regional railroads typically operate 400 to 650 miles of track spanning several states, while short line railroads typically perform point-to-point service over short distances. According to the American Short Line and Regional Railroad Association (ASLRRA), the average length of short line service is 90 miles, and over 58 percent of short line carriers connect with more than 1 class I railroad. As the association points out, short line railroads generally operate the first mile and last mile of U.S. freight rail commerce.

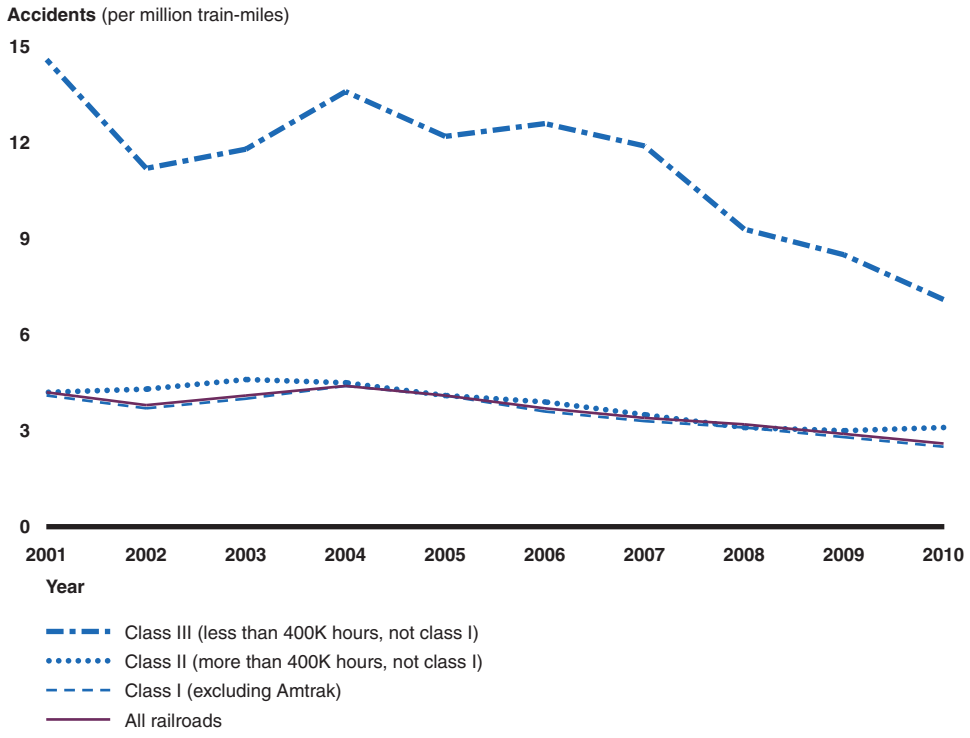
Because railroads operate across millions of train-miles every year, safety is an important concern. In general, railroad safety has improved over the last 10 years. For example, the approximately 1,800 freight train accidents reported to FRA in 2010 represents a decrease of nearly 40 percent from the approximately 3,000 train accidents reported in 2001.[10] Similarly, the number of accidents per million train-miles for all railroads reported to FRA decreased to 2.6 in 2010 from 4.2 in 2001 (see fig. 1). Yet this decline is not equal for railroads of all sizes: In 2010, the rate reported for class III railroads, 7.1 accidents per million train-miles, was more than twice the rate reported for all railroads. FRA attributed the difference in accident rates to differences in operations between larger railroads (which generally operate over longer distances and perform little switching) and smaller ones (which generally operate over shorter distances and perform frequent switching).[11] Because RSIA was passed by Congress in late 2008, FRA officials told us it is too early to tell what effect, if any, requirements contained in the law may have had on railroad

[10]A train accident is any collision, derailment, fire, explosion, act of God, or other event involving operation of railroad on-track equipment (standing or moving) that results in damages greater than the current reporting threshold to railroad on-track equipment, signals, track, track structures, and roadbed. The reporting threshold for calendar year 2011 is $9,400.

[11]Switching is a railway service that is performed under yard rules and regulations and involves, among other things, changing the position of railcars for purposes of loading, unloading, or weighing.

accident rates. They said it may well take years to identify any particular effects.[12]

Figure 1: Train Accidents per Million Train-miles, by Class of Railroad, 2001–2010



Source: GAO analysis of FRA data.

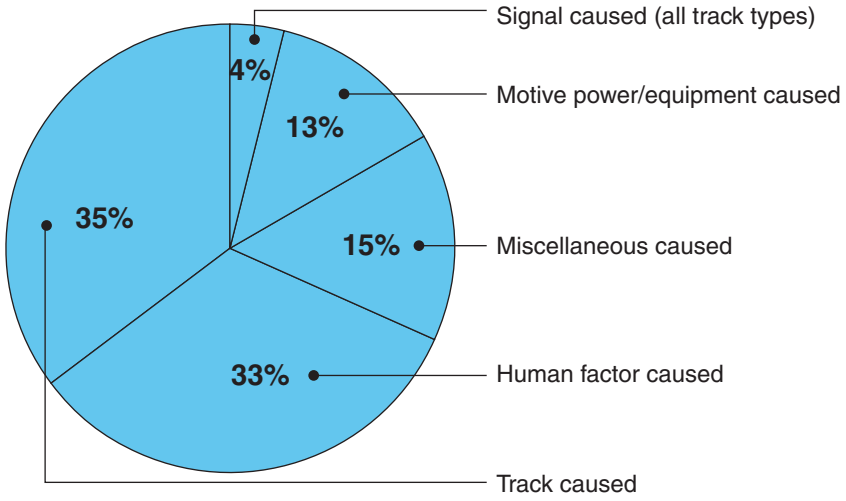
Note: For this analysis, we used FRA's division of the railroad industry based on total annual work hours instead of total annual operating revenues. Class I railroads are the same under both divisions. Class II railroads report 400,000 total annual work hours or more but are not class I railroads, and class III railroads report less than 400,000 total annual work hours.

Train accidents can be caused by a variety of factors. In 2010, human factors—which include such things as failure to use brakes, impairment of an employee's physical condition, and failure to comply with signals—was second only to track (e.g., broken or worn rail) as the primary cause of

[12]In this report, we do not attempt to draw any correlations between safety outcomes (such as changes in accident rates) and changes to hours of service requirements contained in RSIA.

accidents (see fig. 2).[13] As for train accidents overall, the rate for accidents caused by human factors has generally decreased over the last 10 years, and again, the rate is higher for class III railroads than for either class I or class II railroads (see fig. 3). Although there is a general downward trend, FRA attributed the decrease since 2008 to changes it made that year to certain safety regulations to increase railroads' accountability for implementing and complying with sound operating procedures.[14] For example, as of January 1, 2009, every railroad was to have a written program of operational tests and inspections in effect, and the programs were to emphasize those operating rules that cause or are likely to cause the most accidents and incidents.

Figure 2: Major Causes of Train Accidents, 2010

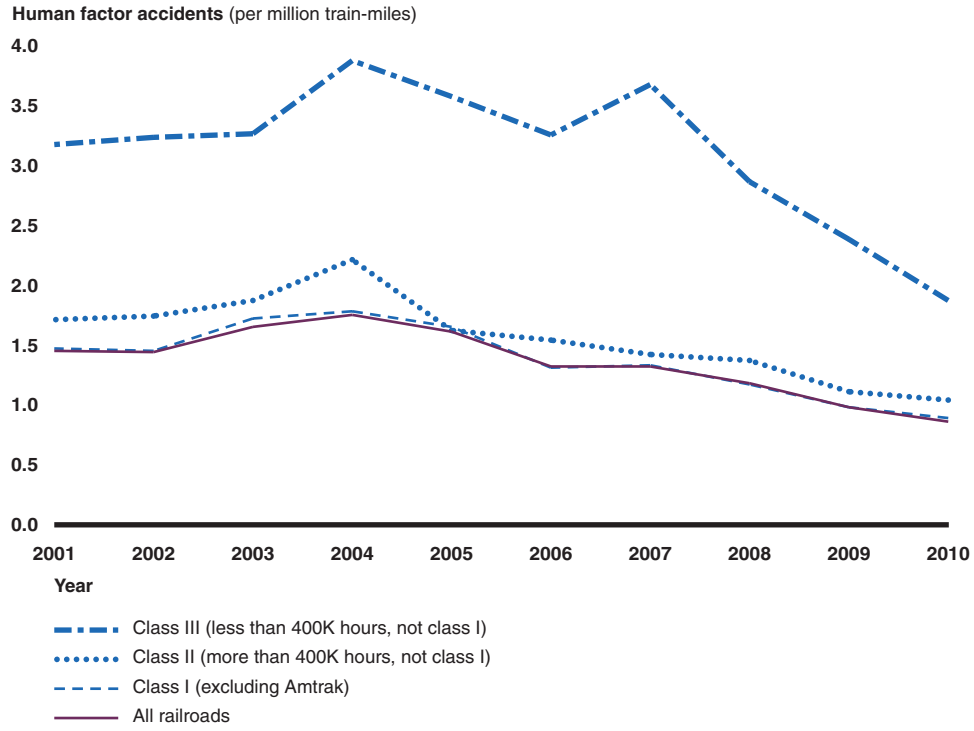


Source: GAO analysis of FRA data.

[13]The third leading cause of train accidents was a category titled "miscellaneous causes." Miscellaneous causes can include such things as environmental conditions (e.g., snow, ice, and dense fog), loading procedures, and highway-rail grade crossing accidents. According to FRA, crossing accidents are analyzed as a separate category and excluded from FRA analyses of train accidents, and usually involve motorist error.

[14]These changes included revisions to 49 C.F.R. § 217.9 and the addition of 49 C.F.R. Part 218, Subpart F.

Figure 3: Human-Factor-Caused Train Accidents per Million Train-miles, by Class of Railroad, 2001–2010



Source: GAO analysis of FRA data.

Note: For this analysis, we used FRA's division of the railroad industry based on total annual work hours instead of STB's division based primarily total annual operating revenues. Class I railroads are the same under both divisions. Class II railroads report 400,000 total annual work hours or more but are not class I railroads, and class III railroads report less than 400,000 total annual work hours.

Beginning with the Hours of Service Act of 1907, hours of service requirements for certain railroads have been governed by statute.[15] The 1907 act limited the work shifts of employees involved in train movement to 16 hours. Amendments to this law in 1969 reduced the maximum time

[15]Pub. L. No. 59-274, 34 Stat. 1415 (Mar. 4, 1907). The original law covered both train employees and dispatching service employees, with respect to common carriers by railroad engaged in interstate or foreign commerce. Although RSIA establishes the maximum number of on-duty hours and minimum rest periods for covered employees, it authorized the Secretary of Transportation to issue regulations to reduce the maximum number of hours an employee may be required or allowed to go or remain on duty or to increase the minimum number of hours an employee may be required or allowed to rest, as well as other regulations to improve safety and reduce employee fatigue.

on duty for train employees from 16 to 14 hours effective immediately, with a further reduction to 12 hours automatically taking effect 2 years later.[16] Amendments in 1976 established hours of service requirements for signal employees.[17] RSIA represented an extensive overhaul of the hours of service law for train employees. Among other things, it limited the number of consecutive days on duty without a required rest period, increased minimum rest periods, required those rest periods to be undisturbed, and placed limitations (caps) on the cumulative total work hours each month (see table 1). RSIA however, allows for the Secretary to waive, under certain conditions, compliance with one provision of the hours of service requirements, namely the consecutive day work limits.[18] RSIA also required the Secretary to conduct two pilot projects no later than October 2010 to analyze specific practices which may be used to reduce fatigue. Finally, RSIA authorized railroads and nonprofit employee labor organizations representing covered service employees to jointly petition the Secretary for approval to establish a pilot project to demonstrate potential benefits of implementing alternatives to strict application of these requirements.[19] As shown in the table, RSIA did not include any specific rules for nighttime operations. In addition to strengthening hours of service requirements, RSIA required the Secretary to develop a long-term strategy for improving railroad safety to cover a period of not less than 5 years, certain railroads to develop and submit to the Secretary plans to implement positive train control[20] by December 2015, and certain railroads to develop safety risk reduction programs, including a fatigue management program. In addition, under RSIA, the Secretary is to promulgate rules on a variety of safety issues. These responsibilities have been delegated to FRA.

[16]Pub. L. No. 91-169, 83 Stat. 463 (Dec. 26, 1969).

[17]Pub. L. No. 94-348 § 4, 90 Stat. 817, 819 (July 8, 1976). RSIA further extended the coverage of hours of service requirements to certain contract and subcontract signal employees. Pub. L. No. 110-432, Div. A., § 108(a).

[18]49 U.S.C. § 21103(a)(4).

[19]The request for the approval of a pilot program also includes a request for a wavier of compliance with hours of service requirements 49 U.S.C. § 21108(b).

[20]Positive train control is a communications-based train control system designed to prevent certain types of train accidents. For more information about this topic, see GAO, *Rail Safety: Federal Railroad Administration Should Report on Risks to the Successful Implementation of Mandated Safety Technology,* GAO-11-133 (Washington, D.C.: Dec. 15, 2010).

Table 1: Selected Hours of Service Requirements for Freight Railroad Train Employees

Description	Pre-RSIA requirement	Post-RSIA requirement
Limitations on time on duty in a single tour	12 consecutive hours of time on duty or 12 nonconsecutive hours on duty if broken by an interim release of at least 4 consecutive hours, in a 24-hour period that begins at the beginning of the duty tour.	12 consecutive hours of time on duty or 12 nonconsecutive hours on duty if broken by an interim release of at least 4 consecutive hours uninterrupted by communication from the railroad likely to disturb rest, in a 24-hour period that begins at the beginning of the duty tour.
Limitations on consecutive duty tours	n/a	May not be on duty as a train employee after initiating an on-duty period on 6 consecutive days without 48 consecutive hours off duty free from any service for any rail carrier at the employee's home terminal.[b] Employees are permitted to initiate a 7th consecutive day when the employee ends the 6th consecutive day at the away-from-home terminal,[b] as part of a pilot project, or as part of a grandfathered collectively bargained arrangement.
Contact during rest time	Railroads permitted to communicate with covered employees during rest time though some communications may be considered service for the railroad.	A railroad may not communicate with covered employees during the statutory minimum off-duty period of 10 consecutive hours, except in cases of emergency. If an employee's rest is disturbed, then the statutory minimum off-duty period begins again from the point of interruption.
Cumulative limits on time on duty (including commingled service)[a]	n/a	Limited to 276 hours of time on duty, in deadhead transportation to a point of final release,[c] or any other mandatory activity for the railroad carrier during a calendar month.
Mandatory off-duty periods	8 consecutive hours (10 consecutive hours if time on duty reaches 12 consecutive hours).	10 consecutive hours of time off duty free from communication from the railroad likely to disturb rest, with additional time off duty if on-duty time plus time in or awaiting deadhead transportation to final release exceeds 12 hours; 48 consecutive hours off duty, free from any service for any railroad carrier, after initiating an on-duty period for 6 consecutive days. Covered employees may initiate a 7th consecutive day of service if the end of a 6th day of service was at an away-from-home terminal[b] as part of a pilot project, or as part of a grandfathered collectively bargained arrangement. If 7 consecutive days are permitted, mandatory off-duty period extended to 72 consecutive hours.

Description	Pre-RSIA requirement	Post-RSIA requirement
Cumulative limits on time on duty (limbo)[c]	n/a	An employee may not spend more than 30 hours per calendar month on duty and waiting for or in deadhead[c] transportation to a point of final release after reaching 12 consecutive hours of time on duty and waiting for or being in deadhead transportation to a point of final release.
Special rules for nighttime operations	n/a	n/a

Source: GAO analysis of RSIA and FRA documents.

Note: N/A means not applicable.

[a]Commingled service for T&E and signal employees is any noncovered service performed at the behest of the railroad and for the railroad that is not separated from covered service by a qualifying statutory off-duty period of 8 or 10 hours or more. For dispatchers, it is any noncovered service mandated by the railroad and performed for the railroad within any 24-hour period containing covered service. Commingled service is counted as time on duty.

[b]Home terminal is the term for the geographic area containing the point where the employee generally reports for duty. An away-from-home terminal is a term for a geographic area where an employee ends a shift, other than a home terminal, and takes his or her statutory minimum off-duty period before continuing on to either a home or an away-from-home terminal on their next shift.

[c]Limbo time means a period of time treated as neither time on duty nor time off duty, and any other period of service for the railroad that does not qualify as either covered service or commingled service. Deadheading is the physical relocation of a train employee from one point to another as a result of a railroad-issued verbal or written directive. Time spent in deadhead transportation from a duty assignment to the point of final release is limbo time. The limitation on limbo time was initially 40 hours per employee per month from July 16, 2009, until October 15, 2009, with that number decreasing to 30 hours per employee per month beginning October 16, 2009, except in certain situations.

Individual railroads are primarily responsible for their own safe operation. However, FRA is the primary federal agency responsible for formulating railroad safety policies and regulations and for monitoring and enforcing railroads' compliance with hours of service and other requirements. FRA has issued statutory interpretations related to covered freight railroad employees' duty and rest time, as well as regulations governing hours of service recordkeeping. FRA has also adopted what it views as a data-driven, risk-based approach to monitoring and enforcement.[21] Under the National Rail Safety Action plan, implemented between 2005 and 2008, FRA used accident, incident, and other safety data to establish a

[21]We previously reported on FRA's safety oversight approach in January 2007. See *Rail Safety: The Federal Railroad Administration Is Taking Steps to Better Target Its Oversight, but Assessment of Results Is Needed to Determine Impact*, GAO-07-149 (Washington, D.C.: Jan. 26, 2007).

framework to direct its regulatory and compliance efforts at the highest priority risks.[22] The plan outlines a number of initiatives aimed at reducing the main types of train accidents, including those caused by human factors or track defects. One of these initiatives, the National Inspection Plan (NIP), uses accident and inspection data[23] to focus inspections on areas that, according to the data, are likely to have safety problems before a serious accident occurs. The NIP provides guidance to each of FRA's eight regional offices on how its inspection resources should be allocated. Additionally, the Office of Railroad Safety issues the National Safety Program Plan, which provides a means of planning special-emphasis activities, such as inspection activities and initiatives that cross regional boundaries and are directed at issues of concern for railroads operating in multiple regions.

To provide oversight, FRA conducts periodic inspections and takes enforcement action.

- FRA inspections address five areas, called disciplines—operating practices, track, hazardous materials, signal and train control, and motive power and equipment (such as locomotives and freight rail cars). Each inspection discipline includes a number of activities related to specific requirements. For example, inspectors in the operating practices discipline—who perform about 80 percent of hours of service inspections—assess railroads' compliance with hours of service requirements for train and dispatching service employees.[24] Typically, inspections are conducted at railroads' operating sites. For example, inspections of hours of service recordkeeping and inspections for compliance with hours of service limitations take place at duty stations or facilities where records are maintained.

[22]FRA launched the National Rail Safety Action plan in May 2005 because, although the annual number of train accidents had been declining since 1995, the rate of accidents had not shown substantive improvement and serious train accidents were continuing to occur.

[23]Other key agency plans focused efforts on the highest priority risks related to train accidents including the department's rulemaking agenda, strategic plan and annual performance plan, and FRA's performance budget.

[24]FRA inspectors conduct two types of inspections related to hours of service—an hours of service inspection to determine if covered employees' work hours fall within RSIA's maximum time on duty and minimum time off duty limits and an hours of service recordkeeping inspection to assess railroads' compliance with applicable FRA recordkeeping regulations.

- To take enforcement action, FRA inspectors may cite violations and recommend assessment of civil penalties.[25] FRA's enforcement policy, which is designed to concentrate enforcement efforts on the areas with the greatest potential safety benefits, specifies that before assessing penalties, inspectors should consider the seriousness of the condition or act, the potential safety hazards, and the current level of compliance of the railroad, among other things. FRA has statutory authority to assess civil penalties in the range of $650 (minimum) to $25,000 (ordinary maximum) for ordinary violations of its regulations. FRA may assess a penalty at the statutory aggravated maximum penalty of $100,000 "when a grossly negligent violation or a pattern of repeated violations has caused an imminent hazard of death or injury to individuals, or has caused death or injury."[26]

In addition to these activities, FRA conducts other types of safety oversight aimed at reducing train accidents, such as monitoring railroad safety data, investigating accidents, and reviewing and investigating complaints, as well as providing training for small railroads. Furthermore, FRA funds research and development to support its safety oversight, by, for example, assisting in the development of new regulations and revision of existing regulations. FRA also has authority to review and approve petitions for waivers of compliance with safety requirements, including exemptions from the hours of service laws for railroads with 15 or fewer covered service employees and waivers of one requirement of the hours of service law, the consecutive day work limits.[27] Finally, FRA is authorized to approve pilot projects that may be conducted to demonstrate the potential safety benefits of alternatives to current safety requirements.

As of July 2011, FRA had 592 rail safety positions, including about 400 inspectors. In addition, about 170 state inspectors work with FRA as part of the State Rail Safety Participation Program.[28] As of 2009, the railroad

[25]Civil penalties are FRA's primary enforcement tool, though the agency may also seek to impose criminal penalties if warranted.

[26]49 U.S.C. § 21303(a)(2).

[27]49 U.S.C. §§ 21102(b), 21103(a)(4).

[28]The Rail Safety Act of 1970 (Pub. L. No. 91-458, title II, 84 Stat. 971 (Oct. 16, 1970)) authorized the states to work with the FRA to enforce federal railroad safety regulations. Currently, the program includes inspectors from 30 states.

industry had about 170,000 employees, 140,000 miles of track in operation, and over 1.3 million freight rail cars. Overall, FRA inspects about 0.2 percent of railroad operations each year. Its goal is to inspect all railroads at least once a year, but it does not always assess a railroad's compliance with all activities related to the requirements in each discipline during each inspection.

When the major hours of service changes in RSIA took effect in July 2009, the nation was in the midst of a serious economic recession, and the railroad industry was experiencing decreases in revenues, traffic, and staffing levels. For example, operating revenues for class I railroads decreased from $61.2 billion in 2008 to $47.8 billion in 2009 before recovering to $58.4 billion in 2010.[29] Revenue ton-miles[30] for class I railroads followed a similar pattern, decreasing from 1.8 billion in 2008 to 1.5 billion in 2009 before increasing to 1.7 billion in 2010. In addition, the number of class I railroad T&E employees decreased from about 65,000 in December 2008 to just under 57,000 in December 2009 before increasing again to about 62,000 in December 2010.

[29]Dollar amounts have not been adjusted for inflation.

[30]A revenue ton-mile is 1 ton of revenue freight transported 1 mile.

RSIA's Requirements Increased Rest Time and Decreased Fatigue Risk While Leaving Opportunities for Further Reductions in Fatigue Risk from Night Work

New Hours of Service Requirements Have Led to Changes in Covered T&E Employees' Work Schedules and Increased Rest Opportunity While Decreasing Hours Worked

RSIA's new hours of service requirements have led to changes in covered T&E employees' work schedules. Both the limits on consecutive work days without required rest (referred to hereafter as consecutive work day limits) and the new requirements for rest, including the requirements for increasing the minimum rest at the end of a shift from 8 to 10 hours, and for this rest to occur during the 24 hours before the start of a new shift and be undisturbed (referred to hereafter as the increased rest requirements) have contributed to the schedule changes. Factors other than RSIA, such as the economic recession, could have played a role in these changes. We attempted to mitigate for the effects of the economic conditions by avoiding choosing months during which the demand for rail service was rapidly declining and we also only analyzed employees that worked in both May 2008 and May 2010 under the assumption that these employees would likely be performing similar work.

Class I and II railroad officials we spoke with said RSIA's consecutive work day limits have led some railroads generally to substitute a schedule with 5 consecutive work days followed by 48 hours of rest, known as a "5 by 2" schedule, for the previously more common schedule with 6 consecutive work days followed by 24 hours of rest, known as a "6 by 1" schedule. Now, use of the 6 by 1 schedule requires an FRA-approved waiver of compliance with hours of service requirements.[31] For affected employees, this schedule change means that during the course of a 7-day period, a day of rest has taken the place of a day of work. RSIA's

[31]RSIA permits railroads to petition for a waiver of compliance to hours of service requirements. Further discussion of petitions for waivers of compliance can be found later in this report.

requirements for increased rest also contributed to the schedule changes. Although RSIA made 10 hours of rest mandatory, some railroad officials we spoke with said they had instituted 10-hour rest periods for covered T&E employees before RSIA took effect. However, this policy generally applied only at home terminals, not at away-from-home terminals. Railroad officials told us the work schedule changes responded to RSIA provisions and also addressed economic factors.

Our analysis of hours worked by the same class I covered T&E employees and covered T&E employees of the participating class II railroads showed a per-employee increase of about 10 hours in the time available for rest for the class I employees in May 2010 compared with May 2008 and a per-employee increase of about 17 hours for the class II employees in May 2010 compared with May 2008.[32] This increase is statistically significant.[33] The extent to which covered employees used the additional time to rest is unknown. Railroad officials told us that some employees have used the extra rest time to work a second job or to do other activities that may not involve rest. For example, an official with a class III railroad told us many of its covered T&E employees have farms that they work when they are not working on the railroad.

The increased time available for rest under RSIA also led covered T&E employees to work fewer hours. The same analysis that we used to determine the increase in available rest time showed the same per-employee decrease in hours worked in May 2010 compared with May 2008—about 10 hours for class I employees and about 17 hours for the selected class II employees—both of which are a statistically significant change. For both the class I and class II covered T&E employees included in our analysis, the total hours worked per employee decreased from 156 in May 2008 to about 146 in May 2010 for class I employees and from 169 in May 2008 to about 153 in May 2010 for class II employees. In addition, for class I covered T&E employees the total number of work shifts (which includes covered and noncovered service

[32]Hours available for rest was determined by calculating the total hours in the month of May and subtracting the total hours worked, which includes both covered and noncovered work performed by class I and class II T&E employees contained in the May 2008 and May 2010 railroad provided data.

[33]As noted above, unless otherwise specified, all statistics (or coefficient estimates) mentioned throughout this report are significantly different from zero with probability of error less than 0.05 (or p-value < 0.05).

for the railroad) per employee decreased from 18 in May 2008 to 17 in May 2010 and class II covered T&E employees saw a decrease from 19 in May 2008 to 18 in May 2010.

Still another effect of RSIA's increase in rest time may be an increase in the amount of time some covered T&E employees spent at terminals other than their home terminal. In responding to our rail industry survey, 6 out of 7 class I railroads reported an increase in the time affected employees spent at away-from-home terminals. In addition, 7 of 14 class II railroads reported that they had away-from-home operations, and of these, 4 reported an increase in the time spent away from home. For the most part, increased time spent away from home was not an issue for the 153 class III railroads that responded to this question in our survey. Of these 153 class III railroads, 10 reported an increase in time at away-from-home terminals for their covered employees. According to both class I railroad and rail labor officials we spoke with, some of the affected covered employees are not happy with the increased time away-from-home, and the officials suggested that the undisturbed rest requirement be reduced from 10 hours to 8 hours at away-from-home terminals to allow covered employees to return home sooner.

Hours of Service Changes Have Generally Reduced Fatigue Potential for Covered T&E Employees

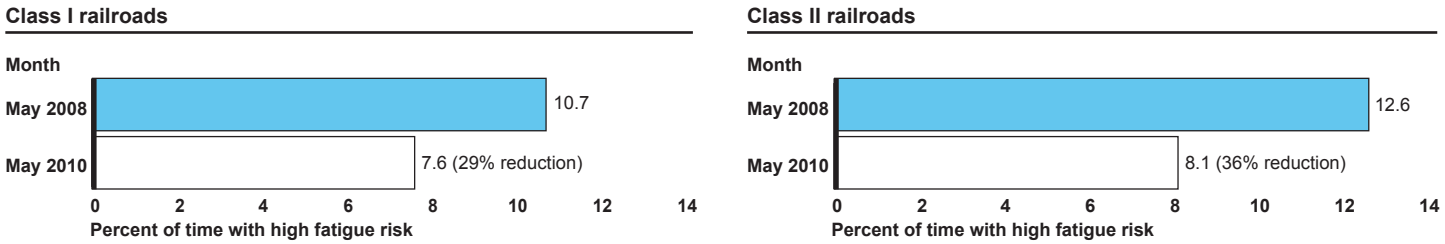
Initial indications are that RSIA's changes generally reduced the fatigue potential for covered T&E employees. According to our analysis of covered T&E employee work schedules, the potential for covered employees to work at high risk of fatigue—a level associated with reduced alertness and an increased risk of errors and accidents—decreased after RSIA took effect.[34] More specifically, our analysis of the May 2008 and May 2010 work schedules for class I and class II covered T&E employees using an FRA-validated fatigue model[35] showed that the percentage of total time worked at high risk of fatigue decreased by 29 percent (3 percentage points) for the class I employees and 36 percent (5

[34]For the purposes of our analysis, we define high risk of fatigue as a FAID score of 70 or higher. See appendix I for further discussion on the fatigue score decision.

[35]We use the term *fatigue model* to refer to the FRA-validated biomathematical model we used for our primary analysis. To analyze fatigue risk, these models incorporate a number of work-related factors, such as shift length, time of day or night when the shift occurs, and number of consecutive days at work. The models do not account for non-work-related factors like chronic illness or sleep disorders.

percentage points) for the class II employees (see fig. 4).[36] Further information on fatigue science and our use of fatigue models appears in appendix II.

Figure 4: Class I and Class II Railroad High Fatigue Risk Level Changes for Covered T&E Employees Based on Total Hours Worked, May 2008 and May 2010



Source: GAO analysis of rail workforce data.

RSIA's consecutive work day limits and requirement for 10 hours undisturbed rest time both may have contributed to the reductions in work-related fatigue indicated by our analysis.

- *Effects of consecutive work day limits on fatigue.* In its March 10, 2011, Notice of Proposed Rulemaking Regulatory Impact Analysis on commuter and intercity passenger rail hours of service requirements, FRA stated that working an increasing number of consecutive days tends to result in reduced sleep as an employee sacrifices time for sleep to attend to personal activities. This tendency would apply to both freight and passenger railroads. FRA's proposed requirements for limiting consecutive days of work for commuter and intercity passenger rail covered T&E employees are based on research from other industries that shows some evidence of increased fatigue risk over successive workdays. In FRA's view, the proposed consecutive work day limits for commuter and intercity passenger rail covered employees were reasonable and necessary because of the increased fatigue risk from working a high number of consecutive days without rest.[37] Rail labor representatives we spoke with also told us they see

[36]All fatigue modeling discussed in this section was conducted using the FAID model.

[37]FRA, *Hours of Service of Railroad Employees; Substantive Regulations for Train Employees Providing Commuter and Intercity Rail Passenger Transportation; Conforming Amendments to Recordkeeping Requirements Notice of Proposed Rulemaking, Regulatory Impact Analysis,* p. 23. Docket No. FRA-2009-0043 Notice No. 1, RIN 2130AC15 (Washington, D.C.: Mar. 10, 2011).

RSIA's consecutive work day limits as beneficial because they provide a break for employees in their work schedules.

- *Effects on fatigue of RSIA's increased rest requirements.* As noted above, the total time available for rest has increased offering more opportunity for employees to rest. In addition RSIA's requirement that rest be undisturbed may be an additional benefit for employees rest. According to rail labor representatives we spoke with, crew calls from railroads during employees' rest periods were a concern before RSIA took effect. The representatives told us that covered employees had complained to them about unnecessary contact by railroads during their rest periods and said that this contact had been disruptive to their rest. Since RSIA has taken effect, they said, such complaints have virtually ceased. It is still early in the implementation process, yet class I railroad officials and rail labor officials we spoke with said that RSIA's requirements, including longer, undisturbed rest time should contribute to a better rested workforce.

The effects of RSIA's hours of service changes on fatigue levels for class III railroads may depend on their operations. We did not analyze class III covered T&E employee work schedules, since their hours of service and employee records were largely paper-based. However, interviews with class III railroads indicated that for some class III railroads, particularly those that had scheduled daytime operations, fatigue may not have been an issue prior to RSIA. In interviews, railroad officials with 2 class III railroads said that fatigue was not an issue for their employees, because they offered service Monday through Friday during the daytime, with occasional Saturday service, depending on customer needs. Both of these railroads had FRA-approved waivers of compliance with hours of service requirements that permitted 6 by 1 work schedules, so that periodically scheduling a sixth day of service was not a concern. In addition, according to these officials, their covered T&E employees generally travel a maximum of 25 to 50 miles, and their work schedules always begin and end at the home terminal. In responding to our rail industry survey, 98 out of 153 (64 percent) of the class III railroads responded that they had changed crew schedules as a direct result of RSIA. This change in crew schedules may indicate previous crew schedules were not compliant with RSIA provisions and changes to the schedules could have improved fatigue. Again, any improvements would likely be due in part to RSIA's consecutive work day limits and increased rest requirements.

Opportunities Remain to Address Fatigue Risks from Night Work

Fatigue science has shown that the risk of fatigue is greater for nighttime work than for daytime work. For example, research on human circadian rhythms (the natural wake and sleep patterns of the human body) has shown that people by nature get tired at night and are more likely to have higher quality, more restorative sleep at night than they are during the day. Working at night can upset these circadian rhythms and result in sleep disruption and potential health problems.[38] Fatigue research has also shown that fatigue increases, or alertness and performance decrease, during night work and that fatigue risk is substantially greater for successive night shifts than for successive day shifts.[39]

Eliminating nighttime work in the freight railroad industry would not be practicable, and RSIA's requirements had little effect on the amount of time covered T&E employees work at night. According to our analysis of the May 2008 and May 2010 work schedules for covered class I and class II T&E employees, the number of per-employee work hours that occurred at night for these employees decreased 4 hours per employee for class I employees and 2 hours for class II employees after RSIA took effect.[40] In general, the freight railroad industry operates every day of the year, 24 hours a day. FRA noted in its Regulatory Impact Analysis for the proposed commuter and intercity passenger rail hours of service rules, that unlike freight service passenger service may be less affected by night work fatigue factors because most scheduled commuter and intercity passenger rail service does not operate during night hours. Additionally, our analysis of the work schedules for these 2 months showed little change in the percentage of covered class I T&E employees whose schedules involved night work—47 percent in May 2008 and 45 percent in May 2010. For the covered class II T&E employees, that percentage was the same in both months—34 percent.

[38]For the purpose of our analysis, we defined night work as work performed between the hours of 11 p.m. and 6 a.m.

[39]Simon Folkard and Torbjorn Åkerstedt, *Trends in the Risk of Accidents and Injuries and Their Implications for Models of Fatigue and Performance*, Aviation, Space and Environmental Medicine, March 2004, Vol. 75, No.3, Section II, p. A163 and p. A165.

[40]We did not analyze work schedules for class III railroads because, as noted, most were paper-based. As a result, we were unable to conduct a similar analysis of night work and fatigue risk for class III covered T&E employees.

Although fatigue science has shown that the risk of fatigue is higher for night work than for day work, RSIA does not differentiate between the two in its hours of service requirements for freight railroads. FRA, however, has differentiated between the two when approving petitions for waivers of compliance with hours of service requirements. For example, when railroads have petitioned for a waiver of compliance with hours of service requirements to allow their employees to work a 6 by 1 schedule with both day and night shifts, FRA has approved such a schedule for daytime shifts, but not for shifts that include the hours between midnight and 6 a.m. FRA does not approve these shifts because of the higher risk of fatigue associated with them. FRA has also differentiated between day and night work in the final hours of service rules for covered train employees providing commuter and intercity passenger rail transportation. Specifically, the rule would not require FRA review and approval, including an assessment of fatigue risk, for work schedules that fall within the parameters of preapproved daytime work schedule templates (generally between 4 a.m. and 8 p.m.). Schedules that include work between 8 p.m. and 4 a.m., must generally be analyzed using an FRA approved fatigue model to assess the potential fatigue risk. FRA review and approval is needed on schedules where fatigue risk is deemed too great. For such schedules, railroads must generally take mitigating action to bring the risk from fatigue to an acceptable level. Additionally, limitations are placed on the number of consecutive days that a covered commuter or intercity passenger railroad T&E employee may work, with the limitations depending on the time of day of the assignments within the series of consecutive days. In making this distinction between nighttime and daytime work assignments, FRA has taken into account the fact that work at night presents a greater risk of fatigue.[41]

Our analysis of the class I and selected class II covered T&E employee work schedules for May 2008 and May 2010 shows that the extent that employees worked hours at night was highly correlated with employees spending at least 20 percent or more of their work time at high risk of fatigue.[42] In our analysis the proportion of employees with 20 percent or

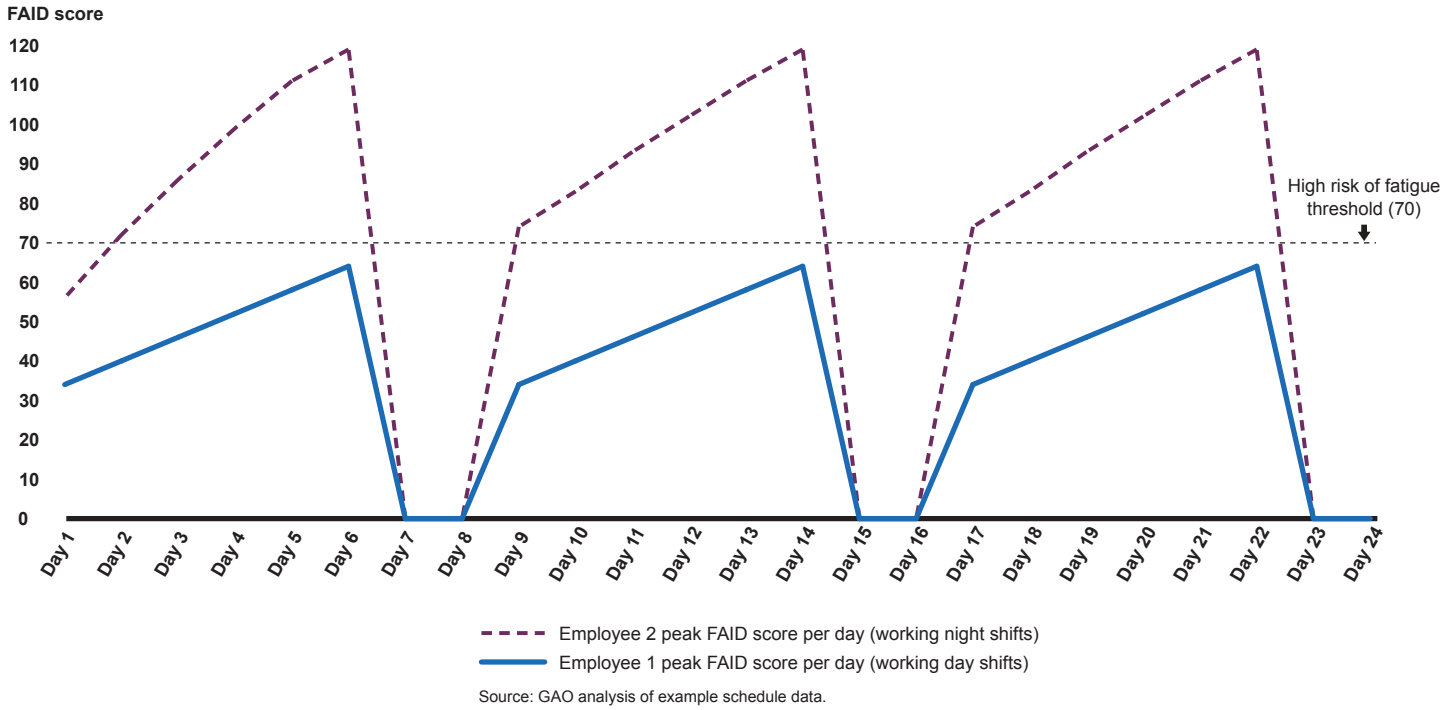
[41]76 Fed. Reg. No. 156, p. 50364 (Aug. 12, 2011).

[42]Specifically we found the correlation coefficient of 0.53 between hours worked at night and the incidence of workers spending at least 20 percent of their hours worked at a high fatigue level.

more of their work time at high risk of fatigue for class I T&E covered employees decreased from 14 percent in May 2008 to 10 percent in May 2010 and from 18 percent in May 2008 to 12 percent in May 2010 for participating class II railroad covered T&E employees. Even though fatigue risk was reduced after the implementation of the new hours of service requirements under RSIA, our findings on the correlation between night work and work hours spent at high risk of fatigue—along with the fatigue model results discussed previously that showed the decline in high risk of fatigue based on total hours worked —indicate that because RSIA did not directly limit the hours worked at night or incorporate night work into the freight requirements, fatigue might not be addressed under the new requirements to the fullest extent possible. Taking hours worked at night into consideration for freight hours of service requirements could hold promise for mitigating the risk of fatigue.

In addition to analyzing actual work schedules from the class I and class II railroad T&E employees, we analyzed three consecutive sets of two hypothetical 6 by 2 work schedules—the maximum number of consecutive work days allowed under RSIA when not returning home from an away-from-home terminal—using a fatigue model to further assess the effects of night work on fatigue. One schedule included only daytime hours with 10 hour shifts from 8 a.m. to 6 p.m. and the other included nighttime hours with 10 hour shifts from 8 p.m. to 6 a.m. According to our analysis, the percentage of time at high risk of fatigue was greater for the hypothetical night work schedule than for the hypothetical day work schedule. The day work schedule had no time spent at high risk of fatigue, while the night work schedule had a total of 67 hours, or 37 percent of total work time, spent at high risk of fatigue. Furthermore, the risk of fatigue for the nighttime work schedule was high for all but one of the work days in the all-night-work schedule, while no work day in the all-day-work schedule fell into the high risk category (see fig. 5). The peak fatigue score shown in the figure is the highest fatigue score achieved on a work schedule day analyzed by the fatigue model. This does not mean the whole scheduled work time was spent working at the peak fatigue level. For example, on the nighttime hours schedule on day 2 according to the model example employee 2 would have spent 32 minutes working at high risk of fatigue with a peak fatigue score of 72. However, according to the model output on day 6 example employee 2 spent 8 hours 6 minutes out of a 10 hour shift working at high risk of fatigue with a peak fatigue score of 119. As our analysis of these hypothetical schedules indicates, consecutive daytime shifts may present a lower risk of fatigue than consecutive nighttime shifts.

Figure 5: Differences in Fatigue Risk for Hypothetical Daytime and Nighttime Work Schedule



Source: GAO analysis of example schedule data.

Note: We used the FAID fatigue model to analyze fatigue risk for these hypothetical work schedules.

New Hours of Service Requirements Have Led to Operational and Administrative Changes That Have Increased Some Railroads' Costs

Operational Changes Have Affected Railroads' Scheduling, Staffing, and Customer Service

According to our survey results, RSIA's hours of service requirements led to a number of effects on railroads' operations, as would be expected with any significant change in statutory or regulatory requirements aimed at improving safety by reducing covered employee fatigue. These effects included changes in how crews and trains are scheduled, increases in staffing levels to maintain operations, and reductions in some railroads' ability to meet customer needs. In general, according to our survey results, smaller railroads found some of the changes more burdensome than did larger railroads. In addition, some railroads incurred one-time or ongoing financial costs, or both, to implement the changes.

Hours of Service Changes Have Led to Alterations in Railroads' Crew and Train Scheduling and Increased Some Railroads' Costs

According to our survey results, RSIA's hours of service requirements—especially its consecutive work day limits and increased rest requirements—substantially changed the way railroads schedule crews. For example, all 7 class I, 8 of 14 class II (about 57 percent), and 98 of 152 class III (about 64 percent) railroads reported changing crew schedules as a direct result of RSIA's hours of service requirements.[43] Such changes would be expected, given the new requirements. Prior to RSIA, covered T&E employees on some railroads often worked well beyond 6 or 7 consecutive days. Officials we spoke with at 1 class I railroad said its train crews often worked 8 consecutive days followed by 3 days off, and officials at another class I railroad said most of its employees worked 6 consecutive days with 1 day off, although covered

[43]Not all respondents to the survey answered each of the questions. An analysis of the distribution of variables for the respondents related to the size of the railroads was compared to distribution of these variables in the entire population of railroads and no significant distributional differences were found.

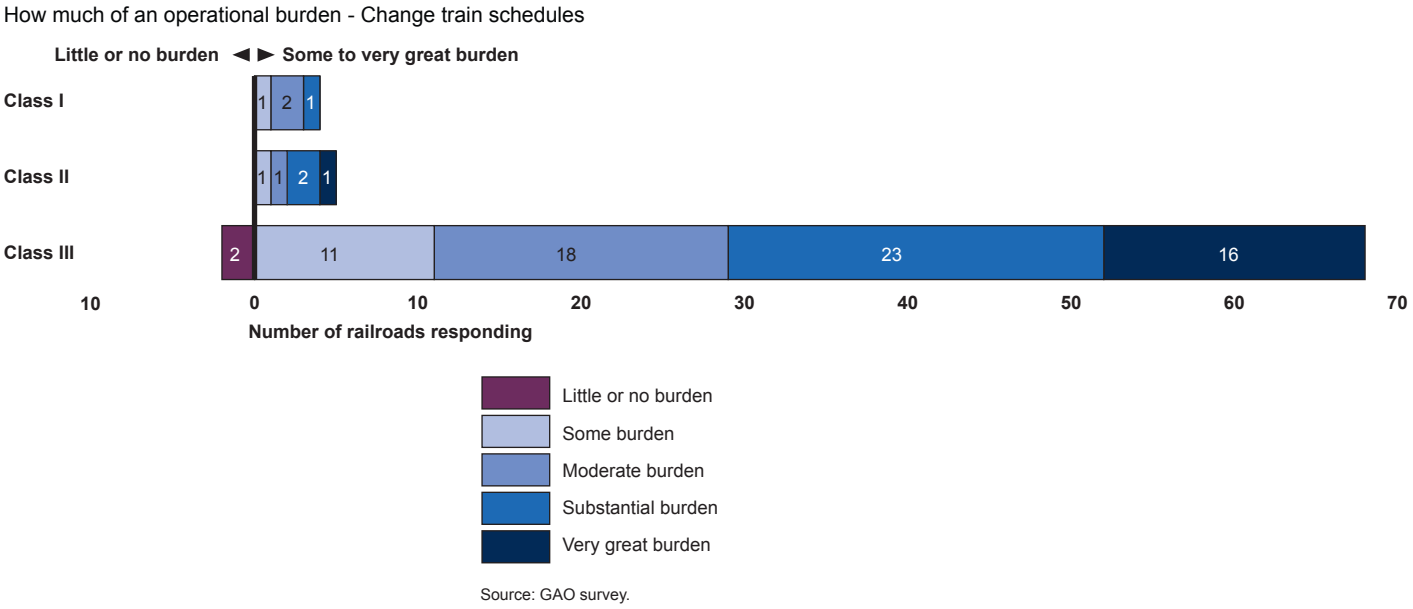
employees often worked 7 days followed by 3 days off or 11 days followed by 4 days off. According to officials we interviewed at 1 class II railroad, a small portion of its covered train employees (about 15 percent) worked up to 22 consecutive days followed by 8 days off. After RSIA, covered employees could no longer work for more than 6 or 7 consecutive days without taking required rest. According to railroad officials, the requirement for 48 hours' rest following 6 consecutive work days has been particularly challenging, and some officials told us they try to avoid working employees 6 consecutive days.

Our survey results indicate that the changes in crew schedules led to changes in train schedules. Specifically, in responding to our survey, 4 of 7 class I railroads reported changing train schedules as a direct result of RSIA's hours of service changes, while 5 of 14 (about 36 percent) class II railroads and just under half (70 of 153) of class III railroads reported making this change. Changes in train schedules particularly affected smaller railroads. According to officials we interviewed from 1 class II railroad, RSIA's changes, particularly the additional time needed for employees to return to work, made it difficult to maintain train schedules and to respond to changes in train operating plans, which are often caused by factors such as mechanical problems and traffic levels. RSIA's changes reduced their flexibility in such situations. An official from another class II railroad told us that RSIA's hours of service changes meant the railroad had to reduce train service from 7 days a week to 6 days because it did not have enough people available to offer service 7 days a week. While this railroad has since hired people and said it expects to resume 7-day service, it was not able to do so for over a year. In some instances, train connections were also affected. For example, a class II railroad official we interviewed said that delays on some of the company's long-distance trains, which the official attributed to RSIA's changes, led to delays on local trains that connected with the long-distance trains. Officials from another class II railroad said RSIA's changes caused them to hold trains out of their rail yard because, until March 2011, they did not have enough people to handle them.

While RSIA's consecutive day limits and increased rest requirements were focused on reducing fatigue and improving safety, a majority of the railroads responding to our survey reported that the resulting changes in crew and train schedules imposed burdens on them, and some of these railroads reported that the changes increased their costs. As shown in figure 6, the burden on railroads from changing train schedules could be very great, especially for smaller railroads. Three of the 4 class I railroads responding to this survey question reported a moderate to substantial

burden, and over 55 percent of the responding class II and III railroads reported a substantial to very great burden. For example, as officials we interviewed from a holding company that owns over 30 smaller railroads said, the burden imposed by changing crew and train schedules was very great for some railroads—such as those that serve grain producers during the harvest season—that need to run trains without interruption at certain seasons to meet demand. According to the officials, RSIA's consecutive work day limits and requirement for more rest between shifts make uninterrupted service like this very difficult to provide. Finally, according to our survey results, changes to crew and train schedules entailed financial costs, particularly for class I railroads. Of the 7 class I railroads, 5 reported incurring financial costs from changing crew schedules and 4 reported incurring such costs from changing train schedules. Fewer class II and III railroads reported incurring such costs, although half (76 of 152) of the class III railroads that reported changing crew schedules reported incurring financial costs for doing so. In some cases, these may have been one-time costs, such as for upgrading hours of service timekeeping systems to accommodate new crew schedules. In other cases, they may have been recurring costs, such as for hiring new employees or bringing employees back from furlough to address issues related to crew or train schedules (discussed later in this report). Costs for additional staff could also be related to service increases responding, at least in part, to improvements in the economy that followed RSIA's implementation in July 2009.

Figure 6: Degree of Burden on Surveyed Railroads from Changing Train Schedules As a Direct Result of RSIA's Hours of Service Changes



Source: GAO survey.

In general, we did not ask the railroads we surveyed to identify specific dollar amounts incurred as a result of RSIA's hours of service changes or to indicate how those amounts may have affected railroad earnings or profits. We did ask the railroads to identify the average annual wages and benefits for employees hired or brought back from furlough as a result of RSIA's changes (discussed later in this report). During our interviews, some railroad officials told us it was difficult to separate the financial effects of RSIA's changes from those of general economic conditions. Nevertheless, even though we did not determine the specific financial effects of RSIA's changes on railroads, it is likely the changes affected the costs, revenues, and earnings for some railroads, at least temporarily. As discussed earlier, such effects are not unexpected given the magnitude of RSIA's hours of service changes and the many actions required by railroads to comply with the law.

Staffing Levels for Some Railroads Increased and There Were Other Effects on Staffing As Well

In implementing RSIA's hours of service changes to improve safety and comply with the law, some railroads reported increasing their staffing levels in response to the changes they made in crew schedules. In general, according to railroad officials we spoke with, staffing levels increased with the changes in crew schedules because, with RSIA's consecutive work day limits and increased rest requirements, covered

T&E employees were less available to work. More specifically, because of RSIA's requirements for 48 instead of 24 hours' rest after 6 consecutive days on duty, and for 10 instead of 8 hours' rest between shifts, employees were generally less available for work and more staff were needed to maintain regular operations. For example, officials we spoke with from a class II railroad said RSIA's requirements for 10 hours' rest between shifts, and for this rest to be undisturbed, could increase the time that covered employees were unavailable for work by between 2 and 4 hours and meant, for this railroad, that more staff were needed to provide pre-RSIA service levels.[44] Additionally, according to an official we spoke with from a class I railroad, RSIA's changes meant that this railroad needed about 200 more T&E employees than it previously did to run the same amount of business. Although we tried to isolate RSIA's effects on railroads' staffing by asking railroads to identify the extent to which they hired new employees or brought employees back from furlough as a direct result of RSIA, we cannot exclude the possibility that some of the changes they reported were also due to improvements in general economic conditions that took place from 2009 to 2010.

To address staffing needs, railroad officials we spoke with told us they called on T&E employees without regular crew assignments, hired new employees, or brought employees back from furlough to help fill the staffing gaps. T&E employees without regular crew assignments are listed on what are called extra boards and are on call to meet crew needs as they arise, giving railroads flexibility to meet staffing needs when regular crews are not available to work. All 7 class I railroads use extra boards, and some smaller railroads may also use them. In addition, railroads reported hiring new people or bringing people back from furlough. Some railroad officials we spoke with said these people were at least initially assigned to extra boards. In responding to our survey, 5 of 7 class I and 7 of 14 class II railroads reported they hired or brought T&E employees back from furlough as a direct result of RSIA's requirements.

[44]Officials we spoke with from a class II railroad said that before RSIA took effect, railroads could have crews back on duty in 8 to 10 hours and could call employees within 2 hours of their on-duty time, as set forth in collective bargaining agreements. After RSIA, with the minimum rest requirement increased from 8 hours to 10 hours and the new prohibition against calling employees during their rest time, crews cannot be back on duty before 12 hours or more. According to FRA, it could take 12 hours or more for an employee to return to work if they are not given a time to report for work again at the end of their prior shift and are given 2 hours to report for work after receiving a duty call, as is common under many collective bargaining agreements.

Proportionally, fewer small railroads reported hiring or bringing employees back from furlough—about 30 percent (46 of 152) of the class III railroads responding to our survey. In some instances, hiring decisions at smaller railroads may have reflected broader economic conditions rather than specific operating needs. For example, an official we spoke with from a class III railroad said the company was apprehensive about long-term hiring because, given the risks of a sudden decline in orders, it might have to lay employees off after investing in their hiring and training.

According to our survey results, the number of T&E employees railroads hired or brought back from furlough varied and increased some railroads' costs. Overall, as would be expected, larger railroads reported hiring or bringing back more employees than smaller railroads. For those railroads we surveyed that reported hiring or bringing people back from furlough, the number of people ranged between 120 and 500 each for the 4 class I railroads, 5 and 40 each for the 7 class II railroads, and 1 and 30 each for the 45 class III railroads. In hiring or bringing T&E employees back from furlough, the railroads incurred ongoing financial costs. According to our estimates, based on the average annual wages and benefits of T&E employees reported by the railroads we surveyed, the average annual cost for the 4 class I railroads ranged from about $11 million to $50 million, and for the 7 class II railroads, it ranged from about $350,000 to $3 million.

While RSIA's requirements affected some railroads' need for staff, the requirements had other effects on staffing as well, including reduced flexibility in using managers and reduced ability to provide guaranteed and other work hours to covered employees:

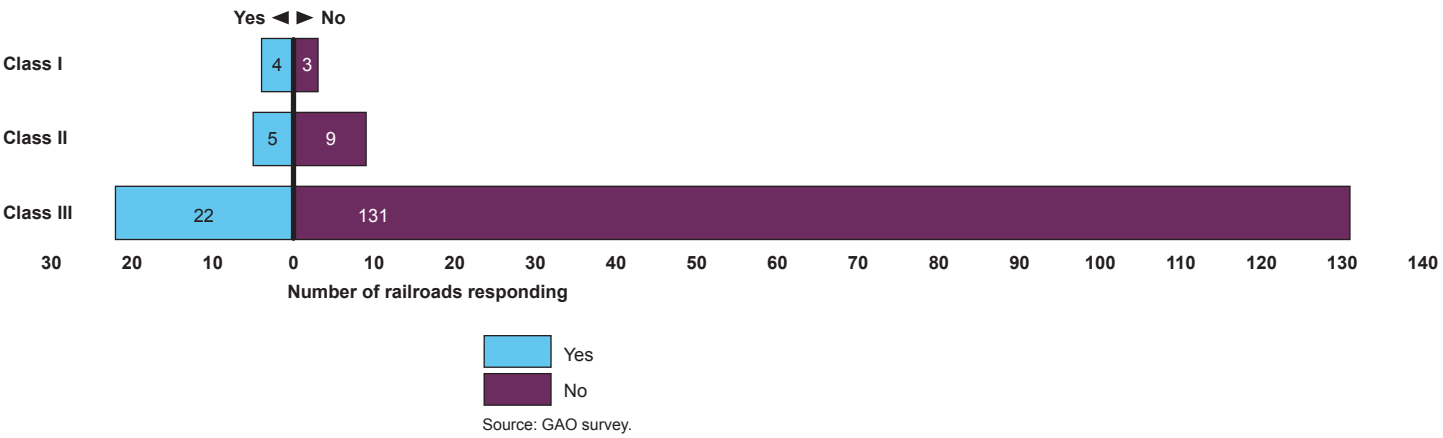
- *Reduced flexibility to use managers to perform covered and noncovered service.*[45] Our survey results indicated that RSIA's changes may have reduced the ability of some managers to perform covered and noncovered service. Most of the larger railroads we surveyed—5 of 7 class I railroads and 12 of 14 class II railroads—reported no reductions in the ability of managers to perform covered service. In contrast, about 36 percent (54 of 151) of class III railroads

[45]For a train employee, covered service is the portion of the employee's time on duty during which the employee is engaged in, or connected with, the movement of a train. Noncovered service is generally time spent performing tasks for a railroad that are not covered by hours of service requirements, such as managing the business.

reported a reduction in managers' ability to perform covered service, and about 30 percent (46 of 151) reported a reduction in managers' ability to perform noncovered service. In general, this issue is of particular importance for smaller railroads. ASLRRA officials told us, that on small railroads, the same person often performs many different functions and it is not unusual for railroad managers to operate trains in place of employees who are sick or on vacation in addition to performing their managerial responsibilities. However, the officials said, if managers do perform such work, they come under RSIA's hours of service limitations, including the monthly cap on total work hours. All of their work hours, including the time spent performing both covered and noncovered service, then falls under the 276-hour cap. The officials said, in some instances, this restriction could prevent managers from performing their regular managerial work.

- *Reduced ability to provide guaranteed work hours to covered employees.* Some railroads, generally by collective bargaining agreement, guarantee a minimum number of work hours or days to employees over a certain period (e.g., 2 weeks). In some cases, the railroads do this to retain a certain class of employee, such as T&E employees. In general, employees are paid for the guaranteed hours or days whether they perform the work or not. For a railroad, not providing work during the guaranteed hours may mean having to pay for work not performed. For an employee, not meeting guaranteed hours or days may mean fewer hours worked, even though the employee may be paid for the time not worked. In responding to our survey, 4 of the 7 class I railroads reported they were not able to meet guaranteed work hours as a direct result of RSIA's requirements, whereas smaller proportions of class II and III railroads reported this issue (see fig. 7).

Figure 7: Number of Surveyed Railroads That Did Not Meet Guaranteed Hours As a Direct Result of RSIA's Requirements, by Class of Railroad



Source: GAO survey.

- *Potentially reduced ability to provide work hours to covered employees each month.* RSIA's monthly cap on total work hours (276 hours) may have altered how railroads are able to use their workforce and the number of hours employees work. A number of railroad officials we interviewed said this cap did not affect their company. However, the majority of railroads we surveyed reported taking employees temporarily out of service as a direct result of RSIA's hours of service changes.[46] This may have resulted from controls railroads implemented to prevent covered T&E employees from exceeding the total monthly work hour cap. For example, in follow-up work on our survey, we learned that all 7 class I railroads established internal thresholds to monitor employee work hours to ensure that employees did not exceed this cap. These thresholds ranged from 250 to 264 hours.[47] We did not determine through our survey and interviews how many T&E employees may have been taken out of

[46]In responding to our survey, all 7 class I, 9 of 14 class II, and 54 of 151 class III (about 36 percent) railroads reported taking employees out of service as a direct result of RSIA's requirements.

[47]Officials we spoke with at one railroad said its threshold varied by crew pool, and officials at another railroad said it did not have a set threshold but rather its crew calling and scheduling system prevented an employee from starting a tour of duty when the average trip time might cause the employee to reach or exceed the total monthly work hour cap.

service because of these thresholds. However, the number of employees reported by our survey respondents as reaching or exceeding the total monthly work hour cap in any particular month in 2010 was small and ranged from 0 to 26 for all railroads surveyed.[48] Whether or to what extent the internal thresholds influenced this number, prevented employees from exceeding the monthly cap, or limited work hours is unknown.

Some of the labor organizations we spoke with expressed concerns about how railroads responded to RSIA's hours of service requirements. For example, officials we interviewed from one organization that represents T&E employees said that a significant portion of its membership had suffered some salary loss from the changes in hours of service requirements and added that covered employees were not being scheduled for more than 252 hours of work in a month in order to avoid reaching or exceeding RSIA's cap on total monthly work hours. The officials said this practice can cost employees as much as 24 hours' pay in a month. Officials from unions representing conductors, signalmen, and yardmasters[49] expressed similar concerns. They primarily attributed reductions in work hours and lost compensation to RSIA's impact on crew schedules as well as to the requirement for 10 hours' undisturbed rest and the monthly work hour cap. For example, an official with a union representing yardmasters told us the requirement for 10 hours' undisturbed rest precludes employees that work in rail yards from working swing (third) shifts as well as regular shifts 7 days a week and this restriction deprives employees of work and reduces earning opportunities. Union officials also told us the internal threshold some railroads use to

[48]This information is similar to the results of a study FRA reported in November 2009. Designed to characterize the work/rest schedules and sleep patterns of U.S. railroad T&E personnel, this study used a background survey and daily log over a 14-day period for a random sample of 809 T&E workers and then extrapolated the daily log data to a 30-day period. According to FRA, 12 of 232 respondents (5.2 percent) whose daily logs had complete work histories would have likely exceeded RSIA's monthly cap had it been in place at the time of the FRA study. See *Work Schedules and Sleep Patterns of Railroad Train and Engine Service Workers*, U.S. Department of Transportation, Federal Railroad Administration, DOT/FRA/ORD-09/22 (November 2009).

[49]Yardmasters coordinate the activities of workers engaged in railroad yard operations. These activities include making up or breaking up trains and switching inbound or outbound traffic to specific sections of a rail line. According to FRA, depending on the exact duties performed, yardmasters may be train employees, dispatching service employees, both, or neither.

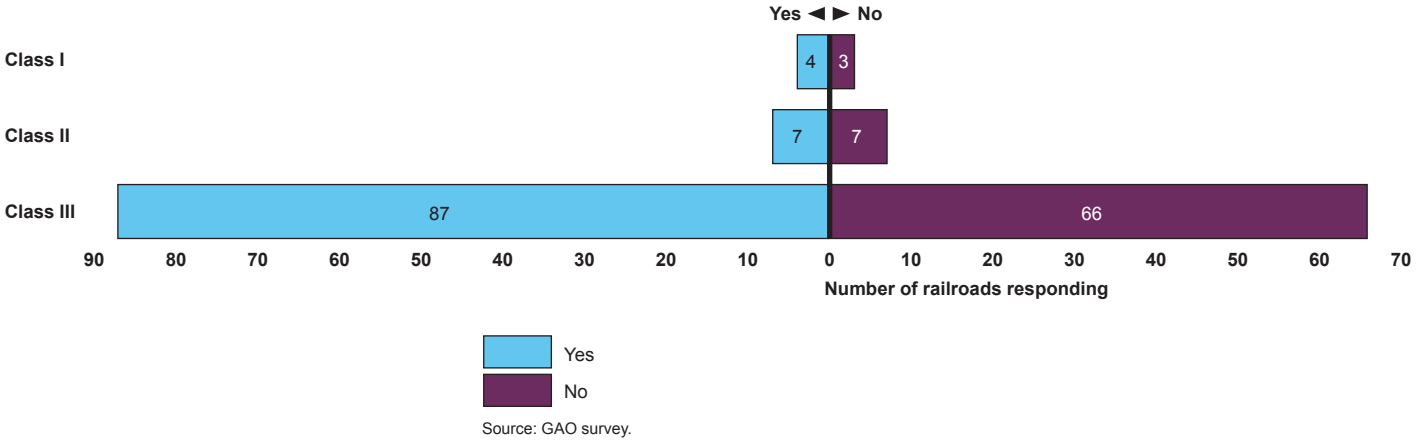
address the monthly work hour cap serves as an artificial cap and essentially deprives employees of additional work hours and earnings.

Hours of Service Changes May Have Affected Some Railroads' Ability to Meet Customer Needs

The changes that some railroads made to implement RSIA's hours of service changes and improve safety may also have limited their ability to provide service and meet customer needs. As figure 8 shows, over half of all railroads (98 of 174 railroads) responding to our survey question reported their ability to meet customer needs was reduced as a direct result of RSIA's hours of service changes. In particular, class I (4 of 7) and class III (87 of 153) railroads reported a reduction. Railroad officials we spoke with largely attributed these effects to RSIA's consecutive work day limits and requirements for increased rest. By affecting crew and train schedules, the officials noted, the requirements have sometimes acted to limit railroads' flexibility to provide train service when and where needed, especially on weekends.

Figure 8: Railroad Industry Responses about Effects on Customer Service As a Direct Result of RSIA Hours of Service Changes, by Class of Railroad

Action occurs as direct result of the RSIA hours of service requirements - Ability to meet customer needs was reduced



Source: GAO survey.

We did not determine the effects of RSIA's requirements on changes in railroad customer service, such as whether railroads lost customers or customers changed modes of transportation following service changes. RSIA's focus was on improving railroad safety but effects on customer service may have occurred. Officials we spoke with at a class II railroad said that, in some instances, the hours of service requirements have led to about a 50 percent loss in weekend crew starts and negative effects on customer service. On weekends, the officials said, some entire industries do not receive train service because people are not available to operate

the trains. Officials we spoke with at several other smaller railroads also told us their weekend service had been affected. For some railroads, reduced customer service may have been temporary. For example, some railroads have petitioned FRA for waivers of compliance from hours of service requirements so they will have the flexibility to provide service for 6 days (e.g., Monday through Saturday), followed by 24 hours' rest rather than the RSIA-mandated 48 hours, if customer needs dictate. In addition, hiring new employees or bringing employees back from furlough may have permitted some railroads to return to service levels that may have decreased initially because the railroads lacked available employees. Officials at one class II railroad told us they believed their ability to keep up with business levels was severely hampered by the lack of covered employees caused by RSIA's hours of service changes. To address the issue, they brought back all their previously furloughed employees and hired even more covered employees. As a result, by March 2011, the officials believed the railroad was getting back to crew levels that were sufficient to meet business needs.

Some shippers and receivers that use rail to meet their transportation needs told us their service had been affected by RSIA. We did not formally survey shippers or receivers that use rail to transport their goods about the possible effects of RSIA's hours of service changes, but responses to questions sent out on our behalf by a trade association (the National Industrial Transportation League) that represents shippers and receivers of a wide mix of commodities, including steel, paper, and agricultural products, indicated that the changes had affected some of them.[50] Of the 28 shippers and receivers that responded to the questions, 10 said their service had been affected by RSIA's hours of service changes, and 7 said their weekend service had been affected. Among the problems with service cited by these shippers and receivers were less predictable service, train crew shortages, and switches missed because crews were unavailable or had "timed out on the clock."[51] The responses

[50]The National Industrial Transportation League reported it has over 600 company members, about a third of which use rail to ship or receive goods. The association surveyed these rail users and received responses from 28 of them.

[51]As identified earlier, switching is a railway service that is performed under yard rules and regulations and involves, among other things, changing the position of railcars for purposes of loading, unloading, or weighing. "Timing out on the clock" occurs when a railroad crew works up to the maximum time allowed by the hours of service requirements (currently 12 hours for T&E crews).

to these customer service problems varied but included increasing rail fleets, switching to trucks to compensate for rail inefficiencies, and increasing inventory or adjusting or shutting down production schedules.

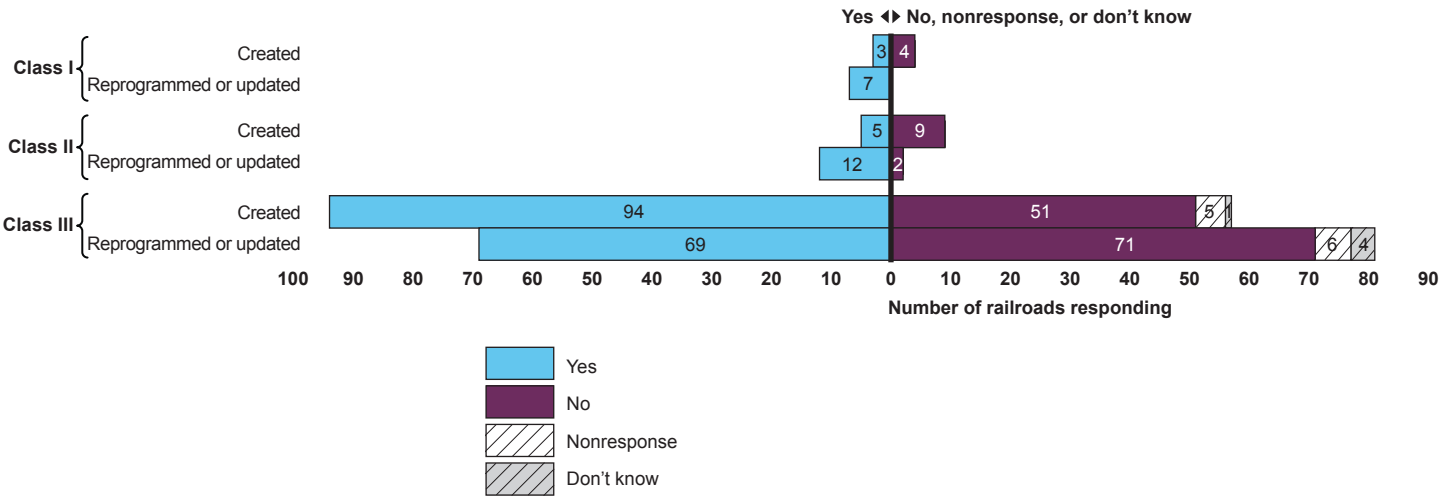
Administrative Changes Involved Recordkeeping Systems and Claims for Lost Work Opportunities

To implement RSIA's hours of service changes, railroads also reported making administrative changes. For example, railroads reported modifying or creating new recordkeeping systems to account for time covered by hours of service requirements, spending more time reviewing hours of service records, and handling more claims for lost work opportunities.

Changes Imposed Recordkeeping Burdens for Most Railroads and Increased Some Railroads' Costs

To accommodate RSIA's new hours of service requirements and create the records necessary to comply with the law, railroads of all sizes reported modifying their timekeeping systems or, in some cases, creating new systems. According to our survey results, most large railroads (all 7 class I railroads and 12 of 14 class II railroads) primarily reprogrammed or updated their existing timekeeping systems, which are generally electronic (see fig. 9). Among other things, officials we spoke with at some railroads said they established ways to track employees' total work and limbo or deadhead hours in a month and, in some cases, incorporated alerts to prevent covered employees from being contacted during undisturbed rest periods. Designing a way to prevent contact was sometimes more difficult than expected because, as officials we spoke with at one class I railroad said, people other than crew schedulers, such as company doctors, security personnel, and payroll personnel, may try to contact a covered employee during a day, and the system has to preclude all such contacts during an undisturbed rest period. In contrast, many small railroads we surveyed reported creating new timekeeping systems. Over half (94 of 151) of the class III railroads reported creating new timekeeping systems. Officials we interviewed at some of the class III railroads said their companies have paper-based hours of service timekeeping systems but use electronic spreadsheets to track covered employees' hours of service. In some cases, the electronic spreadsheets were updated to keep track of such things as total monthly work hours. Additionally, according to some railroad officials we spoke with, their changes were sometimes part of a broader effort to better manage both hours of service and other aspects of their business, such as financial management.

Figure 9: Changes Railroads, or Their Parent Companies, Made Related to Timekeeping Systems As a Direct Result of RSIA's Hours of Service Changes, by Class of Railroad



Source: GAO survey.

To demonstrate compliance with RSIA's hours of service changes, some railroads reported spending more time preparing or reviewing hours of service records—work that officials said sometimes limited their ability to perform other tasks, such as operating their business. Survey respondents who addressed this question, including those from all 7 class I railroads and over 70 percent of class II and III railroads (10 of 14 and 115 of 152, respectively), reported the time required for recordkeeping or recordkeeping review increased as a direct result of RSIA's hours of service requirements. Not unexpectedly, the increased time to prepare or review hours of service records imposed burdens on railroads. In responding to our survey, 6 of the 7 class I railroads reported the additional time for recordkeeping or recordkeeping reviews presented some to a moderate burden, while half (5 of 10) of the class II railroads and about 40 percent (44 of 111) of the class III railroads responding to this question reported a substantial to a very great burden. Over time, the increased efforts to prepare and review hours of service records will likely become part of the normal routine of a railroad. In addition, creating such records is part of helping ensure compliance with the law and achieving its intended safety benefits. However, at least temporarily, some railroads we spoke with said the increased record preparation and review time affected how their business is operated. For example, officials we spoke with at 3 class III railroads, all with paper-based hours of service records,

said the additional information that must be tracked for hours of service records was a burden and the time spent on tracking left less time for other activities, including running the railroad. This was one of these railroads' main issues with RSIA's changes. An official we spoke with at a class I railroad also told us RSIA's changes added an extra layer of reporting to the company's hours of service process, primarily to accommodate RSIA's total monthly work hour caps.

Finally, in responding to our survey, some railroads reported that the timekeeping changes imposed financial costs. In some cases, these may have been one-time costs, and in others, they may have been recurring costs. According to our survey results, all 7 class I railroads, 12 of the 14 class II railroads, and 88 of 150 class III railroads incurred financial costs from introducing or revising hours of service records or recordkeeping systems. We did not collect information on the specific costs incurred. However, some railroad officials we interviewed said the costs ranged into the millions of dollars. According to officials from one class I railroad we spoke with, it spent about $3 million in 2009 for programming changes, including changes to its crew monitoring system. Officials we spoke with at another class I railroad told us it spent about $2 million for programming and upgrades, including converting from paper to electronic records for its signal employees. According to the officials, the cost was primarily for company employees, not a consultant, to do the reprogramming and was a one-time cost. At some other railroads, the costs were for work performed by a mix of in-house staff and outside consultants. Some of the costs were recurring. For example, an official from a class III railroad told us his company spends an extra $500 a month for a manager to review and verify the accuracy of hours of service records.

Railroads Also Reported Increases in Claims Filed for Lost Work Hours or Compensation

After RSIA took effect, some covered employees filed claims for lost work or compensation—that is, requests for payment for work hours or compensation lost because of RSIA's consecutive work day limits or other requirements. Such claims might arise when, for example, an employee who formerly worked a 6 by 1 shift could no longer do so because RSIA requires 48 hours' rest after 6 consecutive days on duty. In responding to our survey, 5 of 7 class I, 6 of 14 class II, and 22 of 152 class III railroads reported that the number of claims for missed work opportunities (hours) or compensation increased as a direct result of RSIA's hours of service changes. The remaining class I and II railroads and 128 of the class III

railroads (about 84 percent) said either the number of such claims stayed the same or the issue was not applicable to them.[52] We did not collect data on the number of claims filed. However, some railroad officials we spoke with said the number of claims filed doubled or tripled from the normal level. For example, a class II railroad official we spoke with estimated that the number of claims filed at his company each month for lost work hours increased from about 5 before RSIA took effect to 10 to 15 afterwards. This official also said the number of claims subsequently went back to 2–3 per month. A class I railroad official told us T&E employees had filed over 500 claims at this company between July 2009 and May 2010, most of which the company was holding in abeyance until it had decided how to handle them.

We do not know how many claims may have resulted in payments to employees or other forms of relief. As noted, one class I railroad we spoke with had not decided at the time of our review how to resolve the 500 claims filed by its employees, in part because the railroad was still considering the status of collective bargaining agreements in relation to RSIA's legal requirements. Officials from this railroad estimated each claim filed averaged approximately $200 and the railroad's potential liability in paying these claims was about $100,000. At other railroads, paying compensation may have been more routine. For example, an official we spoke with at a class II railroad, which was trying to avoid working employees 6 consecutive days, said the railroad had, in virtually every instance, paid claims for compensation filed by T&E employees who had been skipped over for work assignments because they were approaching 6 consecutive days of work.

[52]In addition, 1 class III railroad responded that the number of claims decreased and 1 class III railroad responded "don't know" to this question.

Too Soon to Assess FRA's Hours of Service Oversight, but Implementation of Pilot Project and Waiver Provisions Could Yield More Data to Address Fatigue

FRA Uses a Risk-Based Approach to Oversee Compliance with Hours of Service Requirements

To plan its oversight of railroads' compliance with hours of service requirements, FRA applies the same risk-based approach that it uses to assess compliance generally. This approach relies on a risk-based model that FRA implemented in 2006. The model analyzes FRA's inspection data, together with accident and incident data reported by the railroads through the Accident and Incident Reporting System, and then generates the National Inspection Plan (NIP), which is designed to target FRA's inspections at the greatest safety risks. The NIP allocates inspection resources for each FRA region by inspector discipline (such as operating practices and track),[53] and FRA regions then assign resources to activities (such as hours of service and drug and alcohol control), within each discipline with input from inspectors familiar with each railroad's operations. In addition, FRA regional officials can modify the NIP's allocation of resources among disciplines based on local input, both initially and after 6 months. According to FRA headquarters and regional officials, decisions about how to allocate resources among inspection disciplines and activities are based on factors such as complaints, an inspector's knowledge of a railroad's operation at a given location, and the time and resources available to conduct inspections. This reliance on local input reflects FRA's views that regional officials and inspectors have

[53]As previously indicated, each FRA inspector belongs to one of five expertise areas, called disciplines—operating practices, track, hazardous materials, signal and train control, and motive power and equipment (such as locomotives and tank cars), and according to FRA, each discipline corresponds to certain rail safety or hazardous materials regulations, orders or statutes.

detailed knowledge about railroads' operations that may not be captured in the data used to develop the NIP and that their input results in a stronger inspection plan than one based solely on data analysis.

FRA incorporates data from its Accident and Incident Reporting System into its risk assessment model to help determine the relationship between noncompliance with safety requirements and risk. Specifically, FRA establishes codes for a wide range of violations or conditions, and when railroads report an accident or incident, they enter two codes into the system—one for the primary cause and the other for a contributing cause of the accident or incident. Neither hours of service violations nor, more broadly, fatigue are among the coded options that railroads can choose to enter. Instead, the options include a large number of actions or conditions that FRA considers potentially related to fatigue, such as "failure to release hand brake on cars" and "failure to comply with restricted speed." When FRA investigates an accident or incident with these codes entered as causes, it then attempts to determine whether fatigue was a factor. According to FRA, it does not have a code for hours of service violations because, in its experience, there is not necessarily a relationship between hours of service and fatigue—a fatigued individual can be in compliance with hours of service requirements or, conversely, a violation of hours of service requirements can occur without an individual being fatigued. According to FRA, it does not have a code for fatigue because it already collects information on fatigue when it investigates an accident or incident.[54]

It is Too Soon to Determine if FRA's Hours of Service Oversight Has Changed under RSIA or Needs to Change

It is too soon since RSIA was implemented to determine if the priority that FRA assigns to overseeing railroads' compliance with hours of service requirements has changed or should change. The new hours of service requirements did not take effect for freight railroads until July 16, 2009, and we collected the inspection data through September 30, 2010, a span of 14 months. Hence, the period covered by our audit work is too short for us to identify any trends in inspection results or enforcement actions taken since RSIA's changes went into effect. Furthermore without trend

[54]Specifically, FRA obtains and analyzes the work schedules of all employees involved in an incident or accident for 11 days prior to the accident or incident. FRA analyzes these work schedules using a fatigue model to determine if fatigue may have been a contributing factor to the accident or incident. Such a review of an employee's work schedule may also reveal noncompliance with the hours of service laws.

information, there is little basis at the current time to know whether the priority FRA assigns to overseeing hours of service is best aligned with potential safety risks.

FRA inspectors conduct hours of service inspections and complaint investigations to determine if covered employees have worked longer than limited by law. FRA inspectors also review railroads' hours of service recordkeeping to assess their compliance with FRA regulations that specify, for example, how and when the hours worked by covered employees are to be recorded. According to our analysis of FRA inspection data, FRA inspectors conducted somewhat fewer hours of service and hours of service recordkeeping inspections of freight railroads in fiscal year 2010—the one complete year for which we have data since RSIA took effect—than they did in fiscal year 2008, the last full year before RSIA was implemented. (See table 2.) However, the data for fiscal year 2010 show increases, especially for hours of service inspections, over the data for fiscal year 2009, the transition year. Furthermore, as the table shows, the annual numbers for both types of inspections have varied over the years, especially for hours of service inspections, and there is no indication thus far of a change in FRA's emphasis on hours of service. The data for fiscal year 2010 are consistent with the statements of some FRA officials, who told us FRA placed no special emphasis on hours of service issues after RSIA was implemented and has not changed its hours of service inspections since the change in the law. According to the officials, inspections focus on factors that cause accidents, and hours of service issues have caused few, if any, accidents in recent years. Most railroads responding to our survey also reported that they did not see a change in FRA's handling of hours of service issues. FRA did, however, identify hours of service in the National Safety Program Plan for fiscal year 2010 as a special-emphasis activity for four of FRA's eight regional offices and for the Office of Railroad Safety at FRA headquarters. Yet in three of these regional offices, the efforts are focused on signal employees rather than T&E employees, the largest group of covered employees subject to hours of service limitations.

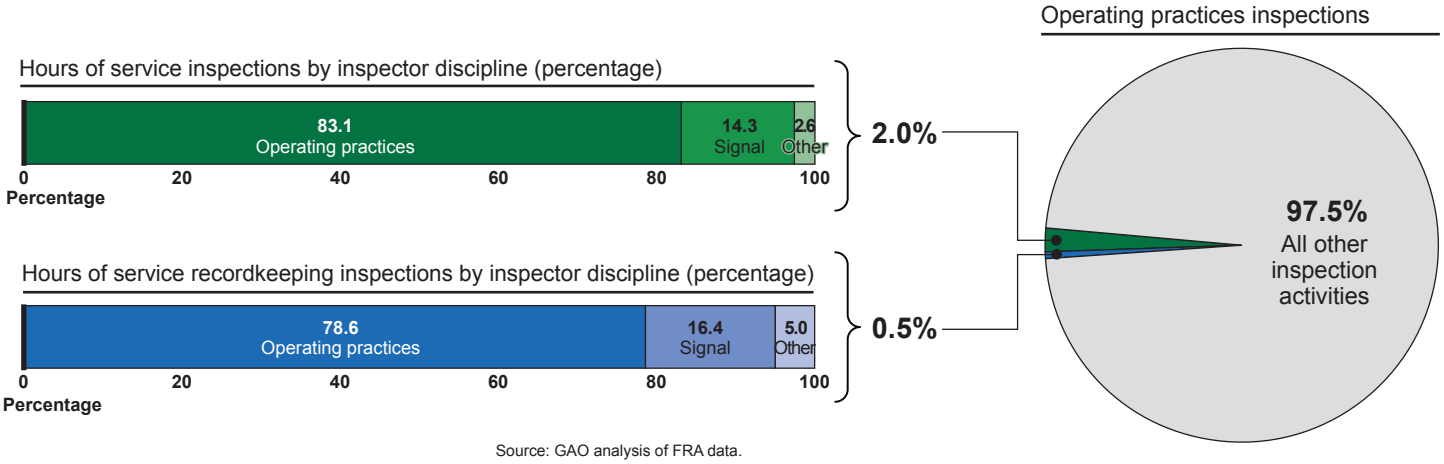
Table 2: Hours of Service and Hours of Service Recordkeeping Inspections of Freight Railroads, Fiscal Years 2005–2010

	2005	2006	2007	2008	2009	2010
All inspections	196,594	220,994	239,211	235,492	254,543	269,882
Hours of service inspections (percentage of all inspections)	264 (0.13%)	207 (0.09%)	198 (0.08%)	309 (0.13%)	157 (0.06%)	250 (0.09%)
Recordkeeping inspections (percentage of all inspections)	962 (0.49%)	1,295 (0.59%)	1,064 (0.44%)	1,056 (0.45%)	1,008 (0.40%)	1,016 (0.38%)

Source: GAO analysis of FRA data.

Overall, from fiscal year 2005 through fiscal year 2010, hours of service and hours of service recordkeeping inspections accounted for a very small percentage of FRA inspections of freight railroads—less than 1 percent of all FRA inspections conducted on freight railroads each year during this period, as indicated in table 2. Furthermore, although operating practices inspectors conducted about 83 percent of the hours of service and about 79 percent of the hours of service recordkeeping inspections, these inspections accounted for less than 3 percent of all operating practices inspections conducted at freight railroads during fiscal years 2005 through 2010 (see fig. 10).

Figure 10: Proportion of Hours of Service and Hours of Service Recordkeeping Inspections Conducted by Selected FRA Disciplines, and As a Portion of All Operating Practices, Fiscal Years 2005–2010

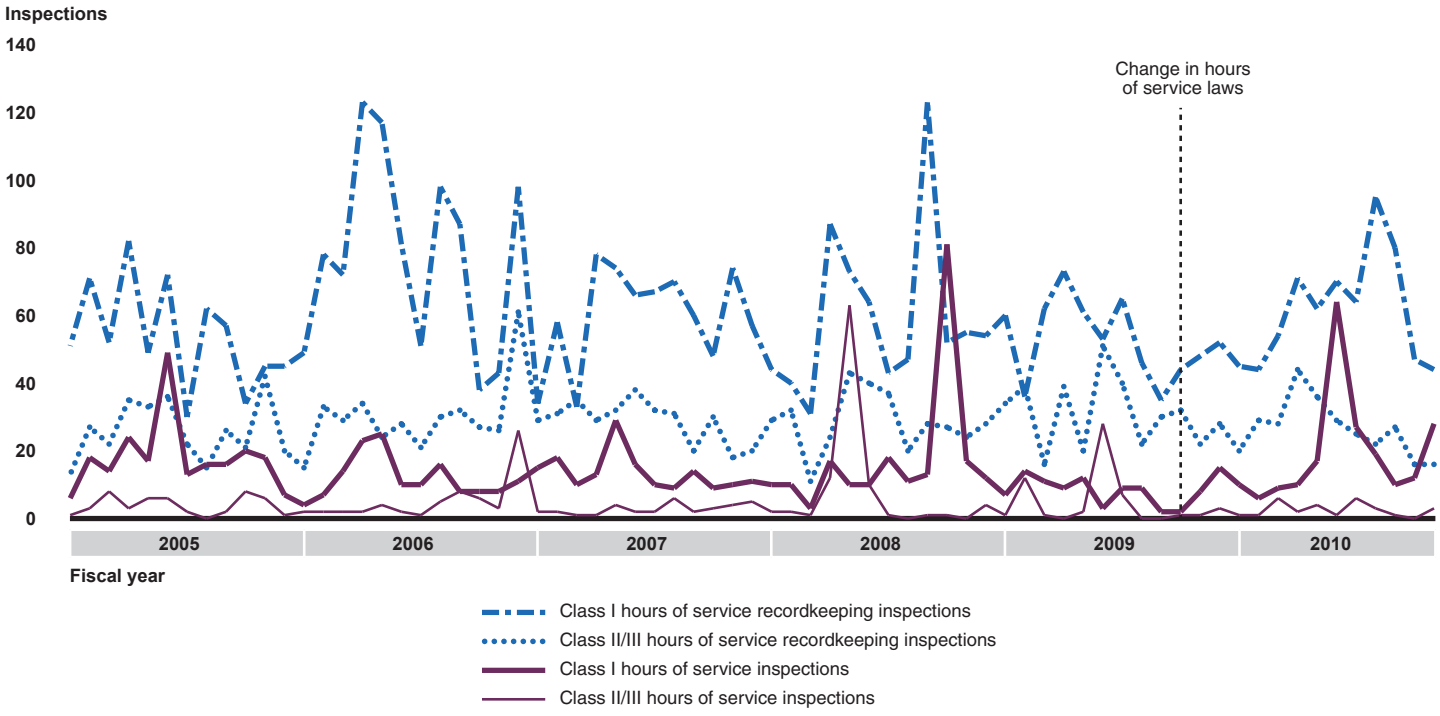


Source: GAO analysis of FRA data.

While our analysis does not indicate any notable change in FRA's overall emphasis on compliance with hours of service and hours of service recordkeeping requirements, it may show proportionally greater attention to the class I railroads, especially for hours of service (see fig. 11). As

previously noted, class I railroads account for over two-thirds of the total rail mileage operated in the United States. For both hours of service and hours of service recordkeeping, the number of inspections increased for the class I railroads and decreased for the class II and III railroads from fiscal year 2009 to fiscal year 2010. Again, however, the data are for a single year, and it is unclear whether any observed change will persist. According to FRA officials, there are no plans to require additional hours of service or hours of service recordkeeping inspections unless there is evidence of an increase in noncompliance on the part of the railroads, or there is an increase in complaints about violations of the hours of service laws.

Figure 11: Hours of Service and Hours of Service Recordkeeping Inspections of Freight Railroads, Fiscal Years 2005–2010



Source: GAO analysis of FRA data.

With just one full year's worth of data since RSIA took effect, we could not discern any changes in FRA's hours of service enforcement priorities. One indicator—the portion of defects identified during inspections that resulted in violations being processed for enforcement—showed no consistent direction, fluctuating variously up or down in fiscal year 2009 from fiscal year 2008 and then reversing direction the following year.

Another indicator—enforcement actions taken—also fluctuated, with the number of hours of service enforcement actions going up in fiscal year 2009 from fiscal year 2008, and then dropping again in fiscal year 2010. Meanwhile, hours of service recordkeeping enforcement actions took the opposite path during the same period, first dropping and then rising (see table 3).

Table 3: Hours of Service and Hours of Service Recordkeeping Enforcement Actions Taken against Freight Railroads, Fiscal Years 2005–2010

	2005	2006	2007	2008	2009	2010
Hours of service						
Enforcement actions	41	51	54	45	51	33
Total proposed penalties[a]	$167,433	$207,525	$163,478	$181,469	$175,016	$67,670
Hours of service recordkeeping						
Enforcement actions	27	47	67	63	41	47
Total proposed penalties	**$84,278**	**$178,189**	**$198,283**	**$156,930**	**$100,736**	**$167,660**

Source: GAO analysis of FRA enforcement data.

[a]Penalty figures are shown in constant fiscal year 2011 dollars.

RSIA Provisions for Pilot Projects and Waivers Create Opportunities to Analyze Safety Effects of Approved Alternatives

Besides establishing new hours of service requirements, RSIA provided for pilot projects and waivers of compliance with hours of service requirements, both of which would create opportunities for FRA and railroads to analyze the effects on safety of approved alternatives to the new hours of service requirements. FRA has been unable to implement two pilot projects mandated under RSIA because no railroads have chosen to participate, and has not exercised its pre-RSIA authority to approve voluntary pilot projects designed to examine the fatigue-reduction potential of alternatives to the current hours of service laws because of flaws in the applications it received. FRA also has the authority to approve petitions for waivers of hours of service requirements in certain circumstances and has approved waiver petitions for some railroads. RSIA required FRA to conduct the mandated pilot projects by October 2010, and to report on the voluntary pilot projects no later than

December 31, 2012;[55] however, RSIA does not require FRA to analyze or report on the safety effects of approved waiver petitions, and FRA has not taken steps to do so.

Mandated and Voluntary Pilot Projects

RSIA required FRA to conduct at least two pilot projects of sufficient size and scope to analyze specific practices that could be used to reduce fatigue for T&E and other railroad employees covered by hours of service requirements. The first pilot project called for the railroad to give a covered employee at least 10 hours' advance notice of a shift assignment. Advance notice of 2 to 4 hours is typical in the industry today. The second pilot project would have created defined shifts for covered employees who receive unscheduled shift calls, such that those employees would be subject to call every other shift, instead of at any time. FRA has not been able to implement either of these mandated pilot projects because no railroad has expressed interest in implementing either project. According to FRA officials, the agency lacks authority to compel railroads to participate. According to both FRA and railroad officials, railroads have not chosen to participate in the pilot projects mandated in the legislation because doing so could put a participating railroad at a competitive disadvantage. More specifically, both projects would decrease a railroad's flexibility to assign covered train employees to report as circumstances warrant—in the first case by requiring advance notice of at least 10 hours, rather than the typical practice of 2 to 4 hours notice, and in the second case by reducing the pool of employees on call by half. Because freight railroads try to work to accommodate their customers, often with last-minute scheduling changes, it is important for them to remain flexible so they can compete with other railroads and other modes of transportation, such as trucks.

While FRA was unable to conduct the two pilot projects mandated in RSIA, it still has authority to approve voluntary pilot projects. This authority, which predates RSIA, allows FRA to approve joint petitions from railroads and nonprofit employee labor organizations representing directly affected covered service employees of the railroads for waivers of compliance with the hours of service law in order to demonstrate the

[55]Pub. L. No. 110-432, Div. A., § 108 (e)(1). RSIA requires the Secretary of Transportation to report to the Senate Committee on Commerce, Science and Transportation and the House Committee on Transportation and Infrastructure no later than December 31, 2012, or if no projects are approved prior to that, no later than 6 months after the completion of a pilot project. Pub. L. No. 110-432, Div. A., § 110.

possible benefits of implementing alternatives to strict adherence to the law, including requirements for maximum on-duty and minimum off-duty periods.[56] According to FRA officials, there was little interest in obtaining waivers for pilot projects prior to the passage of RSIA. Since May 2009, however, FRA has received five petitions for waivers of compliance with hours of service requirements in order to implement voluntary pilot projects. FRA dismissed two of these petitions, because they were not filed jointly, as required, by a railroad and the employee labor organizations representing the affected employees. FRA approved two other petitions for pilot projects requesting waivers, but both were designed to provide administrative alternatives rather than alternatives to the requirements concerning maximum on-duty and minimum off-duty periods.[57] In approving these petitions, FRA noted that because the proposed pilot projects were administrative in nature, they would not impinge on the likely performance or safety of the railroads. Finally, FRA rejected one petition that was designed to identify alternatives to the hours of service laws for addressing fatigue. This petition, filed by the ASLRRA on behalf of its members, sought approval for a pilot project that would, among other things, develop and identify alternative methods to mitigate the risk of fatigue without strict adherence to the new hours of service requirements. While acknowledging that ASLRRA raised salient issues for short-line and small railroads, FRA rejected the petition, noting that it lacked a thorough explanation of the conditions and controls under which the pilot project would be operated to ensure the safety of railroad operations and participating employees. Moreover, according to FRA, the petition failed to identify what additional relief from the hours of service laws was necessary to implement the pilot project.

Other than the petition filed by ASLRRA, FRA has received no petitions for waivers of compliance with hours of service requirements in order to implement voluntary pilot projects that could demonstrate the fatigue-

[56]For railroads without labor organizations, FRA requires that the railroad consult with directly affected covered service employees.

[57]In both of these cases, the railroads in question will split their workforces when calculating their covered employees' 276-hour monthly work hour cap. Half of the workforce will have its hours calculated from the first to the last of the month, and the other half will have its hours calculated from the 15th of the month to the 14th of the following month. The intent of this effort is to avoid the possibility that a large portion of the railroad's covered employees will be at or near the cap at the end of the month, and be unavailable to work. This assurance will allow railroads to continue their operations uninterrupted.

reduction potential of alternatives to RSIA provisions. Information gathered from railroads operating monitored pilot projects could be analyzed to assess the effectiveness of specific practices being used to reduce fatigue. Such information could also be used to examine the effects on safety of, for example, increasing rest requirements for some shifts that extend into night hours, providing fewer hours of rest for employees resting away from their home terminal, or decreasing rest requirements for those covered employees working only regular daytime shifts. The results of such analysis could be used to inform the RSIA-required report to Congress by December 2012 on the effectiveness of the voluntary pilot projects.

Waivers of Hours of Service Requirements

Even though no pilot projects currently afford opportunities for gathering and analyzing data on the safety effects of alternatives to the new hours of service requirements, FRA could obtain such data from railroads operating with approved waivers of compliance with the new hours of service requirements. FRA has the authority to approve petitions for waivers of the statutory requirements related to the consecutive work day limits if a collective bargaining agreement provides for a different arrangement, and such an arrangement is in the public interest and consistent with railroad safety.[58] As of June 30, 2011, FRA had received 17 petitions for waivers of compliance with hours of service requirements and had fully approved 8 of them, including 1 filed by ASLRRA that covers 142 of its member railroads.[59] In total, 157 railroads have approved waivers of compliance with hours of service requirements, 2 of which are class I railroads. The remainder are class II or III railroads. The approved waivers recognize that the risk of fatigue is greater for night shifts than for day shifts, as discussed earlier in this report. Specifically, all of the approved waivers allow scheduled shifts of 6 consecutive work days followed by 24 hours' rest (6 by 1 schedules), rather than the 48 hours' rest (6 by 2 schedules) required by law, provided that the shifts during those 6 consecutive days do not extend into the hours between

[58] 49 U.S.C. § 21103(a)(4).

[59] In addition to these 17 petitions, FRA approved one railroad's petition for an emergency waiver of the hours of service requirements in order to support flood relief efforts along the Missouri River in June 2011. Because this was an emergency waiver, we excluded it from our analysis. The ASLRRA petition originally covered 301 railroads, but some did not meet the joint filing requirements to obtain the waiver. FRA determined that 142 railroads met the requirements.

midnight and 6 a.m. Table 4 provides information on the disposition of the waiver petitions submitted to FRA from May 2009 through June 2011.

Table 4: Disposition of Petitions for Waivers of Limitations on Hours of Service for Railroad Employees, May 2009 through June 2011

Disposition of petition (number of petitions)	Description
Approved (8)	24 hours' rest (rather than 48 hours as required in law) following 6 consecutive days of shift starts, provided that those 6 days do not extend into the hours between midnight and 6 a.m.
Partially approved (1)	Approved 24 hours' rest (rather than 48 hours as required in law) following 6 consecutive days of shift starts, provided that those 6 days do not extend into the hours between midnight and 6 a.m. However, denied a waiver for on-call employees on a pattern of 11 days on call and 3 days off.
Denied (1)	Waiver of the 276-hour total monthly work hour cap for management employees who engage in limited covered service for no more than 25 percent of their hours during a month.
Dismissed (3)	Petitions did not meet the requirements for a joint filing by a railroad and the labor organization representing the directly affected employees (or for employee concurrence where there is no labor organization representation). In addition, one petition requested a waiver from a provision that FRA does not have the authority to waive.
Withdrawn (2)	One railroad withdrew to be included in the ASLRRA petition, while the other withdrew its petition and sought no other relief.
Pending decisions (2)	Both petitions request approval for 24 hours' rest (rather than 48 hours as required in law) following 6 consecutive days of shift starts.

Source: GAO analysis of FRA data.

RSIA did not require FRA to collect data or report on the safety effects of approved waiver petitions, as it did for the voluntary pilot projects, and FRA has not taken steps to do so. According to an FRA official, establishing a level of fatigue among employees working under the conditions of one of the approved voluntary waivers would require an evaluation of the employees' work and rest schedules using a fatigue model such as FAST. The easiest way to collect such data, the official said, would be to have inspectors evaluate these employee schedules at randomly selected railroads. The official acknowledged that having data about railroads operating under waivers could help determine the feasibility of alternatives to RSIA's current requirements, such as a modification of the requirement for 48 hours' rest after 6 consecutive work days for certain scheduled shifts.

Conclusions

Since RSIA was only recently implemented, it is still too early to determine whether its changes to hours of service requirements will materially affect freight railroad safety. Initial indications are positive, as our analysis of selected covered T&E employee work schedules shows. Rest time for these employees has increased, and the amount of time they work at a high risk of fatigue has decreased—up to about 36 percent for some railroads. However, as can be expected of changes in laws to improve safety, these benefits have also resulted in some costs to both railroad employees and the industry. Our work shows that some covered employees saw reductions in their work hours and, according to information from our survey of the railroad industry and related interviews, many railroads made changes in crew and train schedules, incurred additional costs to hire new employees or bring employees back from furlough to maintain operations and comply with the law, and saw reductions in their ability to provide service to customers when and where needed. More important, although the time spent working at a high risk of fatigue decreased for some T&E employees, RSIA did not address work performed during night hours, which, according to both scientific literature and our analysis of covered T&E employee work schedules, represents a major factor in fatigue risk. Therefore, opportunities for reducing the risk of fatigue remain, especially since night work is integral to freight rail operations. Moreover, we believe further analysis of the safety implications of both day and night work, and of actions that could be taken to mitigate the associated fatigue risks, could point to opportunities for trade-offs that would reduce the overall risk of fatigue yet potentially allow for a relaxation of RSIA provisions that railroads and employees said were particularly burdensome to them—such as the consecutive work day limits before mandatory rest.

The federal government also plays an important role in helping promote safe railroad operations through its inspection and enforcement actions. FRA's risk-based approach to oversight is intended to align the agency's inspection and enforcement resources with risks. The NIP provides a good foundation for doing this, including the use of local input to ensure resources are focused on the specific risks that may lead to accidents. As we saw from the data, it is too soon to determine if the emphasis FRA has so far given to hours of service requirements best aligns with the risks associated with the RSIA changes and this will bear watching going forward. Additionally, in our view, FRA is missing opportunities to better identify the potential costs, benefits, and safety implications of alternatives to the current hours of service requirements. While voluntary pilot projects were envisioned in RSIA and offer the opportunity for FRA and railroads to try alternative approaches and learn from them, interest

from the industry has, to date, been low. Realizing the full benefits from pilot projects will require additional outreach to the rail industry and other stakeholders to generate ideas on how pilot projects could be structured so they generate interest and participation, including ways to minimize potential competitive disadvantages to participants. Both pilot projects and waivers could generate information that would be of use in aligning oversight resources with risks, analyzing fatigue issues, and deciding how to reduce fatigue risks in the railroad industry, as well as informing FRA's December 2012 report to Congress on voluntary pilot projects.

Recommendations for Executive Action

To ensure that FRA's implementation of hours of service requirements in the freight railroad industry maximizes opportunities to reduce the risks of accidents and incidents related to fatigue, we recommend that the Secretary of Transportation direct the Administrator of FRA to take the following action:

- Evaluate and develop recommendations about the relative impact of consecutive days worked and work performed during night hours on the potential for fatigue and risk of accidents in the freight railroad industry. This evaluation should attempt to determine if taking night work into consideration in the hours of service limitations (such as by requiring more rest after night work) would enable some relaxation of the current limits on consecutive days worked before rest is required in such a way that the same or better overall reduction in fatigue risk occurs while mitigating negative effects on employees and railroad operations. In performing this evaluation, FRA should consider scientific and medical research related to fatigue and fatigue abatement and data from pilot projects and waivers of compliance with hours of service requirements that relate to fatigue levels and consecutive days worked and work performed at night. FRA should also communicate the results of the evaluation to appropriate congressional committees for their consideration.

To improve FRA's targeting of its inspection resources and understanding of the effect of work hours on fatigue, we recommend that the Secretary of Transportation direct the Administrator of FRA to take the following action:

- Work with the railroad industry to identify pilot projects that could be implemented to test the fatigue reduction potential of alternatives to the current hours of service laws. Also, collect safety indicator and accident and incident data from participants in pilot projects and railroads with waivers of compliance with hours of service

requirements to determine the effects of such pilot projects and waivers on covered employee fatigue and participant safety performance. FRA should then incorporate the results of both efforts into the risk assessment process used to determine the allocation of inspection resources and report the results to appropriate committees of Congress.

Agency Comments and Our Evaluation

We provided a draft of this report and the e-supplement to DOT for review and comment. We met with FRA officials, including the Deputy Chief Counsel, on September 19, 2011. DOT expressed concerns about a portion of our second recommendation that it incorporate activity-level data into the NIP's development of inspection priorities and that it add a code for hours of service issues to the Accident and Incident Reporting System. According to DOT, the NIP provides a comprehensive framework to manage hundreds of competing inspection activities—including hours of service inspections—and incorporating activity-level data as we suggested would imply a level of precision that does not exist. DOT also emphasized the value of FRA inspectors' input into the priority-setting process and suggested that an increased reliance on data could reduce FRA's flexibility and efficiency in responding to and managing local issues. In addition, DOT considered adding an hours of service code to the Accident and Incident Reporting System redundant, since railroads are already required to report excess service hours to FRA every month. Furthermore, FRA said that adding such a code would not be helpful, since an hours of service violation may not indicate fatigue. According to FRA officials, a covered employee could be fatigued while complying with hours of service requirements or a covered employee could be noncompliant with hours of service requirements without being fatigued. FRA officials told us that accidents and incidents generally occur because someone misaligned a switch, failed to observe a signal, or failed to take some other physical action. These may or may not have been caused by fatigue but adding a code for hours of service would not indicate fatigue levels. FRA officials noted that several cause codes in the Accident and Incident Reporting System can indicate fatigue and that FRA investigators follow up to assess the role of fatigue when railroads identify those codes as causes of accidents. FRA officials also noted that a review of recent reports on rail accidents, including reports from the National Transportation Safety Board, found none that identified hours of service as a cause of an accident.

After we met with FRA officials, they provided additional information on how FRA uses activity-based inspection data (including hours of service

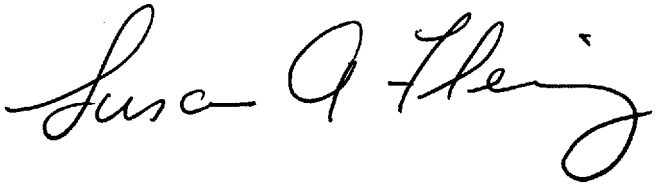
data) to develop the NIP and furnished us with a list of codes included in the Accident and Incident Reporting System that show some correlation with fatigue. In light of our discussions with FRA and our analysis of the information it subsequently provided, we withdrew the portions of our second recommendation that FRA incorporate activity-level data into the risk assessment process and add one or more codes to the Accident and Incident Reporting System to identify the role of hours of service in railroad accidents. The information provided by FRA shows that hours of service activity-based data is being used to develop the NIP and adding one or more codes to the Accident and Incident Reporting System for hours of service might not be helpful in identifying broader issues of the role fatigue plays in accidents. Rather, such information is more likely to come from FRA's accident investigations, which can also identify if violations of hours of service requirements play a role in rail accidents.

FRA officials also raised concerns about the wording of some definitions used in our survey of the rail industry about hours of service issues. FRA questioned whether the rail industry was familiar enough with requirements of the law so that the definitions we used did not result in inaccurate responses. We did not change the wording of the definitions contained in the survey presented in our e-supplement to this report as a result of FRA's comments because the e-supplement is meant to present the survey as it was made available to respondents. We believe the information provided by the survey is accurate and respondents understood our survey and RSIA requirements sufficiently to provide appropriate responses. To this end, we fully pretested the survey prior to administering it; pretest participants raised no substantive concerns about the terms defined in the survey. Our e-supplement product (GAO-11-894SP) contains additional information about FRA's comments.

DOT also provided technical comments that we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution of this report until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of Transportation, the Administrator of FRA, and the Director of the Office of Management and Budget. The report will also be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or flemings@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix III.



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Appendix I: Objectives, Scope, and Methodology

To better understand the changes to freight railroad hours of service requirements made by the Rail Safety Improvement Act of 2008 (RSIA), we reviewed the (1) impacts of the hours of service changes on the covered train and engine (T&E) workforce, including potential impacts on fatigue; (2) operational and administrative impacts of the hours of service changes on the railroad industry; and (3) actions taken by the Federal Railroad Administration (FRA) to oversee compliance with hours of service requirements and implement RSIA provisions related to hours of service pilot projects and waivers.

The scope of this engagement was limited to the freight railroad industry. The RSIA hours of service requirements became effective for these railroads on July 16, 2009. We did not include commuter and intercity passenger railroads, since at the time of our work FRA was in the process of developing new hours of service requirements for these railroads. Our scope included freight railroads of all sizes. The freight railroad industry is divided into three classes: I, II, and III, based on their operating revenues. In 2009, annual operating revenues were at least $378.8 million for class I railroads, between $30.3 million and $378.8 million for class II railroads, and less than $30.3 million for class III railroads. The class designation differs slightly from another designation that FRA uses for accident and incident reporting, under which railroads are divided into groups. FRA's group 1 is equivalent to class I. The division between groups 2 and 3 is based on the total number of annual work hours reported to FRA. Group 2 railroads report 400,000 or more total annual work hours but are not class I railroads, and group 3 railroads report less than 400,000 total annual work hours. According to FRA officials, groups 2 and 3 are not necessarily the same as classes II and III, but the differences may not be large. For reporting purposes we use the class designation because (1) it is a common means of identifying railroads and (2) the railroads included in class II or III may not be significantly different from those in group 2 or 3, respectively.

The following describes some of the key methodologies we used to address our objectives.

Structured Collection and Analysis of Covered Employee Work Schedules and Use of Fatigue Models

To address the impacts of the hours of service changes on the covered T&E workforce, including potential impacts on fatigue, we collected and analyzed covered T&E employee work schedule data and used the Fatigue Audit InterDyne™ (FAID) biomathematical fatigue model. We initially requested covered T&E employee work schedules for all 7 class I, 15 class II, and a sample of 86 class III railroads. However, not all the class II and III railroads we contacted had electronic records; instead, most maintained paper-based hours of service records. We determined that the process for collecting and transcribing the paper-based work schedules into electronic format for analysis was not feasible given our time and resource constraints. Accordingly, we focused our data collection on electronic records from class I railroads and those class II railroads that responded to our inquiries and could provide electronic hours of service records. In addition, we conducted focused telephone interviews with 69 randomly sampled class III railroads with 5 or more full-time-equivalent employees covered by hours of service requirements to obtain information about their operations.

For our analysis of electronic hours of service records, we included all work schedules for all covered T&E employees that had work schedule data for both May 2008 and May 2010 and had at least 7 days of scheduled work in both these months. All 7 class I railroads submitted the requested records, and 6 class II railroads[1] provided electronic records that met our requirements. The final data set covers the May 2008 and May 2010 work records for 52,205 class I covered T&E employees and 963 class II covered T&E employees. We selected May 2008 and May 2010 for our analysis because they represent months before and after RSIA's implementation. In addition, choosing the same month for both years helps to avoid any seasonal differences in the rail industry. We also discussed the time frames for our analysis with rail industry representatives, and they generally agreed with our selection. To assess the reliability of the data provided, we performed tests to detect and eliminate anomalies such as duplicate records, overlapping shifts, shifts with start or end time errors, and data for employees who did not work in both time periods. Where appropriate, we contacted railroads to correct these anomalies. We also sent a questionnaire to the railroads to obtain information about the quality control procedures for their electronic

[1]These railroads were the Belt Railway of Chicago, Consolidated Rail Corporation, Indiana Harbor Belt Railroad, Paducah & Louisville Railroad, Port Terminal Railroad, and Wheeling and Lake Erie Railroad.

systems. We determined that the data were sufficiently reliable for the purposes of this report.

Our analysis of employee work schedules was focused on answering key questions designed to identify the effects of RSIA's changes on the covered T&E workforce, such as whether total work time changed. We analyzed class I and class II work schedules separately because this approach allowed us to recognize there may be operational differences between the two classes of railroads. Among other things, we examined work schedule data to determine the total hours worked, total shifts worked, total rest time, and total hours worked at night[2] in both time periods for both classes of railroad. Total hours worked and total shifts worked were measures we used to determine if there were impacts on the amount of work performed. We used total hours of work and total hours worked at night along with fatigue model outputs as measures for estimating the impact of night work on fatigue risk levels.

We estimated fatigue risk levels for work schedule data using the FAID model, a biomathematical fatigue model that has been used for fatigue analyses of railroad work schedules. FRA has validated FAID, as well as the Fatigue Avoidance Scheduling Tool™ (FAST), for use in analyzing the railroad employees' fatigue risk levels—the only two models that FRA had validated for such use at the time of our work. The FAID model is commonly used in the railroad industry for fatigue analysis, and FRA has used FAST to conduct fatigue analyses for regulatory purposes (such as reviews of petitions for waivers of compliance with hours of service requirements). We performed separate fatigue model analyses for class I and class II railroads and included in our analyses all the work schedules in our final data set for both class I and class II employees.

In conducting our fatigue analyses, primarily using the FAID model, we established a tolerance level—that is, a fatigue score that, if breached, indicates a potentially unacceptable level of fatigue risk. We selected a fatigue score of 70 as the threshold for high risk of fatigue, scores of 61 through 69 for elevated risk of fatigue, and scores below 60 for acceptable risk of fatigue. Fatigue experts, the rail industry, and FRA differ on acceptable fatigue risk score thresholds. We selected 70—a

[2]For the purposes of our analysis, we defined night work as work preformed between the hours of 11 p.m. and 6 a.m.

conservative score—as our threshold for high risk of fatigue partly because FRA, in its FAID validation and calibration report,[3] said a FAID score greater than 70 would indicate extreme fatigue and partly because we wanted to err on the side of caution in our use of the model for fatigue analysis. After our analysis was performed FRA issued its final hours of service rule for passenger rail employees that set the high fatigue threshold for FAID at 72. Additionally, we used the FAID model as its producer and fatigue experts directed, that is, to analyze aggregate-level data to determine fatigue risk among the covered workforce or to analyze generic examples of work schedules to determine fatigue risk. We did not use the fatigue models to determine fatigue risk for individual covered employees.

To better understand the relationship between night work and fatigue we examined whether the number of hours employees worked at night was correlated with spending time at high risk of fatigue according to the outputs of the FAID fatigue model. In particular we calculated the correlation between night hours and the incidence of employees spending at least 20 percent of their hours at high risk of fatigue. We chose the 20 percent of time at high risk to be consistent with FRA's commuter and intercity rail final hours of service rule, in which a fatigue model indicating that 20 percent or more time spent at high risk of fatigue would trigger further mitigation of a rail work schedule by railroads and approval of mitgation by FRA. The correlation coefficient was 0.53.

Both the data we collected and the analysis we performed have limitations. As we discussed earlier, an economic recession began in 2008 and it affected the demand for rail services significantly. For the months we collected rail workers' schedules, May 2008 and May 2010, overall rail operations were different, with considerably higher levels of overall rail service in 2008. Although our findings on the differences in work schedules across these time periods may be, in part, a reflection of the differences in the macroeconomic environment, we attempted to mitigate that factor in two ways. We avoided choosing months during which the demand for rail service was rapidly declining. In May 2008, the recession was not greatly impacting the rail industry and by May 2010, demand was picking up from its lows during late 2008 and 2009. Also, we

[3]FRA, *Procedures for Validation and Calibration of Human Fatigue Models: The Fatigue Audit InterDyne Tool*, DOT/FRA/ORD-10/14 (Washington, D.C.: November 2010).

only used employees that worked in both months under the assumption the same employees would likely be performing similar work tasks in the two periods.

Additionally, the fatigue models have limitations. In particular, fatigue models are developed around an average person as the base point. Fatigue models do not consider situations specific to an individual that could influence whether an individual's fatigue levels and score are the same as or different from those calculated by the model. Finally, the models incorporate assumptions about sleep time and sleep quality, since it is not possible to determine how long or how well a specific individual sleeps during non-work time. Even with these limitations, we determined that the rail data and fatigue model results were sufficiently reliable for the purposes of this report.

Survey of the Railroad Industry

To identify the operational and administrative impacts of the RSIA hours of service changes on the railroad industry, we conducted a web-based survey of railroads. To identify survey participants, we used FRA's 2009 Accident and Incident Reporting database.[4] In general, federal regulations require that all U.S. railroads report monthly to FRA on accidents and incidents that occur on their railroads.[5] Exceptions include such railroads as those that operate freight trains only on track inside an installation that is not part of the general railroad system of transportation and rail mass transit operations in urban areas that are not connected to the general railroad system of transportation.[6] Reports are to be made about accidents or incidents that occurred during a month or to indicate that no accidents or incidents occurred. As noted, FRA reports accident

[4]Accidents and incidents is a term used to describe an entire list of reportable events, including fatalities, injuries, and illnesses; collisions, derailments, and similar accidents involving the operation of on-track equipment causing reportable damage above an established threshold; and impacts between railroad on-track equipment and highway users at crossings. The 2011 damage threshold for reporting accidents and incidents is $9,400.

[5]The monthly report must be submitted within 30 days following the month to which it applies. See 49 C.F.R. §§ 225.11 and 225.19. See 49 C.F.R. Part 225 for accident and incident reporting requirements.

[6]FRA also exempts certain railroads that haul passengers inside an installation that is insular—that is, generally has no public highway-rail grade crossings or bridges over public roads or waters used for commercial navigation and does not share a common corridor with another railroad.

and incident data for class I (excluding the National Railroad Passenger Corporation, or Amtrak), class II, and class III railroads. To ensure the reliability of FRA's database for our purposes, we (1) reviewed federal regulations to better understand which railroads are required to report accident and incident data and which railroads might be exempt from reporting, (2) reviewed relevant database documentation, including FRA's guidelines for reporting accidents and incidents, to understand what data are reported and what controls are used to ensure the reported data are accurate and reliable, and (3) interviewed FRA officials and reviewed FRA written responses to our questions to understand the controls FRA used to ensure the data were accurate and reliable. Based on these steps, we believe the database was sufficiently reliable for our needs.

We used FRA's Accident and Incident Reporting database, since it contained the most recent data available on U.S. railroads at the time we performed our work. We excluded from the database passenger-related railroads, tourist and historic railroads that had limited operations, railroads exempt from reporting, and newly started railroads that had not yet built up a record of accidents and incidents. The universe of freight railroads surveyed included all 7 class I railroads, all 15 class II railroads, and all class III railroads that had five or more full-time-equivalent employees (based on work hours reported to FRA) covered by hours of service requirements in 2009. We chose five full-time-equivalent employees as our threshold to, among other things, eliminate railroads that (1) might be too small to have hours of service impacts, (2) operate only part of the year (seasonal or intermittent operators), and (3) have only a few employees who may be used as needed for operations only within a plant or other manufacturing facility. The survey selections were designed to include participants from all three classes of railroads representing large, medium, and small entities. We calculated the percentage of full-time-equivalent employees covered by hours of service requirements based on discussions with FRA officials and estimates of the percentage of the railroad employee population covered by hours of service requirements used by FRA in previous rulemakings. Out of the 561 class III railroads in the database, we calculated there were 234 with five or more full-time-equivalent employees covered by hours of service requirements. We determined that two of these railroads were not eligible for the survey because one was not a railroad (it was a centralized dispatching center for several railroads) and one had ceased operations in 2009 and, according to an official from this railroad, had no experience with the RSIA hours of service changes. In total, we surveyed 254 railroads—7 class I railroads, 15 class II railroads, and 232 class III railroads.

To develop our survey questions, we relied on a comprehensive list of questions that we used to interview railroads about hours of service issues before we conducted the survey. We identified key issues from the railroads' responses to the questions and used these to develop the survey questionnaire. In addition, we conducted four pretests of the survey, one with a class I railroad, one with a class II railroad, and two with two class III railroads. Two pretests were done in-person and the other two were done over the telephone. The railroads were selected to get a variety of large, medium, and small railroads. During the pretests, we obtained feedback on such things as the type of questions being asked, the clarity of the questions, and whether additional issues should be included. We used this feedback to revise the survey instrument, including adding questions to cover additional issues and clarifying certain survey questions. After completing the survey questions, we sent an e-mail announcement of the survey to the 256 railroads initially included in our survey (including the 2 that we subsequently excluded as ineligible) on January 10, 2011. These railroads were notified that the questionnaire was available online and were given unique passwords and usernames on January 13, 2011. We sent follow-up e-mail messages on February 1, February 16, and March 16, 2011, to those railroads that had not yet responded. We conducted the survey from January 13, 2011, to April 15, 2011.

Because we did not survey a sample of railroads, our survey has no sampling errors. However, the practical difficulties of conducting any survey may introduce nonsampling errors. For example, difficulties in interpreting a particular question, or the type of information available to some respondents but not others, could introduce unwanted variability into the survey results. We took steps in the data collection and data analysis stages to minimize such nonsampling errors. As we previously indicated, we collaborated with GAO survey specialists to design a draft questionnaire and pretested versions of the questionnaire with four members of the survey population. From these pretests, we made revisions as necessary to reduce the likelihood of nonresponse and reporting errors on our questions. We examined the survey results and performed computer analyses to identify inconsistencies and other indications of error and addressed such issues, where possible. A second, independent analyst checked the accuracy of all computer analyses to minimize the likelihood of errors in data processing. In addition, GAO analysts answered respondents' questions and resolved difficulties that respondents had in answering our questions.

The overall response rate for this survey was 72 percent, with 7 out of 7 of class I railroads, 14 out of 15 class II railroads, and 163 out of 232 class III railroads responding. An analysis of the distribution of variables for the respondents related to the size of the railroads was compared to the distribution of these variables in the entire population of railroads, and no important distributional differences were found.

In addition to the data from the survey provided in this report, each survey question, along with responses to it, is presented in GAO-11-894SP, an electronic supplement to this report.

Analysis of FRA Inspection and Enforcement Data

To determine the extent to which FRA conducts inspections of railroads' compliance with hours of service and hours of service recordkeeping requirements, we obtained information from FRA's Railroad Inspection System for PC. This system allows inspectors to enter inspection data via their personal computers in order to maintain electronic records. FRA provided data for all inspections conducted by FRA inspectors from fiscal year 2005 through fiscal year 2010. We then excluded data for inspections of all entities that were not freight railroads. From the remaining data, we identified the number of hours of service and hours of service recordkeeping inspections that were conducted on freight railroads during this 6-year period. We analyzed inspection results by class of railroad and determined the frequency with which deficiency findings identified during inspections resulted in an enforcement activity.

To identify the enforcement actions FRA has taken in response to noncompliance with hours of service and hours of service recordkeeping requirements, we obtained data from FRA's Railroad Enforcement System. FRA's Office of Railroad Safety enters the information related to violations that have been recommended for citation against railroads and others in the Violation Generation Tracking System database, which populates the Railroad Enforcement System, which in turn is used by attorneys and staff to support the enforcement process. The data we obtained included all enforcement actions taken by FRA from the start of fiscal year 2005 through the end of fiscal year 2010. From this information, we identified all hours of service and hours of service recordkeeping violations involving freight railroads. We reviewed the data to identify the extent to which FRA pursues enforcement actions for hours of service violations, as well as the dollar amount it assesses in the form of fines and penalties.

To assess the reliability of the inspection and enforcement data provided by FRA, we reviewed previous GAO reports about FRA's databases and FRA's efforts to ensure the data's reliability and conducted electronic testing of required data elements to identify omissions, anomalies, or obvious errors. In addition, we interviewed agency officials knowledgeable about the data quality control procedures and the data produced by the systems. We also determined whether the databases we used had been audited either internally or by external organizations. We determined that the data were sufficiently reliable for the purposes of this report.

Additional Methodologies

To further address our objectives, we reviewed laws and regulations related to hours of service issues and reviewed various studies and other documents. To address impacts of RSIA's hours of service changes on the covered T&E workforce, including potential impacts on fatigue, we reviewed literature related to fatigue and work schedules and reviewed two reports prepared by FRA to validate the usability of the fatigue models FAST and FAID to assess the fatigue risk associated with railroad covered employee work schedules.[7] These two reports provided information on such topics as how the models assess fatigue levels, assumptions used in making such assessments, how fatigue scores relate to the probability of accidents, and limitations of the model results. This information guided our use of the models to assess fatigue risk in the work schedules we reviewed. We also reviewed FRA's March 22, 2011, Notice of Proposed Rulemaking on new hours of service requirements for commuter and intercity passenger railroads, FRA's Regulatory Impact Analysis associated with this rulemaking, and the final hours of service rules which were issued in August 2011.[8] In particular, we were interested in FRA's evaluation of fatigue risk associated with consecutive days worked and work performed during night hours.

To address FRA's actions to ensure compliance with hours of service requirements, we reviewed documentation related to the National Rail Safety Action Plan, National Inspection Plan, and National Safety

[7]FRA, *Validation and Calibration of a Fatigue Assessment Tool for Railroad Work Schedules*, Final Report DOT/FRA/ORD–08/04 (Washington, D.C.: November 2008), and FRA, DOT/FRA/ORD—10/14 (Washington, D.C.: November 2010).

[8]76 Fed. Reg. 50630 (Aug. 12, 2011).

Program Plan. We also obtained selected FRA regional inspection plans to identify how inspection resources are allocated at the local level. Finally, we obtained data on petitions filed by railroads and others from May 2009 through June 2011 for waivers of compliance with hours of service requirements. These data included information on who filed petitions, when they were filed, and what their status was as of June 2011. We verified these data with FRA and confirmed the status of each petition with FRA officials.

To address our objectives, we also interviewed relevant individuals and organizations, including the following:

- *Federal officials*, including those from the National Transportation Safety Board, FRA headquarters, and FRA regions 3, 4, 5, and 6. We selected these regional offices because we were already doing other work in the regions and the offices are geographically dispersed across the country. These four regional offices accounted for 60 percent of the hours of service inspections conducted from fiscal year 2005 through fiscal year 2010, and their territories cover all or parts of 23 states. We discussed with FRA the methods and procedures used to assess the fatigue risk in the railroad industry, the potential operational and administrative impacts of RSIA's hours of service changes on the railroad industry, and the processes and procedures FRA uses to ensure compliance with hours of service requirements. We also discussed FRA's actions to implement pilot projects related to hours of service and FRA's handling of petitions for waivers of compliance with hours of service requirements and the status of these petitions.

- *Fatigue and sleep research experts.* We interviewed officials from the firms involved in developing the FAST and FAID models, the Institute of Behavioral Research and InterDynamics, Inc., respectively, as well as fatigue and sleep research experts. Our discussions with the model developers focused on how and why the models were developed, what assumptions were used in the modeling process, how we should use the models to assess fatigue risk in the railroad industry, and what limitations might be associated with the model results. After we acquired the models, officials from these companies also trained us in how to use the models and how to interpret their results. We also interviewed four experts in fatigue research. We spoke with these individuals about issues related to work and fatigue and factors relating to the potential for fatigue risk. We also solicited their views

about fatigue models in general and the two fatigue models we acquired to analyze covered employee work schedules.

- *Railroad and railroad trade association officials.* We interviewed officials from all 7 class I railroads, 6 class II railroads, and 6 class III railroads as well as officials from a holding company that was the parent company for 39 class III railroads and 1 class II railroad. We discussed such issues as the effects of the hours of service changes on railroads and the covered workforce and the federal role in hours of service. We also discussed hours of service issues with officials from the Association of American Railroads, which represents the interests of class I railroads and the National Railroad Passenger Corporation, and the American Short Line and Regional Railroad Association, which primarily represents the interests of class II and III railroads. We also spoke with officials from the American Public Transportation Association about work they were doing to develop hours of service requirements for commuter and intercity passenger railroads. We were particularly interested in their views on the relationship between railroad work schedules and the potential for fatigue.

- *Representatives of labor organizations.* We interviewed representatives from the Brotherhood of Locomotive Engineers and Trainmen, American Train Dispatchers Association, United Transportation Union, Transportation Communications Union, Brotherhood of Railroad Signalmen, National Conference of Firemen and Oilers, and the Transportation Trades Department of the AFL-CIO. These organizations represent various employees that would be covered by railroad hours of service requirements, including train and engine employees, signalmen, and dispatchers. According to these organizations, they represent over 100,000 employees covered by hours of service requirements. We solicited their views on the effects of RSIA's hours of service changes on their members, the benefits of these changes, and the federal role in monitoring and enforcing hours of service changes. We also solicited their views on waivers and exemptions to hours of service requirements for which railroads have applied.

We conducted this performance audit from April 2010 to September 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: The Development of Biomathematical Models of Fatigue

This appendix discusses (1) why concerns about fatigue in the modern workplace have increased, (2) the nature of biomathematical models that have emerged to better understand sleep-work schedules and fatigue, and (3) GAO's use of biomathematical fatigue models for analyzing the effect on workers of RSIA's hours of service changes.

Workplace Fatigue Is a Growing Concern in Modern Industrial Society

Over the past several decades, technology has enabled, and the globalization of society has increasingly come to expect, round-the-clock activities. Society has become "24/7." Planning for sleep is difficult when work schedules are unpredictable, and work that takes place outside normal business hours often requires people to sleep when humans are normally awake. These characteristics of the modern work world have led to a growing concern about human fatigue and its consequences in the workplace. These issues are particularly important to the rail industry, since rail workers often work on short notice and rail operations often occur at night.

When a person does not get enough sleep, certain areas of the brain involved in cognition are affected, engendering fatigue and an associated state of diminished capacity. This diminished capacity can have a variety of ramifications that may be of concern. For example, when fatigued, humans have more difficulty maintaining attention, become less communicative, and have reduced situational awareness. They are then at greater risk of committing errors in their work, which can ultimately lead to more accidents. Concern about these effects has led to the development of tools for better understanding worker fatigue, predicting its extent, and mitigating its effects.[1]

[1]David Neri, "Preface: Fatigue and Performance Modelling Workshop, June 13–14, 2002," *Aviation, Space, and Environmental Medicine*, Vol. 75, No. 3, Section II (March 2004).

Biomathematical Models Have Been Developed to Estimate Workplace Fatigue

Over the past several decades, a science has developed that examines the nature of human sleep and the effects of sleep deprivation. More recently—in about the past 20 years—a variety of researchers have developed tools that are designed to use data on individuals' sleep-wake patterns to estimate a variety of outcomes such as fatigue, cognition, and accident risk. Most of the current models are based on or informed by what is known as the "two-process model" of sleep regulation, developed in the early 1980s.[2]

Generally, the two-process model posits that alertness is a function of two primary factors:[3]

- *The status of sleep/wake balance.* The first factor rises and falls based on time spent sleeping and time spent awake. The model essentially posits that a person's alertness decays during waking hours and is restored with sleep and that the patterns of decay and restoration are reasonably predictable. The longer a person is awake, the more fatigued that person will become, and the associated reduction in alertness increases the risk of errors and accidents. Alertness can only be restored through sleep, and the model generally assumes that the first few hours of sleep contribute the most to recovery. That is, sleep intensity is greatest when sleep debt is at its greatest, which is during the first few hours of sleep.

- *Circadian influence.* The second factor is related to circadian rhythm. Essentially, humans are hard-wired to sleep during the night and to be awake during the day. When people do sleep during the day, their rest is seldom as restorative as night sleep. First, it is apparently difficult to sleep during the day when core body temperatures are higher. Second, day sleep may be more prone to disruptions that limit its benefit. Third, the circadian pressure to sleep is highest at night, so humans tend to be less alert and more prone to lapses in attention at

[2]Drew Dawson, Y. Ian Noy, Mikko Härmä, Torbjorn Åkerstedt, and Gregory Belenky, "Modelling Fatigue and the Use of Fatigue Models in Work Setting," *Accident Analysis and Prevention* 43 (2011) 549-564, and Melissa M. Mallis, Sig Mejdal, Tammy T. Nguyen, and David F. Dinges, "Summary of the Key Features of Seven Biomathematical Models of Human Fatigue and Performance," *Aviation, Space, and Environmental Medicine*, Vol. 75, No. 3, Section II (March 2004).

[3]A third factor, referred to as "sleep-inertia" is also included in some so-called "three-process models of sleep." This factor adjusts for a lag in fully obtaining predicted alertness just after awakening.

times when sleep normally occurs. Thus, fatigue—independent of the first factor, which addresses the extent of sleep deficit—tends to accrue more quickly when people work at night.

While most of the current biomathematical models of fatigue incorporate these factors into their analysis, they differ in how the factors are structured. In particular, there is variation in the assumptions about function form and other mathematical underpinnings to the models. For example, there may be differences in how the rate of decay in cognition with waking hours is formulated, or the manner in which circadian factors are accounted for in the formulas. Moreover, the models vary in the specific outputs they provide. And finally, they vary in terms of the inputs necessary. Some require actual sleep histories, while others infer how much sleep a person would be likely to obtain from the person's work hours.

The development of biomathematical fatigue models is very recent, and the models have critical limitations that are important for interpreting and using their outputs. The models provide a suggestion about the alertness of humans generally, not of individuals. Individuals vary widely in how they fatigue for a variety of reasons including differences in their personal circadian rhythms, their health, and social responsibilities.

GAO Acquired Two Models for Use In Analyzing the Effects of Hours of Service Changes on Rail Worker Fatigue

GAO was asked to examine whether and how RSIA's changes to the hours of service laws affect rail worker fatigue. To do this, we determined that, despite the limitations of the current biomathematical fatigue models, there was merit in using them to study predicted fatigue based on railroad workers' history of work schedules before and after the rules were implemented. In particular, we determined, through discussions with several experts in sleep-fatigue research, that using the models to assess the change in scores for a set of workers after the new law was implemented was a reasonable use of these models because our focus is not on the scores of any particular workers, but rather on the trend in overall scores given changed scheduling patterns.

Through discussion with Federal Railroad Administration (FRA) officials and others we determined that, at the time of our work, there were only two current biomathematical fatigue models that had been validated by FRA for use in assessing fatigue in the rail industry and that were appropriate to acquire for possible use in our analysis. We acquired both models. The first, the Fatigue Avoidance Scheduling Tool™ (FAST), was originally developed for military use by Dr. Steven R. Hursh, et al.; the

second, the Fatigue Audit InterDyne™ (FAID) tool, was developed by Gregory D. Roach, Adam Fletcher, and Drew Dawson from the Centre for Sleep Research, University of South Australia. In particular, the FRA validation examined whether the models' predicted level of fatigue correlated with rail accidents deemed to have a "human" causal component, but not with rail accidents that had no identified human cause. FRA found this relationship for both models.

Both of these models require similar data on railroad workers' work schedules and provide generally similar outputs. In particular, both models require data, by employee, on work shift start and end times for the period of time to be evaluated. The FAST model also requires information on the locations of each shift's start and end, and average commute times for those locations. Both models operate by taking this information and inferring the likely sleep employees are obtaining between their work shifts. After estimating how much time and at what time of day employees are awake and asleep, the models estimate—depending on the model—scores for elevated fatigue or reduced effectiveness.

Appendix III: GAO Contact and Staff Acknowledgments

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Staff Acknowledgments

In addition to the individual named above, Sara Vermillion, Assistant Director; Amy Abramowitz; Elizabeth Eisenstadt; Lorraine Ettaro; Patrick Fuchs; Kathleen Gilhooly; Christopher Jones; Richard Jorgenson; Mitchell Karpman; Amanda Miller; Dae Park; and Betsey Ward made key contributions to this report.

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