U.S. Department Of Transportation
Federal Motor Carrier Safety Administration

NOTICE OF PROPOSED RULEMAKING

Electronic On-Board Recorders and Hours-of-Service Supporting Documents

Preliminary Regulatory Evaluation

Regulatory Impact Analysis

Initial Regulatory Flexibility Analysis

Unfunded Mandates Analysis

January 24, 2011

Prepared by
Analysis Division
Federal Motor Carrier Safety Administration
U.S. Department of Transportation

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) or regulatory evaluation provides an assessment of the costs and benefits of requiring motor carriers to use electronic on-board recorders (EOBRs) to track driving and duty time. The Federal Motor Carrier Safety Administration (FMCSA or the Agency) is issuing a Notice of Proposed Rulemaking (NPRM) that this RIA accompanies to improve compliance with the Hours of Service (HOS) regulations for (49 CFR Part 395) commercial motor vehicle (CMV) drivers. EOBRs track driving time and other activities electronically, providing largely the same information currently collected on paper records of duty status (RODS).

A Final Rule on EOBRs for HOS compliance (EOBR I) was published on April 5, 2010, 75 FR 17207,[1] providing the technical requirements for EOBRs and mandating their installation and use for a period of two years on all power units of carriers with recurrent HOS compliance problems, those found in a compliance review to have a 10 percent or greater violation rate (pattern violation) for any regulation in Appendix C to 49 CFR Part 385 ("1X10 Remedial Directive Carriers").[2] FMCSA determined that an approach designed to target only HOS violators would (1) be most likely to improve the safety of the motoring public on the highways in the near term, and (2) effectively utilize motor carrier and Federal and State enforcement resources.

FMCSA proposes to expand the requirement for EOBR use to a larger number of motor carriers and to require these devices to be permanently installed and utilized for tracking of drivers' HOS. This RIA examines three options for the broader EOBR mandate that differ solely on the number of carriers, drivers, and power units affected. Whereas the 1X10 Remedial Directive targeted a relatively small number of carriers, approximately 5,700 firms with 139,000 CMVs, this second EOBR rule could potentially affect the entire motor carrier industry subject to the HOS rules, about 500,000 carriers with 4 million CMVs. The Agency proposes to implement the rule three years after the

1 Final Rule, "Electronic On-Board Recorders for Hours-of-Service Compliance," Fed. Reg. 49, No. 64 (April 5, 2010): 17207-17252.

2 Appendix C, 49 C.F.R. § 385 (2010).

publication of a final rule; this accounts for the time needed for EOBR vendors to produce adequate numbers of the devices.

The Agency gathered cost information from publicly available marketing materials and contact with EOBR vendors. The analysis for EOBR I focused on the least expensive device determined to be compliant with the rule.[3] The Agency has chosen to base its calculations on a higher cost device in this RIA. The manufacturer of the devices used as the basis for the EOBR I is relatively small, and, although the Agency believed that a sufficient number of units for 1x10 remedial directive carriers would be available at this price from this vendor or its competitors, it did not find evidence indicating that a sufficient number of—the Agency estimates that about 2 million will be needed—these least cost units are available for a broad industry mandate. The Agency also has not found any compelling evidence or economic arguments that market forces would cause EOBR device prices to fall. The performance standards for EOBRs require manufacturers to use mature, off-the-shelf technology currently implemented in fleet management systems (FMS) already sold in a large, competitive market. EOBR functionality will likely be added to these devices. The Agency is receptive to comments on its analysis of the EOBR and FMS market.

FMCSA uses a higher cost device such as the one discussed in Appendix B (Alternative Estimates of EOBR Device Costs) of the EOBR I RIA.[4] Although the manufacturer produces more expensive devices than the one evaluated in the EOBR I RIA, the higher costs of its products reflects additional functions and features unrelated to the EOBR HOS tracking feature. The Agency believes the unit considered in this analysis represents a reasonable upper limit for costs. After amortizing purchase and repair costs over time and evaluating monthly operational costs, the per-unit device costs would be slightly higher than those presented in the EOBR I RIA, but the Agency still believes that these costs are not overly burdensome to motor carriers. The Agency has found the range

3 The least expensive device that satisfies the requirements of the proposed rule was found to be the RouteTracker sold by Turnpike Global, now part of Xata Corporation. Cost data are based on the use of this device with the Sprint network. See the EOBR I RIA for a complete discussion of costs of this device.

4 Qualcomm Mobile Computing Platform (MCP) 200.

of device costs to be narrow: Annualized costs for the low cost device were estimated to be $525, and annualized costs for the high cost device were estimated to be $785. - Appendix F of this RIA contains a more detailed discussion of EOBR device costs. Moreover, EOBRs would eliminate or significantly simplify several of the paperwork processes associated with paper RODS, and the monetized paperwork burden reduction offsets most of the device costs for motor carriers and their drivers currently using paper RODS. Appendix F of this RIA contains additional discussion of the availability and prices of EOBRs.

This analysis also evaluates the costs and benefits of motor carriers' improved compliance with the underlying HOS rules through the use of EOBRs. The Agency has updated its assessment of the baseline level of non-compliance with the HOS rules to account for changes in factors such as inflation, a decline in HOS violations that preceded the mandate for EOBR use, and the decline in CMV-related crashes. Included in this analysis as alternative baselines are options from the recently published NPRM for the HOS rules for property carriers. (Option 1 of the HOS NPRM is to retain the current HOS rules) [75 FR 82170 (Dec.29, 2010)]). The major changes for both HOS options is to allow at most 13 hours of on-duty time within the daily driving window; limit continuous on-duty drive time to seven hours, at which point a thirty-minute off-duty or sleeper-berth period would be required; and to require at least two overnight periods per 34-hour restart. HOS Option 2, however, also reduces daily drive time from 11 to 10 hours, while HOS Option 3 retains 11 hours of drive time. To avoid confusion between the HOS options and the options for the EOBR NPRM, HOS Option 2 and HOS Option 3 are referred to as Baseline 2 and Baseline 3.

As stated, the Agency is currently considering three options for the EOBR mandate. Option 1 would be to require EOBRs for all drivers currently using paper RODS. Option 2 (often referred to as "RODS+" in this RIA) expands Option 1 to include nearly all passenger-carrying CMVs and all shipments of bulk quantities of hazardous materials, regardless of whether the drivers use paper RODS or are exempted from doing so as described under the "short-haul operations" provisions in 49 CFR 395.1(e). The Agency believes that the higher potential for injuries and fatalities in crashes involving passenger-carrying CMVs and shipments of bulk hazardous materials could warrant additional safety requirements for these operations. Option 3 would include all CMV operations subject to HOS requirements.

The NPRM being evaluated also proposes changes to the HOS supporting document requirements. The Agency has attempted to clarify its supporting document requirements, recognizing that EOBR records serve as the most robust form of documentation for on-duty driving periods. FMCSA neither increases nor decreases the burden associated with Supporting Documents for HOS Compliance. These proposed changes are expected to improve the quality and usefulness of the supporting documents retained. The improved quality of the supporting documents will subsequently increase the effectiveness and efficiency of the Agency's review of motor carriers' HOS records during on-site compliance reviews, thereby increasing its ability to detect HOS rules violations. The Agency is currently unable to evaluate the extent to which the proposed changes to the supporting documents requirements will lead to reductions in crashes.

The table below summarizes the analysis. The figures presented are annualized using seven percent and three percent discount rates.

Executive Summary. Annualized Costs and Benefits (2008$ millions)

		7 Percent Discount Rate			3 Percent Discount Rate		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,586	1,643	1,939	1,554	1,610	1,900
II	HOS Compliance Costs	398	404	438	398	404	438
III	Total Costs (I+II)	1,984	2,047	2,377	1,952	2,014	2,338
IV	Paperwork Savings	1,965	1,965	1,965	1,965	1,965	1,965
V	Safety Benefits	734	736	746	734	736	746
VI	Total Benefits (IV+V)	2,699	2,701	2,711	2,699	2,701	2,711

VII	Net Benefits (VI-III)	715	654	334	747	687	373
VIII	Baseline 2 Net Benefits	799	738	418	831	771	457
IX	Baseline 3 Net Benefits	859	798	478	891	831	517

FMCSA has estimated that all options presented in this RIA have positive net benefits under any baseline, that is, under any version of the HOS rules. However, the greatest safety impacts of the HOS rules are seen in long-haul (LH) operations, and the inclusion of short-haul (SH) operations diminishes the net benefits of this EOBR rule, although SH RODS users would experience sizable paper work savings that boost the net benefits of the rule.[5] Therefore Option 3, which includes all carrier operations, results in much lower net benefits as compared to Options 1 and 2. The alternative baselines reflect changes to the HOS rules that affect only LH, RODS-using operations.

5 The distinction between SH and LH operations is an important analytical concept for evaluating HOS rules and EOBRs, However, operationally, it is extremely difficult for enforcement personnel to differentiate between drivers and CMVs by length of haul. Consequently, the Agency does not believe a LH only option would be practical.

Table of Contents

Index of Tables and Charts

1 Background

1.1 Agency Mission

Transportation safety is the Department of Transportation's (DOT's) top strategic priority. Because the human toll and economic cost of transportation accidents are substantial, improving transportation safety is an important objective of all DOT modes. Within DOT, FMCSA is primarily focused on safe use of public roadways by motor carriers with the goal of reducing crashes, injuries, and fatalities involving large trucks and buses. The Secretary of Transportation has promulgated the Federal Motor Carrier Safety Regulations (FMCSRs) to further this purpose. In carrying out its safety mandate, FMCSA develops and enforces regulations that balance motor carrier safety with industry efficiency.[6]

The goal of the HOS regulations (49 CFR Part 395) is to promote safe driving of commercial motor vehicles by limiting on-duty and driving time and ensuring that drivers have adequate time to obtain rest. FMCSA conducts regular checks at the roadside and during compliance reviews to ensure that drivers are operating within the HOS limits. Surveys have shown, however, that many CMV drivers violate HOS limits, and that many also falsify their paper RODS to give the appearance of legal operation.[7,8] A recent online survey, conducted by United Safety Alliance, Inc., revealed that over 78% of its respondents believe that the most common, deliberate HOS violation is log-time as being off-duty when actually on-duty. The survey also discovered that "77% of the respondents admitted to deliberately violating the HOS regulations in the past and 55% said they were still currently deliberately violating the rules." Furthermore, survey respondents were asked to estimate how many days per month that they were in violation. Respondents admitted to intentionally violating HOS regulations 6 days per month, and unintentionally at least 5 days per month, either by accident, oversight, or honest mistake.[9] The

---

6 Federal Motor Carrier Safety Administration, "FMCSA's Strategy," http://www.fmcsa.dot.gov/about/what-we-do/strategy/strategy.htm (accessed June 30, 2010).

7 McCartt, A. T., L. A. Hellinga, and M. G. Solomon. Work Schedules Before and After 2004 Hours-of- Service Rule Change and Predictors of Reported Rule Violations in 2004: Survey of Long-Distance Truck Drivers. Proc., 2005 International Truck and Bus Safety and Security Symposium, Alexandria.

8 Commercial Vehicle Safety Alliance, "Roadcheck 2007 Results Show Safety Improvements Are Needed" June 29, 2007, www.cvsa.org.

9 "2006 HOS Survey Results," Ol'Blue, United Safety Alliance (USA), Inc. Online self-administered survey

National Transportation Safety Board and safety advocacy groups have recommended mandatory use of EOBRs as a way to increase compliance with HOS regulations.

1.2 Description of Proposed Rule

This RIA provides an assessment of the costs and benefits of requiring motor carriers to use EOBRs to track driving, on-duty, off-duty, and sleeper berth time. This requirement would be set primarily to improve compliance with the HOS limits on CMV drivers. EOBRs track driving time and other activities electronically, providing similar information to the currently used paper RODS. However, use of EOBR technology would significantly reduce or eliminate false or erroneous driving time records, and could reduce false and erroneous on-duty, off-duty, and sleeper-berth entries. The Agency published a Final Rule on EOBRs (EOBR I) on April 5, 2010, specifying their technical requirements and mandating their installation and use for a period of two years on all power units of carriers with recurrent HOS compliance problems, those found in a compliance review to have a 10 percent or greater violation rate (pattern violation) for any regulation in Appendix C to 49 CFR part 385 ("1X10 Remedial Directive Carriers"). The effective date of this Final Rule is June 4, 2012. A full RIA assessing the costs and benefits of EOBRs was prepared for EOBR I, but the analysis of EOBR benefits and costs has been updated to more precisely evaluate the impacts of these devices when they are required for a majority of or all CMV operations. The Agency has also published an NPRM on the HOS rules, and this RIA also evaluates EOBRs against two of the proposals in that NPRM.

The Agency has yet to identify any device that functions solely as an EOBR. Rather, electronic HOS recording is a simple extension of many fleet management systems (FMS) which offer mobile communications and tracking and are integrally synchronized with the CMV, the two most critical hardware requirements for the EOBRs. Carriers required to acquire and use EOBRs will most likely obtain new FMS that offer EOBR functionality. As it did in EOBR I, the Agency will continue to recognize that carriers that already have in place FMS will have a low or no cost alternative to acquiring EOBR functionality. These carriers will simply begin using their devices' EOBR feature or to upgrade their devices to this functionality.

---

conducted August 15 – October 31, 2006. http://www.olblueusa.org/survey/ (accessed January 6, 2011).

1.3 Executive Order 12866 (Regulatory Planning and Review)

FMCSA has determined that this rulemaking is a significant regulatory action under Executive Order 12866,[10] Regulatory Planning and Review, and significant under Department of Transportation regulatory policies and procedures because the economic costs and benefits of the rule exceed the $100 million annual threshold and because of the substantial Congressional and public interest concerning the crash risks associated with driver fatigue.

1.4 Policy Options Considered

FMCSA is proposing to extend the mandate for EOBRs to permanent installation and use of these devices for the majority of motor carrier operations. However, the costs and benefits of such a broad mandate are not identical across all types of options. The options the Agency has chosen to evaluate reflect public comments the Agency received in past EOBR and HOS rulemakings, recommendations from other Government entities, and the Agency's safety priorities.

The Agency is currently considering three options regarding the scope of the EOBR mandate. Option 1 would require EOBRs for all drivers required to use paper RODS. Option 2 expands Option 1 to include nearly all passenger carrying CMVs and all shipments of bulk quantities of hazardous materials (bulk HM), regardless of whether the drivers use paper RODS or are exempted from doing so as described under the "Short-haul operations" provisions in 49 CFR 395.1(e). The Agency believes that the higher potential for injuries and fatalities in crashes involving passenger-carrying CMVs and shipments of bulk hazardous materials warrant additional safety requirements for these operations. Option 3 is the broadest in scope within the Agency's legal authority, and would include all CMV operations subject to the HOS requirements.

The Agency did not consider an alternative for proposing mandatory use of EOBRs only for LH operations in the current NPRM. Proposing to require EOBR use for LH CMVs would present

---

10 Exec. Order No. 12866, Fed. Reg. 58, No. 190 (September 30, 1993): 51735-51744

difficulties for implementation because there is no current regulatory definition of "long-haul" and it is likely that attempts to establish a definition would cause confusion among carriers and enforcement officials. For example, some drivers and carriers may fall under the definition and be subject to the EOBR requirement on an intermittent basis making it difficult to assess the safety benefits for the periods where such carriers do not engage in LH operations.

1.5 Baselines for Analysis

The Agency considered three baselines for its analysis. The first uses the current state of compliance and estimated compliance costs and safety benefits from stricter enforcement of the current HOS rules. In constructing this baseline, the Agency began with the baseline level of non compliance developed for changes made to the HOS rules in 2003[11] and carefully reviewed and integrated all subsequent changes that have led to the current regulations. Furthermore, the recomputed baseline includes adjustments that reflect the decrease in HOS violations found in roadside inspections and the overall improvement in motor carrier safety since the 2003 HOS RIA was produced. Compliance costs and safety benefits were also rescaled for inflation and the current estimates of the monetized costs of CMV crashes.

FMCSA evaluated costs and benefits against two alternative baselines derived from Options 2 and 3 proposed in the HOS NPRM regarding property carriers that has been recently published (Option 1 of the HOS NPRM is to retain the current HOS rules)[75 FR 82170 (Dec 29, 2010)]). The major changes for both HOS options is to allow at most 13 hours of on-duty time within the daily driving window; limit continuous on-duty drive time to seven hours, at which point a 30-minute off-duty or sleeper-berth period would be required; and to require at least two overnight periods per 34-hour restart. HOS Option 2, however, also reduces daily drive time from 11 to 10 hours, while HOS Option 3 retains 11 hours of drive time. To avoid confusion between the HOS options and the options for the EOBR NPRM, HOS Option 2 and HOS Option 3 are referred to as Baseline 2 and Baseline 3.

11 The 2003 and subsequent HOS rule changes have applied to property carrying operations only. The Agency found negligible differences in its overall estimates of costs and benefits when passenger carriers were evaluated separately from property carriers.

The Agency also estimated EOBRs' effectiveness in reducing HOS violations and improving safety. EOBR data are not continuously monitored for violations, and even if they were, not all HOS violations would be documented. Consequently, the Agency cannot assume that EOBR use will lead to perfect compliance with the HOS regulations. Safety benefits and compliance costs in all three baselines are therefore reduced to reflect the limitations of the devices.

All monetary values are in year 2008 dollars. This is the same basis as the 2010 HOS RIA, and facilitates comparison between the two analyses.

1.6 Implementation of Proposed Rule

This RIA separately considers several categories of motor carrier operations. Short-haul (SH) operations for vehicles are defined as those that occur within 150 air-miles of their base, and LH operations for vehicles are defined as those that occur outside of the 150 air-mile radius. SH drivers are generally not required to keep RODS if they work fewer than 12 hours a day, start and stop at the same location, and operate within a 100-air mile radius (under the provisions of 49 CFR 395.1(e)(1)) or operate certain vehicles within a 150-air mile radius (under the provisions of 49 CFR 395.1(e)(2)).[12] The Agency estimates that 25 percent of SH operations are exempt from RODS requirements.[13]

The SH and LH group together is the entire regulated freight and passenger transporting population subject to HOS regulations. Because of their higher potential for fatalities and injuries, FMCSA examined passenger carrying and bulk hazmat operations. Last, the Agency divided carriers into three size groups, large (greater than 1,000 CMVs), medium (151 to 1,000 CMVs), and small (150 CMVs or fewer). The Agency found that the percentages of operations in LH and SH differ across these size categories.

The Agency proposes full implementation to occur three years after the rule is published to allow

12 These SH drivers are allowed to substitute time-cards for RODS.

13 See the currently approved supporting statement for the HOS Information Collection Request (ICR) (OMB control number 2126-0001) . The ICR estimates that 35 percent of interstate and *intrastate* drivers (assuming States adopt compatible HOS provisions for intrastate drivers) would be exempt from RODS requirements. The Agency assumes that a lower percentage, 25 percent of the interstate-only population of drivers, would be exempt from RODS.

for sufficient availability of EOBRs. This rule would likely become effective no earlier than 2014, four years after the technical specifications were published in EOBR I, and two years after the first 1x10 remedial directive carriers will have been required to use the devices. Moreover, a significant number of motor carriers have already adopted automatic on-board recording devices (AOBRDs) for HOS recording and monitoring, therefore would likely adopt EOBRs when units meeting the technical requirements become available. Nevertheless, the Agency is uncertain whether motor carriers and EOBR device manufacturers will be prepared for a mandate as broad as those being proposed in this NPRM even by 2014, and has requested comments on this topic in the NPRM.

2 Overview of Motor Carrier Industry

2.1 Regulated Motor Carriers

FMCSA estimates that approximately 500,000 motor carriers with 4,000,000 drivers and 3,637,000 CMVs are currently subject to the HOS rules. Roughly 60 percent of the industry is engaged in SH operations and 40 percent in LH operations, although these percentages vary with different segments of the industry. Table 1 below summarizes the number of affected carriers, drivers, and CMVs in total and for the individual segments analyzed. The explanation of how these numbers were derived can be found in Appendix A.

Table 1: Summary of Regulated Entities (thousands)

		Total	Motor-coach	Other Pass-enger	Bulk HM	Large	Medium	Small
Total	Carriers	504	10	10	18	<1	2	464
	Drivers	4,000	54	199	396	1,860	711	780
	CMVs	3,637	49	181	360	1,691	646	710
LH	Drivers	1,619	28	40	238	558	356	399
	CMVs	1,472	25	36	216	507	323	365
SH	Drivers	2,381	28	159	158	1,302	356	378
	CMVs	2,165	25	145	144	1,184	323	344

The magnitude of costs and benefits of this proposed rule is determined by the number of drivers and CMVs covered by the mandate. However, the effects of different sources of costs and benefits are not uniform for all drivers and CMVs. For example, the safety benefits of the HOS rules are highest for LH drivers, those most at risk to suffer from inadequate rest because of longer continuous daily driving periods and nights spent away from home, and, for team drivers, sleeping in a CMV in motion. For these reasons, LH carriers are the most likely to already be using EOBRs or FMS to efficiently route their drivers or to track their whereabouts. A full EOBR mandate can likely be accomplished more rapidly and at lower costs for LH operations. SH operations accrue smaller safety benefits from the HOS rules, and those SH carriers exempt from paper RODS requirements likely have no voluntary EOBR use and would not benefit from the elimination of paper RODS afforded by EOBRs.

2.2 Current AOBRD/EOBR and FMS Use

Many carriers already use AOBRDs and FMS, and will likely voluntarily adopt EOBRs when units meeting the technical requirements are available. As it did in EOBR I, the Agency excludes any voluntary use of AOBRDs and EOBRs from its analysis. Although one might believe that the pace of voluntary adoption would increase with the release of the EOBR technical requirements, the Agency notes that the requirements for AOBRDs have been in the FMCSRs since 1988 and, although some sectors of the motor carrier industry (specifically, many private motor carriers of property[14]) use AOBRDs extensively, the estimated adoption rate by motor carriers overall is only approximately 12 percent for LH operations and 4 percent for SH. The Agency therefore believes that without an EOBR mandate, its actions have had little effect on voluntary EOBR adoption and that it is most appropriate to evaluate benefits and costs with respect to mandated, rather than voluntary, use of these devices.

The Agency's perception is that carriers that voluntarily adopt new technologies has been that these carriers are generally larger, more efficient, and safer than average. In other words,

---

[14] Leavitt, Wendy. "HOS and electronic logs: fleets hold lead." *FleetOwner* Oct. 28, 2009. http://fleetowner.com/management/news/hos-electronic-logs-1028/ (accessed 30 June 2010).

carriers would not have voluntarily adopted EOBRs to address safety problems but because of a culture of safety consciousness that extends across many of its business decisions. Survey data collected by Corsi et al.[15] seem to verify this hypothesis: Their data found a negative corellation between current voluntary EOBR use and past SafeStat[16] scores, that is voluntary EOBR users had lower past scores, indicating that they were relatively safer relative to other carriers. With respect to this analysis of an EOBR mandate, voluntary adopters likely have better underlying HOS compliance records, and therefore lower net benefits of EOBR use than those carriers that will utilize the devices only when mandated to do so. Because the net benefits of this rule pertain only to these carriers that have not yet installed EOBRs, they may be understated in this analysis. It is important to note, however, that voluntary adopters likely accrue other benefits that are not necessarily part of minimal EOBR functionality, but that arise from other fleet management capabilities in the systems EOBRs may be bundled with. However, the EOBR performance specifications are such that an EOBR may be a stand-alone system that can only electronically monitor HOS, so these other potential productivity benefits have not been evaluated here. The Agency seeks data and information from current users of EOBR devices about any business benefits that they have observed.

This RIA uses an updated model for forecasting voluntary use of EOBRs or AOBRDs and FMS without any EOBR mandate. Details on how this forecast was constructed are presented in Appendix B of this RIA. The Agency forecasted voluntary use only for LH operations and, based on data observed in 2005, assumed that voluntary use for SH operations will be one-third that of LH. As a consequence, while voluntary EOBR and FMS usage approaches 100 percent, SH voluntary use never exceeds 33 percent. This seems reasonable in light of the fact that SH CMVs operate close enough to their terminals such that HOS monitoring and CMV tracking is not problematic. Table 2 presents the forecasts of voluntary EOBR and FMS use that would have occurred without the EOBR mandate. Included is the percentage of carriers who would already be required to use EOBRs under a 1x10 remedial directive; they are excluded from the analysis for this rule because the benefits and costs of their using EOBRs were already accounted

[15] Cantor, D.E. et al. (2009). "Do Electronic Logbooks Contribute to Motor Carrier Safety Performance." *Journal of Business Logistics* 30(1), 203-23. See Appendix E for an expanded discussion of this research.
[16] SafeStat combines current and historical safety performance information to measure the relative safety fitness of commercial motor carriers. This information includes Federal and State data on crashes, roadside inspections, on-site compliance review results and enforcement history.

for under EOBR I.

Table 2: Current and Projected EOBR and FMS Use

	FMS Use		AOBRD or EOBR Use		
Year	LH	SH	LH	LH 1X10	SH
2007	29%	10%	10%	0%	3%
2008	31%	10%	11%	0%	4%
2009	33%	11%	12%	0%	4%
2010	35%	12%	13%	0%	4%
2011	37%	12%	14%	0%	5%
2012	40%	13%	16%	10%	5%
2013	42%	14%	17%	10%	6%
2014	44%	15%	19%	10%	6%
2015	46%	15%	20%	10%	7%
2016	49%	16%	22%	10%	7%
2017	51%	17%	24%	10%	8%
2018	53%	18%	26%	10%	9%

2.3 Total EOBRs Required

The estimates presented in the previous two sections are used to produce estimates of the number of EOBRs that will need to be produced to meet the Agency's proposed mandate. A large portion of EOBR supply will be met by existing FMS which, as discussed in the next section, significantly reduces the cost of this rule. Table 3 presents the estimates of new EOBRs and upgradeable FMS needed for the LH and SH drivers and CMVs presented in table 2 above. Conversations with motorcoach companies and vendors indicate that passenger-carrying operations are not given attention by FMS vendors. The logistics of passenger transport, which generally follows predetermined schedules and routes, differ from the logistics of property transport, in which pickup and delivery of loads may be scheduled with little to no notice and in which the type of cargo, vehicle size, and weight can require more careful routing of CMVs. Consequently, the Agency assumes that the current use of EOBRs and FMS is insignificant in passenger carrying operations, and uses 0 percent in its calculations. Data in the shaded rows are carried forward into later stages of the analysis for the calculations of total costs and benefits.

Table 3: SH and LH Drivers and CMVs Affected by Rule (thousands or percentages)

			Passenger Carriers	Bulk HM Carriers	Other Property Carriers
LH	I	Drivers	68	238	1,313
	II	CMVs	61	216	1,195
	III	EOBR Use	0%	29%	29%
	IV	FMS Use	0%	44%	44%
	V	Drivers w/o EOBRs (I × (1 - II))	68	169	932
	VI	CMVs w/o EOBRs (II × (1 - III))	61	153	848
	VII	CMVs needing new EOBRs (VI × (1 - IV))	61	86	475
	VIII	CMVs w/ FMS Upgrade (VI × IV)	0	67	373
SH	IX	Drivers	187	158	2,036
	X	CMVs	170	144	1,851
	XI	EOBR Use	0%	6%	6%
	XII	FMS Use	0%	15%	15%
	XIII	Drivers w/o EOBRs (IX × (1 - XI))	187	149	1,914
	XIV	CMVs w/o EOBRs (X × (1 - XI))	170	135	1,740
	XV	CMVs with New EOBRs (XIV × (1 - XII))	170	115	1,479
	XVI	CMVs w/ FMS Upgrade (XIV × XII)	0	20	261

For the calculation of paperwork savings, it is also necessary to divide the SH populations into those using RODS and those not using RODS. SH operations that are exempt from RODS under one of the SH provisions will accrue no paperwork savings from EOBR use and are unlikely to currently use EOBRs. Table 4 presents this subdivision. Many calculations in this table refer back to table 3.

Table 4: SH non-RODS and SH RODS Drivers and CMVs Affected by Rule (thousands)

			Passenger Carriers	Bulk HM Carriers	Other Property Carriers
SH w/o RODS	XVII	Drivers w/o EOBRs (XIII * 25%)	47	37	479
	XVIII	CMVs w/o EOBRs (XII * 25%)	43	34	435
	XIX	CMVs with New EOBRs (XVIII × (1 - XII))	43	29	370

	XX	CMVs w/ FMS Upgrade (XVIII × XII)	0	5	65
SH w/ RODS	XXI	Drivers w/o EOBRs (XIII - XVII)	140	112	1,435
	XXII	CMVs w/o EOBRs (XIV - XVIII)	127	101	1,305
	XXIII	CMVs with New EOBRs (XV - XIX)	127	86	1,109
	XXIV	CMVs w/ FMS Upgrade (XVI - XX)	0	15	196

3 EOBR Device Costs

3.1 New EOBR Costs

The Agency is basing its estimate of EOBR purchase cost on one FMS that offers electronic HOS monitoring and is representative of mid-2010 state-of-the-practice devices. Cost information was gathered from a conversation with a sales representative from this manufacturer.[17] Although the $1,675 purchase price of this unit is on the high end of the range of prices the Agency is aware of, its manufacturer has the largest share of the FMS market. Therefore units sold at this price are currently the most abundantly available. The manufacturer states that it generally covers all repairs within a three-year initial warranty period, and that it has been charging $300-$500 per repair outside of the warranty period. The vendor also claims that its devices are extremely durable and are specially tested to ensure they withstand the rigors of CMV operation; it states that many of its early model FMS units have been in service for more than a decade. Although it is unlikely that all EOBRs will remain serviceable for such long periods, less durable units would likely have lower purchase prices, and amortized over time, the purchase and repair costs of the unit considered in the analysis may equal the purchase and repair or replacement costs of other units. In its analysis, the Agency assumes that $500 repairs will be required in the fifth and tenth years of the devices' operational lives. As is the case for the purchase price, the Agency believes it is using a relatively high estimate for repair costs.

Two other costs related to the device are considered in the analysis. The first is the cost of

17 Cost information for the Qualcomm Mobile Computing Platform (MCP) 100 was acquired through conversation with Qualcomm sales representative, Angelo Matera, and FMCSA during a meeting on May 12, 2010.

installation. The vendor of the device FMCSA is using in this analysis states that installation by an experienced technician would take an hour or two per unit. This RIA will use an installation cost of $100, which is approximately two hours of labor cost for a CMV technician. The Agency believes the installation of this device is relatively more complex than that of other units. For example, the device used for the RIA in EOBR I was simply plugged into a CMVs OBDII port, a procedure that took only a few seconds. The last cost is that for monthly service fees for the unit. The minimum service package, which covers all FMS functions and HOS monitoring, costs $40 per month.

In this analysis, the Agency has assumed complete ownership, or access, to computer technology by motor carriers, as their use is known to be ubiquitous among all businesses. Also, this assumption has been adopted from EOBR I analysis, therefore, the analysis did not consider an estimation of the cost of purchasing new equipment (i.e., PCs). The Agency seeks public comments on this assumption.

3.2 EOBR Monitoring on Current FMS

Many FMS currently offer an HOS monitoring feature. Vendors of these devices have told the Agency that they are already modifying the functionality of these devices to comply with the technical requirements of EOBR I. Almost all FMS currently sold offer the two most important hardware features necessary for EOBRs, location tracking and synchronization with the CMV engine, and the Agency believes that most upgrades will be relatively inexpensive software changes. Although HOS monitoring is often included in a single monthly fee, some manufacturers offer a la carte pricing for that particular feature. Two vendors contacted for EOBR I quoted prices of $5 or $8 per month for this additional service.[18] The higher number is used in this RIA.

3.3 Training Costs

18 RouteTracker charges an additional $5 for HOS functionality and Qualcomm charges $8. Qualcomm has since dropped its a la carte pricing for this function, but the Agency prefers to be conservative and to use its higher price quote in this RIA.

In analyses conducted for EOBR I, FMCSA included the costs of training drivers, motor carrier office staff, and state police and other roadside inspection staff on how to use the devices and access electronic records, but in this RIA FMCSA has opted to exclude these costs as insignificant. Spread over the 140,000 CMVs affected by EOBR I, annualized training costs amounted to only $26 per CMV.[19] Training of enforcement staff accounted for $6 of that cost, and because this training has to be undertaken for EOBR I, it is not a cost of this rule. Training costs borne by carriers were spread over two years (the period of time a carrier remains under a remedial directive). When the devices are installed permanently, these figures would be amortized over more years, further reducing the estimated cost per CMV.

Most importantly, however, is that as the Agency has continued to talk with FMS vendors and to learn how these units function, it has come to believe that use of the EOBR features by drivers and access to the electronic RODS by carriers are largely intuitive and self-explanatory. Vendors have demonstrated that they have tried to make these devices as easy-to-use as possible for the motor carrier industry. A sales representative from the vendor of the device used in this analysis was able to demonstrate to FMCSA staff the EOBR features of his firm's device in just a few minutes. Other devices Agency staff has seen use either touch screens or simple buttons or keys for interacting with the device. The RouteTracker device analyzed for EOBR I used the driver's cell phone as its user interface. Among the tasks most drivers are already able to accomplish with current communications technology, such as mobile phones, computers, and FMS, using EOBR functions would rank as one of the simplest, and would certainly require no additional expertise from drivers. Also, by the time this rule becomes effective, the Agency believes that most drivers will have had some interaction with an FMS if not an EOBR in the course of their careers. The Agency is also certain that new drivers will learn to use EOBRs much more rapidly than to learn how to manually fill in paper RODS. Allowing for 5 minutes' worth of initial training per driver at a rate of $27 per hour[20] yields an initial training cost of $2.25 per driver, and using the ratio of 1.1 drivers per CMV (or EOBR)[21] yields a cost of about $2.50 per EOBR. Because it is a one-time cost—new drivers in the future will substitute EOBR training for paper RODS training already occurring—it should be amortized over the ten-year

19 Exhibit 6 of the EOBR I RIA.
20 Labor costs related to EOBRs are discussed below in detail in section 5.2 of this RIA.
21 See Appendix A of this RIA.

horizon of this analysis, which yields an annualized value (using a 7 percent discount rate) of $0.33 per EOBR. Given that the Agency uses a relatively high EOBR cost estimate in this analysis, it has opted not to include this minor adjustment for training costs.

Also, carrier office staff should be able to access and review the electronic records of their drivers more easily. The vendors of devices offering EOBR features that the Agency is aware of all offer a World Wide Web based hosting system for driver electronic RODS. Carrier staff need only log on to a secure web site to have access to all their drivers' records. The Agency believes that the tasks required of carrier office staff to view and audit the records from EOBRs are no more complex than those they should already be able to complete for other office work, and assumes that no additional training will be needed by carrier office staff.

3.4 Annualized Estimates of EOBR Costs

Based on the information described above and data gathered earlier for the EOBR I RIA, the Agency calculated annualized costs per device. These results are presented in table 5. All costs are discounted over 10 years and to the beginning of year 1. The analysis uses the total device cost of $785 per year.

Table 5: Annualized EOBR Costs

	New EOBR Purchase		EOBR-Ready FMS
	EOBR I Device	EOBR II Device	
Description of Monthly Costs	$45=($35 for EOBR Service + $10 for Cell Phone Data Service)	$40 Fee for HOS Monitoring	$8 fee for HOS Monitoring
Monthly Operating Cost Discounted to Beginning of Year (12 Payments Discounted at 7%÷12)	$520	$462	$92

Description of Startup Costs	$35 for Initial Fee	$1675 for Device + $100 for Installation, $500 for Repair	$0 (Power Units Already Equipped with Hardware)
Startup Costs	$35	$1,775	$0
Repair Costs in 5th and 10th Years		$500	
Annualized Startup Costs	$5	$323	$0
Total Annualized Costs	$525	$785	$92

4 Baseline for HOS Compliance Costs and Safety Benefits

4.1 Overview of Analysis

The total level of non-compliance with the HOS is extremely difficult to measure because violators have an incentive to hide their behavior. FMCSA does have extensive data on HOS violations from roadside inspections, compliance reviews, and safety audits, but, because the Agency cannot continually monitor every carrier and driver, this is an incomplete picture of HOS compliance. The last analysis to comprehensively assess total non-compliance was conducted for the 2003 HOS rule and resulted in estimates in costs and benefits of full compliance with the HOS rules relative to a "status quo," that is a real-world baseline of daily and weekly drive and duty times. However, data on total compliance have not been collected since then, but the Agency does not assume that the status-quo baseline has remained static since 2003. Rather, it assumes that total HOS compliance has changed proportionally to changes in HOS violations found in roadside inspections, and additionally that the safety impacts of HOS non-compliance has changed proportionally to changes in overall societal damages from CMV crashes adjusted for revised estimates of fatigue involvement in those crashes. The following sections demonstrate step-by-step how the Agency updated the 2003 baseline to reflect the present status of compliance.

FMCSA carefully reviewed all of its past HOS rulemaking analyses back to the 2003 rule, the point at which the Agency evaluated the underlying level of non-compliance with the HOS rules prior to changes already implemented or proposed in the recently published HOS NPRM. 75 FR 82170 (Dec 29, 2010). From that point through the current HOS NPRM, each analysis of changes to the HOS rules has evaluated the impacts of rule changes with respect to the fraction of operations affected by the changes. That is, they represent the incremental costs and benefits of full enforcement to changes to the rule compared to the costs and benefits of full enforcement of the existing rules. Consequently, starting from the 2003 status quo baseline, the costs and benefits of subsequent changes can be layered on to create figures representing costs and benefits of eliminating non-compliance with the rules currently in effect. Figures were also adjusted for inflation and underlying improvements in overall motor carrier safety and compliance with the HOS regulations.

Because the Agency has recently published proposed revisions to the HOS rule, the Agency seeks comments related to the approach by which HOS is used within this rule.

4.2 Baseline for Compliance Costs

Compliance costs associated with the HOS rules from the perspective of a mandate for EOBR use represent the costs of moving the motor carrier industry from the current level of less-than-one-hundred-percent compliance to full compliance with the current, or any set of HOS rules. The Agency used several steps to construct a baseline, that is, the maximum compliance costs EOBRs would force carriers to bear if these devices brought about perfect enforcement of the HOS rules, the current HOS rules and two of the proposed HOS options, as described in section 1.5 of this RIA. Table 6 below presents the results of each level of this process. In step one (I), FMCSA used figures from the "Current/100%" column of Exhibit 9-15 of the 2003 HOS RIA.[22] These figures estimated the costs of moving motor carriers to full compliance with the pre-2003 HOS rules. Step 2 (II-III) adds the incremental changes to compliance costs from changes to the rules put in effect in 2003; these figures are from the "FMCSA" column of Exhibit 9-13 of the 2003 RIA. Step 3 (IV-VI) adds the 2005 HOS rule changes—see Exhibits ES-2 and ES-5 of the

22 See the "Regulatory Impact Analysis and Small Business Impact Analysis for Hours of Service Options, FMCSA, December 2002, Contract No. DTFH61-01-F-00218/GS-10F-1024J, Contractor ICF Consulting, Inc., available at http://www.regulations.gov/#!documentDetail;D=FMCSA-2004-19608-0080 (accessed January 4, 2011).

2005 RIA[23]—deflated[24] to the same year 2000 dollars as the 2003 figures.[25] Step 4 arrives at the baseline for the current rules by adjusting from year 2000 to 2008 dollars (122%) and the 16 percent decline (84% = 100% - 16%) in HOS violations discovered in roadside inspections since the 2003 rules went into effect. The calculation of this decline in the out of service (OOS) violation rate is presented in Appendix C of this RIA. The final steps simply add the incremental costs of the two alternative baselines derived from the 2010 HOS RIA.

The 2003, 2005, and 2010 HOS rule baselines are taken from their respective RIAs which are available for public comment in the docket and summarized in Appendix H.

Table 6: Derivation of Compliance Cost Baselines

Annual Compliance Costs of Current and Alternative Baselines (millions)				
		Compliance Costs		
		SH	LH	Total
I	Full Compliance vs. Non Compliance Status Quo, Pre-2003 HOS Rule ($2000)	232	1,954	2,186
II	Full Compliance with 2003 HOS Rule Changes ($2000)	168	-1,073	-905
III	2003 HOS Rule Baseline ($2000) (I + II)	400	881	1,281
IV	2005 HOS Rule Changes ($2004)	0	34	34
V	2005 HOS Rule Changes ($2000) (IV ÷ ~109%)	0	31	31
VI	2005 HOS Rule Baseline ($2000) (III + V)	400	912	1,312
VII	Current Compliance Cost Baseline ($2008) (VII × ~84% × ~122%)	411	938	1,349
Alternate Base Lines				
VIII	HOS Option 2 Incremental Cost ($2008)	0	1,030	1,030

23 See the "Regulatory Impact Analysis and Small Business Impact Analysis for Hours of Service Options," in Final Rule, "Hours of Service of Drivers," 70 FR, 49982-49992(Aug. 25, 2005),, available at http://www.regulations.gov/#!documentDetail;D=FMCSA-2004-19608-2094 (accessed January 4, 2011).
24 The GDP deflator is used in this RIA for all price level adjustments.
25 The SH provisions exempting certain SH operations from paper RODS were also introduced in 2005. There is no compliance issue associated with receiving an exemption from paperwork burden, so these figures are excluded.

IX	HOS Option 2 Total Compliance Cost ($2008) (VII + VIII)	411	1,968	2,379
X	HOS Option 3 Incremental Cost ($2008)	0	520	520
XI	HOS Option 3 Total Compliance Cost ($2008) (VII + X)	411	1,458	1,869

4.3 Baseline for Safety Benefits

The calculations of the safety benefits follow similar steps as the compliance cost calculations. Table 7 below presents the results of each level of this process. Step one (I) figures are pulled from the "Current/100%" column of Exhibit 9-16 of the 2003 HOS RIA.[26] These figures estimated the safety benefits of moving motor carriers to full compliance with the pre-2003 HOS rules. Step 2 (II-III) adds the incremental changes to safety from changes to the rules put in effect in 2003; these figures are from the "FMCSA" column of Exhibit 9-6 of the 2003 RIA. Step 3 (IV-VI) adds the 2005 HOS rule changes—see Exhibits ES-2 and ES-5 of the 2005 RIA[27]—deflated to the same year 2000 dollars as the 2003 RIA figures.[28] Step 4 arrives adjusts for a 203 percent increase in the average value of a CMV crash, which reflects both inflation from 2000 to 2008 and a higher value of statistical life (VSL), since the 2003 HOS RIA was produced. The calculation of this increase in the value per crash is presented in Appendix D. Step 5 inflates safety benefits to account for the Agency's revised estimate of fatigue related crashes, as discussed in the HOS NPRM RIA (see also Appendix D of this RIA) [. The Agency had estimated 7 percent as the percentage of CMV crashes attributable to CMV driver fatigue, but the 2010 HOS RIA bases its analysis on 13 percent, which results in an adjustment of 186 percent (13%÷7%). The final steps simply add the incremental benefits of the two alternative baselines presented in the HOS NPRM. Importantly, the HOS NPRM analysis calculates additional benefits from driver health improvements brought about by the proposed changes to

26 See the "Regulatory Impact Analysis and Small Business Impact Analysis for Hours of Service Options, FMCSA, December 2002., available at http://www.regulations.gov/#!documentDetail;D=FMCSA-2004-19608-0080 (accessed January 4, 2011).

27 See the "Regulatory Impact Analysis and Small Business Impact Analysis for Hours of Service Options," in Final Rule, "Hours of Service of Drivers," 70 FR 49982-49992 (Aug. 25, 2005):, available at http://www.regulations.gov/#!documentDetail;D=FMCSA-2004-19608-2094 (accessed January 4, 2011).

28 The SH provisions exempting certain SH operations from paper RODS were also introduced in 2005. There is no compliance issue associated with receiving an exemption from paperwork burden, so these figures are excluded.

the rule.

Table 7: Derivation of Safety Benefit Baselines ($ millions)		SH	LH	Total
I	Full Compliance vs. Non Compliance Status Quo, Pre-2003 HOS Rule ($2000)	22	429	451
II	Full Compliance with 2003 HOS Rule Changes ($2000)	10	225	235
III	2003 HOS Rule Baseline ($2000) (I + II)	32	654	686
IV	2005 HOS Rule Changes ($2004)	0	20	20
V	2005 HOS Rule Changes ($2000) (IV ÷ ~109%)	0	18	18
VI	2005 HOS Rule Baseline ($2000) (III + V)	32	672	704
VII	Current Safety Benefit Baseline ($2008) (VII × 203%)	65	1,364	1,429
VIII	Rebase to Higher Estimate of Underlying Fatigue ($2008) (VII × 186%)	121	2,537	2,658
Alternate Base Lines				
IX	HOS Option 2 Incremental Benefit ($2008)	0	1,410	1,410
X	HOS Option 2 Total Safety Benefit ($2008) (VIII + IX)	121	3,947	4,068
XI	HOS Option 3 Incremental Benefit ($2008)	0	1,080	1,080
XII	HOS Option 3 Total Safety Benefit ($2008) (VIII + XI)	121	3,617	3,738

4.4 EOBR Effectiveness

In the last few years, the Agency has entered into settlement agreements with a few carriers in which it waived civil penalties for violations discovered in compliance reviews in exchange for the carriers agreeing to install AOBRDs with enhanced functionality (such as automated location-tracking). The Agency examined roadside inspection and crash data to evaluate the effectiveness of these devices at reducing violations and crashes for these carriers. Analysis of crash data is inconclusive. To date, relatively small carriers have entered these agreements, and although their crash rates may have been high, crashes were too infrequent to yield statistically significant measures of the safety impacts of enhanced AOBRDs. FMCSA will continue to monitor the data for these carriers. Roadside inspection HOS violation data, however, were plentiful and yielded statistically significant results. The overall out of service HOS violation rate fell 70 percent for these carriers, but many of the violations eliminated were those for missing and improper RODS, which may not mask violations to driving or on-duty time limits. Consequently, the Agency focused on driving and on-duty time violations, which it estimates EOBRs can reduce 40 percent. Therefore, in addition to baseline compliance of current HOS rules, the implementation of EOBR devices is estimated to eliminate 40 percent of remaining out of service HOS violations. Appendix E contains a more detailed description of this calculation and other analyses and studies the Agency considered for estimating EOBR effectiveness.

The 2010 HOS RIA does not measure the current state of compliance with the current proposal. FMCSA has used the level of non-compliance with the pre-2003 rule, with some adjustments, including one which accounts for the current size of the carrier population affected by this rule..

4.5 Attainable Compliance Costs and Safety Benefits

The baselines presented in sections 4.2 and 4.3 were adjusted to reflect the maximum efficacy of EOBRs. These results are presented in tables 8 and 9 below.

Table 8: Attainable Annual Compliance Costs with 40% EOBR Effectiveness (2008$ millions)

	SH	LH	Total
Baseline 1 Compliance Cost	164	375	539
Baseline 2 Compliance Cost	164	787	951
Baseline 3 Compliance Cost	164	583	747

Table 9: Attainable Annual Safety Benefits with 40% EOBR Effectiveness (2008$ millions)

		SH	LH	Total
XIII	Current Safety Benefit	48	1,015	1,063
XIV	HOS Option 2 Safety Benefit	48	1,579	1,627
XV	HOS Option 3 Safety Benefit	48	1,447	1,495

4.6 Compliance Costs and Safety Benefits per EOBR

In order to complete the analysis, the Agency computes compliance costs and safety benefits per EOBR installed. It assumes that the benefits of EOBR use have already accrued to those operations currently employing AOBRDs or EOBRs, 12% of LH operations and 4% of SH operations (the year 2009 row of table 2). EOBRs are installed on individual CMVs and, as indicated in table 1, there are currently 1,472,000 LH CMVs and 2,165,000 SH CMVs. The number of LH CMVs without AOBRDs or EOBRs is 1,295,000 ((1-0.12)×1,472,000) and the number of SH CMVs without AOBRDs or EOBRs is 2,078,000 (((1-0.04)×2,165,000), for a total of 3,374,000 CMVs without the devices. The attainable compliance costs and safety benefits per EOBR are calculated by dividing the values in tables 8 and 9 by the number of CMVs without AOBRDs or EOBRs. An adjustment was made to the LH figures to account for the fact that the 1,295,000 CMVs that currently do not have EOBRs contain CMVs of 1X10 carriers, those with the worst HOS compliance records that are covered under EOBR1, which will not be effective until 2012. The compliance costs and safety benefits of those remaining CMVs will be slightly lower than the current state of the industry after the 1X10 remedial directive goes into effect.[29] Tables 10 and 11 present the results of these calculations.

---

29 The approximately 140,000 CMVs covered under the EOBR1 rule, the 1X10 group, represent about 10.8 percent of the total number of LH CMVs that have not yet been outfitted with EOBRs. CMVs in the 1X10 group were found to have double the violation rate and 1.4 times the crash risk per HOS violation compared to other carriers. The unadjusted per EOBR cost is implicitly a weighted average of 1X10 and other CMVs, so that:
(a) WeightedAverageCost = (140,0001X10 CMVs × 2violation rate × UnweightedAverageCost + (1,295,000CMVs - 140,0001X10 CMVs) × UnweightedAverageCost) ÷ 1,295,000CMVs
(b) UnweightedAverageCost ÷ WeightedAverageCost = 1,295,000CMVs ÷ (140,0001X10 CMVs × 2violation rate + (1,295,000CMVs - 140,0001X10 CMVs)) .
Solving this equation yields a value of 0.90 as an adjustment factor for compliance costs, that is, per EOBR compliance costs for non-1X10 CMVs are 0.90 times the average for all CMVs. An analogous safety benefit adjustment equation that includes the higher crash risk is:

Table 10: Attainable Annual Compliance Cost per EOBR

		A	B	C	D
		SH	LH	LH Adjusted (B × 90%)	Total
XII	Current Compliance Cost	79	289	261	160
XIII	HOS Option 2 Compliance Cost	79	608	547	282
XIV	HOS Option 3 Compliance Cost	79	450	405	221

Table 11: Attainable Annual Safety Benefit per EOBR

		A	B	C	D
		SH	LH	LH Adjusted (B × 84%)	Total
XII	Current Safety Benefit	23	784	658	315
XIII	HOS Option 2 Safety Benefit	23	1,219	1,024	482
XIV	HOS Option 3 Safety Benefit	23	1,117	938	443

5 Paperwork Savings

5.1 Summary of Paperwork Savings

The use of EOBRs will significantly reduce the paperwork and recordkeeping burden associated with the HOS regulations. Drivers will benefit the most: EOBRS will greatly reduce the time they spend completing their RODS and eliminate the time that some of them currently spend forwarding their RODS to their employers while they are away from the motor carriers' terminals. Comments received for the NPRM on the EOBR I rule suggest that carriers often do not recognize these savings because drivers are not always compensated for completing these tasks. Regardless, the Agency has long recognized in the estimates it prepares for the HOS Information Collection Request supporting statements that the largest portion of burden falls

---

(b2) UnweightedAverageBenefit ÷ WeightedAverageBenefit = 1,295,000CMVs ÷ (140,0001X10 CMVs × 2violation rate × 1.4CrashRisk + (1,295,000CMVs - 140,0001X10 CMVs)).
Solving this second equation yields a value of 0.84 as an adjustment factor for safety benefits.

directly to drivers. With EOBR use, carriers will accrue clerical time savings and will altogether avoid the cost of purchasing paper log books. Table 12 below summarizes the paperwork and recordkeeping savings for each driver using an EOBR.

Table 12: Annual Paperwork Savings per Driver Switching from Paper RODS to EOBR

Driver		Clerk	Cost of Log Books	Total Paperwork Savings
Filling RODS	Submitting RODS	Filing RODS		
$486	$56	$116	$30	$688

5.2 Labor Costs

The Agency estimated the hourly labor costs of drivers and motor carrier clerical staff. A motor carrier employee at some supervisory level would also handle the RODS in their duties reviewing them, but the Agency assumes that electronic RODS will undergo the same scrutiny as paper RODS, and therefore does not estimate any time savings for these employees. This analysis uses a fringe benefit percentage of 1.52[30] for motor carrier staff and a base wage of $15 per hour for clerical staff and $18 for drivers.[31] Multiplying these base wages by the fringe benefit factor yields labor costs of about $23 for clerks and $27 for drivers. Drivers are assumed to undertake these activities during non-compensated, off-duty time, whereas filing is part of normal paid clerical duties. The clerical wage was inflated by 27 percent to include firm overhead.[32] The final labor costs used were $29 for clerks and $27 for drivers.

5.3 Driver Time Savings

EOBRs do not fully eliminate driver time spent logging HOS. Although changes from on-duty

30 Table 10, Employer costs per hour worked for employee compensation and costs as a percentage of total compensation. "Employer Costs for Employee Compensation, December 2009" available at http://www.bls.gov/news.release/archives/ecec_03102010.htm (accessed July 21, 2010).
31 Occupational Employment Statistics, May 2008. Standard Occupation Code 53-3032 for drivers and 43-3031 for clerks.
32 Berwick, Farooq. "Truck Costing Model for Transportation Managers". Upper Great Plains Transportation Institute, North Dakota State University (2003). http://ntl.bts.gov/lib/24000/24200/24223/24223.pdf (accessed January 4, 2010).

driving to on-duty non-driving are logged automatically by monitoring of the CMVs motion, a driver will still have to interact with these devices to log in at the beginning of the work shift, to log out at the end of the work shift, and to change duty status to off-duty and, if applicable, sleeper berth time. The Agency estimates that drivers fill out on average 240 RODS per year. EOBRs are estimated to reduce the amount of time drivers spend logging their HOS by 4.5 minutes per RODS. EOBRs are also assumed to completely eliminate the time drivers spend filing or forwarding their RODS to the carriers, which the Agency estimates takes 5 minutes and occurs 25 times per year. These estimates match those used in the currently approved HOS Information Collection Request supporting statement. Total annual estimated time savings per driver are 18 hours for filling out the RODS (4.5 minutes × 240 RODS ÷ 60 minutes per hour) and 2.08 hours for forwarding RODS (5 minutes × 25 occurrences ÷ 60 minutes per hour). These result in annual labor or time cost savings per driver of $486 (18 hours × $27 per hour) plus $56 (2.08 hours × $27 per hour). The Agency seeks comment from the public on the accuracy of these estimates.

5.4 Clerical Time Savings

Because electronic RODS will likely be automatically transmitted and stored on a secure website, carrier clerical staff will no longer have to handle these documents. The Agency had estimated that it took carrier clerical staff only a minute to file each RODS, and EOBRs will now completely eliminate that task, resulting in annual time savings of 4 hours per driver (1 minute × 240 RODS ÷ 60 minutes per hour). The labor cost saving of clerical time is $116 (4 hours × $29 per hour).

5.5 Paper Cost Savings

Vendors such as JJ Keller sell bound packets containing a month's worth of paper RODS for about $2.50. EOBRs will eliminate the need for these materials, resulting in annual cost savings per driver of $30 (12 monthly log books × $2.50).

6 Results of Analysis

6.1 Results for All Options

Tables 13, 14, and 15 show the steps used to arrive at the final cost and benefit figures. Table 13 establishes the numbers of drivers and CMVs affected, and what fraction of CMVs will require wholly new EOBR purchases rather than upgrades to FMS. Table 14 applies the figures in table 13 to per unit or per driver estimates of costs and benefits to arrive at totals for all operations included under each option. Table 15 shows net benefits under the two alternate HOS baselines. Net benefits are positive for all three options, although they are substantially lower in option 3 with the inclusion of SH operations exempt from RODS.

Table 13: Drivers and CMVs (thousands)

		Option 1: RODS	Option 2: RODS+	Option 3: All
I	LH Drivers	1,169	1,169	1,169
II	LH EOBRs, New	622	622	622
III	LH EOBRs, FMS Upgrade	440	440	440
IV	Non RODS SH Drivers	0	84	563
V	Non RODS SH EOBRs, New	0	72	442
VI	Non RODS SH EOBRs, FMS Upgrade	0	5	70
VII	RODS SH Drivers	1,687	1,687	1,687
VIII	RODS SH EOBRs, New	1,322	1,322	1,322
IX	RODS SH EOBRs, FMS Upgrade	211	211	211
X	EOBRs, New Purchases (II+V+VIII)	1,944	2,016	2,386
XI	EOBRs, FMS Upgrades (III+VI+IX)	651	656	721

Table 14: Costs and Benefits

		Option 1: RODS	Option 2: RODS+	Option 3: All
XII	Annualized EOBR Cost	$785	$785	$785
XIII	Annualized FMS Upgrade Cost	$92	$92	$92
XIV	Total EOBR Cost (X×XII+XI×XIII) (millions)	$1,586	$1,643	$1,939
XV	LH Compliance Costs per LH CMV	$261	$261	$261
XVI	SH Compliance Costs per SH CMV	$79	$79	$79
XVII	Total Compliance Costs ((II+III)×XV+(V+VI+VIII+IX)×XVI) (millions)	$398	$404	$438

XVIII	Total Costs (XIV+XVII) (millions)	$1,984	$2,047	$2,377
XIX	Paperwork Savings per RODS Driver	$688	$688	$688
XX	Total Paperwork Savings ((I+VII)×XIX) (millions)	$1,965	$1,965	$1,965
XXI	LH Safety Benefits per LH CMV	$658	$658	$658
XXII	SH Safety Benefits per SH CMV	$23	$23	$23
XXIII	Total Safety Benefits ((II+III)×XXI+(V+VI+VIII+IX)×XXII) (millions)	$734	$736	$746
XXIV	Total Benefits (XX+XXIII)	$2,699	$2,701	$2,711
XXV	Net Benefits (millions)	$715	$654	$334

Table 15: Net Benefits, Alternate Baselines

		Option 1: RODS	Option 2: RODS+	Option 3: All
XXVI	Additional Net Benefits per LH CMV Baseline 2	$79	$79	$79
XXVII	Additional LH Net Benefits Baseline 2 ((II+III)×XXVI) (millions)	$84	$84	$84
XXVIII	Total Net Benefits Baseline 2 (XXV+XXVII) (millions)	$799	$738	$418
XXIX	Additional Net Benefits per LH CMV Baseline 3	$136	$136	$136
XXX	Additional LH Net Benefits Baseline 3 ((II+III)×XXIX) (millions)	$144	$144	$144
XXXI	Total Net Benefits Baseline 3 (XXV+XXX) (millions)	$859	$798	$478

6.2 Alternative Implementation Schedule, Results for All Options

FMCSA also evaluated an alternative implementation plan, one that would allow for gradual adoption of EOBRs by motor carriers over a five-year period. One of many possible implementation schedules would require EOBRs in all motorcoaches in year 1, other passenger carrying operations in year 2, bulk HM operations and large property carriers in year 3, medium sized property carriers in year 4, and small property carriers in year 5. Although after implementation has been completed, net benefits would be about the same for both the alternative and proposed implementation schedules, they are slightly lower under the five-year option because some net benefits are delayed later in the ten-year horizon evaluated in this RIA. Appendix G contains a detailed explanation of how these estimates were calculated. Tables 16, 17, and 18 show the steps used to arrive at these cost and benefit figures. Net benefits are again positive for all three options, although they are substantially lower in option 3 with the inclusion of SH operations exempt from RODS.

Table 16: Drivers and CMVs, Alternative Implementation (thousands)

		Option 1: RODS	Option 2: RODS+	Option 3: All
I	LH Drivers	1,131	1,131	1,131
II	LH EOBRs, New	565	565	565
III	LH EOBRs, FMS Upgrades	463	463	463
IV	Non RODS SH Drivers	0	84	557
V	Non RODS SH EOBRs, New	0	71	427
VI	Non RODS SH EOBRs, FMS Upgrade	0	5	78
VII	RODS SH Drivers	1667	1667	1667
VIII	RODS SH EOBRs, New	1300	1300	1300
IX	RODS SH EOBRs, FMS Upgrade	216	216	216
X	EOBRs, New Purchases (II+V+VIII)	1,865	1,936	2,292
XI	EOBRs, FMS Upgrades (III+VI+IX)	679	684	757

Table 17: Costs and Benefits, Alternative Implementation

		Option 1: RODS	Option 2: RODS+	Option 3: All
XII	Average Annualized EOBR Cost	$560	$564	$546
XIII	Average Annualized FMS Upgrade Cost	$68	$68	$66
XIV	Total EOBR Cost (X×XII+XI×XIII) (millions)	$1,090	$1,139	$1,301
XV	Average LH Compliance Costs per CMV	176	176	176
XVI	Average SH Compliance Costs per CMV	55	56	53
XVII	Total Compliance Costs ((II+III)×XV+(V+VI+VIII+IX)×XVI) (millions)	$265	$270	$288
XVIII	Total Costs (XIV+XVII) (millions)	$1,355	$1,409	$1,589

XIX	Paperwork Savings per RODS Driver	476	476	476
XX	Total Paperwork Savings ((I+VII)×XIX) (millions)	$1,332	$1,332	$1,332
XXI	Average LH Safety Benefits per CMV	544	544	544
XXII	Average SH Safety Benefits per CMV	20	20	19
XXIII	Total Safety Benefits ((II+III)×XXI+(V+VI+VIII+IX)×XXII) (millions)	$590	$592	$598
XXIV	Total Benefits (XX+XXIII)	$1,922	$1,924	$1,930
XXV	Net Benefits (millions)	$567	$515	$341

Table 18: Net Benefits, Alternative Implementation, Alternate Baselines

		Option 1: RODS	Option 2: RODS+	Option 3: All
XXVI	Additional Net Benefits per LH CMV Baseline 2	228	228	228
XXVII	Additional LH Net Benefits Baseline 2 ((II+III)×XXVI) (millions)	$55	$55	$55
XXVIII	Total Net Benefits Baseline 2 (XXV+XXVII)	$622	$570	$396
XXIX	Additional Net Benefits per LH CMV Baseline 3	390	390	390
XXX	Additional LH Net Benefits Baseline 3 ((II+III)×XXIX) (millions)	$94	$94	$94
XXXI	Total Net Benefits Baseline 3 (XXV+XXX) (millions)	$661	$609	$435

7 Summary of Results and Comparison of Options

Table 19 presents the results under a one-year implementation for all options and for all baselines using both 7 percent and 3 percent discount rates. Option 1 yields the highest net benefits, whereas net benefits are $320 million lower as compared to Option 2 with the addition of all SH non-RODS operations in Option 3.

Table 19: Summary of All Options and Baselines, One-Year Implementation

		7 Percent Discount Rate			3 Percent Discount Rate		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,586	1,643	1,939	1,554	1,610	1,900
II	HOS Compliance Costs	398	404	438	398	404	438
III	Total Costs (I+II)	1,984	2,047	2,377	1,952	2,014	2,338
IV	Paperwork Savings	1,965	1,965	1,965	1,965	1,965	1,965
V	Safety Benefits	734	736	746	734	736	746
VI	Total Benefits (IV+V)	2,699	2,701	2,711	2,699	2,701	2,711
VII	Net Benefits (VI-III)	715	654	334	747	687	373
VIII	Baseline 2 Net Benefits	799	738	418	831	771	457
IX	Baseline 3 Net Benefits	859	798	478	891	831	517

Table 20 presents the results under a five-year implementation for all options and for all baselines using both 7 percent and 3 percent discount rates. Option 1 yields the highest net benefits, whereas net benefits are $174 million lower as compared to Option 2 with the addition of all SH non-RODS operations in Option 3.

Table 20: Summary of All Options and Baselines, Five-Year Implementation

		7 Percent Discount Rate			3 Percent Discount Rate		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,090	1,139	1,301	1,090	1,139	1,301
II	HOS Compliance Costs	265	270	288	279	284	303
III	Total Costs (I+II)	1,355	1,409	1,589	1,369	1,423	1,604
IV	Paperwork Savings	1,332	1,332	1,332	1,401	1,401	1,401
V	Safety Benefits	590	592	598	622	624	631

VI	Total Benefits (IV+V)	1,922	1,924	1,930	2,023	2,025	2,032
VII	Net Benefits (VI-III)	567	515	341	654	603	428
VIII	Baseline 2 Net Benefits	622	570	396	713	662	487
IX	Baseline 3 Net Benefits	661	609	435	752	701	526

8 Sensitivity Analyses

8.1 Faster Rate of Voluntary EOBR Adoption

The Agency considered if its EOBR adoption forecast was too low, and evaluated the cost and benefits of its options using higher levels of voluntary use. Carriers that would voluntarily use EOBRs may have delayed their purchases until the final technical specifications for the devices were published and until devices compliant with these specifications became available. Furthermore, the publication of this NPRM and the potential subsequent final rule may prompt carriers to get ahead of the implementation schedule, in particular if they believe there is a risk of units not being available when widespread required use begins. The Agency created estimates of costs and benefits based on a doubling of its forecast for voluntary EOBR use. The results of this analysis are presented in table 21.

Table 21: Summary of All Options and Baselines with Faster Voluntary EOBR Adoption ($millions)

		One-Year Implementation			Five-Year Implementation		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,386	1,441	1,715	953	999	1,150
II	HOS Compliance Costs	320	325	357	208	213	230
III	Total Costs (I+II)	1,706	1,766	2,072	1,161	1,212	1,380

IV	Paperwork Savings	1,683	1,683	1,683	1,132	1,132	1,132
V	Safety Benefits	556	557	567	430	431	437
VI	Total Benefits (IV+V)	2,239	2,240	2,250	1,561	1,563	1,569
VII	Net Benefits (VI-III)	533	474	178	401	351	189
VIII	Baseline 2 Net Benefits	596	537	241	439	389	227
IX	Baseline 3 Net Benefits	641	582	286	469	419	257

8.2 Other Agency Actions Improving Enforcement

The Agency is poised to propose and implement several other rules and programs that it anticipates will improve safety before this EOBR rule would become effective. The most notable of them with regards to HOS enforcement is the Comprehensive Safety Analysis (CSA), under which the Agency will propose to perform targeted interventions on carriers' specific problem areas rather than rely solely on comprehensive compliance reviews. One of those specific problem areas is driver fatigue/HOS compliance. This will allow the Agency to spread its enforcement resources over more carriers and will lead to more carriers facing enforcement actions for poor HOS compliance.

In the main body of the analysis, the Agency did not attempt to forecast additional safety and compliance improvements that would precede the effective date of this rule. It did find that roadside inspection HOS OOS violations have declined to about 84 percent of their 2004 levels, and in this sensitivity analysis FMCSA assumes that by the first compliance date, violations will drop again to 84 percent of their current levels, for a cumulative effect of about 70 percent (84%×84% ~ 70%) of their 2004 levels. The Agency also observed that the average number of annual fatal crashes over 2007 and 2008 was 93 percent of the amount calculated for the 2003 HOS RIA analysis, and assumes that by the first compliance date fatal crashes will have dropped to 93 percent of their current levels, for a cumulative effect of about 85 percent (93%×93%~

85%) of the levels estimated in the 2003 HOS baseline, a 15 percent (100%-85%) reduction the attainable safety benefit pool. The results of this analysis are presented in table 22. Net benefits are negative for option 3 with the current HOS rules as a baseline.

Table 22: Summary of All Options and Baselines with Improved Enforcement

		One-Year Implementation			Five-Year Implementation		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,586	1,643	1,939	1,090	1,139	1,301
II	HOS Compliance Costs	331	336	365	221	225	239
III	Total Costs (I+II)	1,917	1,979	2,304	1,311	1,363	1,541
IV	Paperwork Savings	1,965	1,965	1,965	1,332	1,332	1,332
V	Safety Benefits	611	613	621	491	492	498
VI	Total Benefits (IV+V)	2,576	2,578	2,586	1,822	1,824	1,829
VII	Net Benefits (VI-III)	659	599	282	512	461	288
VIII	Baseline 2 Net Benefits	743	683	366	567	516	343
IX	Baseline 3 Net Benefits	803	743	426	606	555	382

8.3 Alternate Values of Statistical Life

The Agency calculated safety benefits and net benefits using a lower value of statistical life (VSL), \$3.3 million, and a higher VSL, \$8.7 million, as compared to the primary estimate of \$6.0 million (all VSL figures in year 2008 dollars). The results of these alternative analyses are presented in tables 23 and 24 below. With a lower VSL, option 3 has negative net benefits under both implementation plans, and option 2 has negative net benefits with the five-year schedule only when the current HOS rules are the baseline. All options have positive net benefits when an

$8.7 million VSL is used.

Table 23: Summary of All Options and Baselines with $3.3 Million VSL

		One-Year Implementation			Five-Year Implementation		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,586	1,643	1,939	1,090	1,139	1,301
II	HOS Compliance Costs	398	404	438	265	270	288
III	Total Costs (I+II)	1,984	2,047	2,377	1,355	1,409	1,589
IV	Paperwork Savings	1,965	1,965	1,965	1,332	1,332	1,332
V	Safety Benefits	456	457	463	366	367	371
VI	Total Benefits (IV+V)	2,421	2,422	2,428	1,697	1,698	1,702
VII	Net Benefits (VI-III)	437	375	51	342	290	114
VIII	Baseline 2 Net Benefits	521	459	135	397	345	169
IX	Baseline 3 Net Benefits	581	519	195	436	384	208

Table 24: Summary of All Options and Baselines with $8.7 Million VSL

		One-Year Implementation			Five-Year Implementation		
		Option 1: RODS	Option 2: RODS+	Option 3: All	Option 1: RODS	Option 2: RODS+	Option 3: All
I	EOBR Costs	1,586	1,643	1,939	1,090	1,139	1,301
II	HOS Compliance Costs	398	404	438	265	270	288
III	Total Costs (I+II)	1,984	2,047	2,377	1,355	1,409	1,589

IV	Paperwork Savings	1,965	1,965	1,965	1,332	1,332	1,332
V	Safety Benefits	1,002	1,004	1,018	804	807	815
VI	Total Benefits (IV+V)	2,967	2,969	2,983	2,136	2,138	2,147
VII	Net Benefits (VI-III)	983	922	606	781	730	558
VIII	Baseline 2 Net Benefits	1,067	1,006	690	836	785	613
IX	Baseline 3 Net Benefits	1,127	1,066	750	875	824	652

9 Regulatory Flexibility Analysis

9.1 Introduction

The Regulatory Flexibility Act of 1980, Pub. L. 96-354, 94 Stat. 1164 (5 U.S.C. 601-612) requires Federal agencies to consider the effects of the regulatory action on small business and other small entities and to minimize any significant economic impact. The term “small entities” comprises small businesses and not-for-profit organizations that are independently owned and operated and are not dominant in their fields, and governmental jurisdictions with populations of less than 50,000. Accordingly, DOT policy requires an analysis of the impact of all regulations on small entities, and mandates that agencies strive to lessen any adverse effects on these businesses.

A Regulatory Flexibility Analysis must contain the following:

A description of the reasons for the action by the Agency.

A succinct statement of the objectives of, and legal basis for, the rule.

A description — and, where feasible, an estimate of the number — of small entities to which the rule applies.

A description of the reporting, recordkeeping, and other compliance requirements of the rule, including an estimate of the classes of small entities that will be subject to the requirement and the types of professional skills necessary for preparation of the report or record.

Identification, to the extent practicable, of all relevant Federal rules that may duplicate, overlap, or conflict with the rule.

A description of any significant alternatives to the proposed rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposed rule on small entities

9.2 Description of Reasons for Action by the Agency.

FMCSA proposes to amend Part 395 of the FMCSRs to require the installation and use of EOBRs for most CMV operations. CMV drivers are currently required to record their HOS (driving time, on- and off-duty time) in paper logbooks, although some carriers have voluntarily adopted an earlier standard for HOS recording using devices known as AOBRDs. On April 5, 2010, FMCSA published a rule mandating EOBR use for a two-year period by commercial motor carriers that fall under the Remedial Directive defined in Subpart J of Part 385 (75 FR 17208). Remedial Directive carriers are required to install EOBRs in each CMV regardless of the date of manufacture of the vehicle.[33] These carriers will have been found during a single compliance review (CR) to have violation rates greater than or equal to 10% for the HOS rules listed under the Appendix C of Part 385 of the FMCSRs. Although, after the compliance date of EOBR I, EOBRs will already be required for those carriers with the poorest compliance records with the HOS regulations, the Agency believes that the benefits of EOBR use by the remaining majority of the motor carrier industry will exceed the costs associated with these devices.

The HOS regulations are designed to ensure that driving time, one of the principal ‘‘responsibilities imposed on the operators of commercial motor vehicles,’’ does ‘‘not impair their ability to operate the vehicles safely’’ (49 U.S.C. 31136(a)(2)). Driver compliance with the HOS rules helps ensure that ‘‘the physical condition of commercial motor vehicle drivers is adequate to enable them to operate the vehicles safely’’ (49 U.S.C. 31136(a)(3)). FMCSA believes that properly designed, used, and maintained EOBRs would enable motor carriers to track their drivers’ on-duty driving hours accurately, thus preventing regulatory violations or excessive driver fatigue.

Improved HOS compliance will prevent commercial vehicle operators from driving for long periods without opportunities to obtain adequate sleep. Sufficient sleep is necessary to ensure that a driver is alert behind the wheel and able to respond appropriately to changes in the driving

33 A provision has been included to exempt Remedial Directive carriers from EOBR use if they already employ AOBRDs.

environment.

Substantial paperwork and recordkeeping burdens are also associated with HOS rules, including time spent by drivers filling out and submitting paper RODS and time spent by motor carrier staff reviewing, filing, and maintaining these RODS. EOBRs will eliminate all of the clerical tasks associated with the RODS and significantly reduce the time drivers spend recording their HOS. These paperwork reductions offset most of the costs of the devices.

9.3 Objectives and Legal Basis.

The Agency is issuing an NPRM proposing to mandate the use of EOBRs by the majority of CMV operations. The objective is to reduce the number of crashes caused by driver fatigue that could have been avoided had the driver complied with the HOS rules. The legal basis for this proposed rule is described in the NPRM.

9.4 Small Entities Affected.

Under criteria established by the Small Business Administration (SBA), firms with annual revenues of less than $25.5 million are considered small for all North American Industrial Classification System (NAICS) codes falling under the truck transportation sub-sector (NAICS 484) or the bus transportation sub-sector (NAICS 485). Many motor carriers, however, are private carriers that transport goods or passengers for parent companies who are primarily not engaged in truck transportation, for example, airlines, railroads, retail stores, and landscaping or home contracting businesses with SBA size thresholds associated with their industries that are different from those used for truck or bus transportation.

FMCSA does not collect revenue data for most carriers nor can it identify carrier-by-carrier which industry sub-sectors each firm belongs to. Carriers do, however, report the number of power units they operate in the U.S. on Form MCS-150. With regards to truck power units, the Agency determined in the 2003 Hours of Service Rulemaking RIA[34] that a power unit produces

34 Regulatory Analysis for: Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations, Final Rule-Federal Motor Carrier Safety Administration. 68 FR 22456 (Apr. 23,2003).

about $172,000 in revenue annually (adjusted for inflation).[35] According to the SBA, motor carriers with annual gross revenue of $25.5 million are considered small businesses.[36] This equates to about 150 power units (25,500,000/172,000). FMCSA believes that this 150 power unit figure would be applicable to private carriers as well: Because the sizes of the fleets they are able to sustain are indicative of the overall size of their operations, large CMV fleets can generally only be managed by large firms. There is a risk, however, of overstating the number of small businesses because the operations of some large non-truck or bus firms may require only a small number of CMVs. The Agency has identified about 482,000 motor carriers that operate 150 or fewer power units, about 99% of property carriers.

For passenger carriers, the Agency conducted a preliminary analysis to estimate the average number of power units (PUs) for a small entity earning $7 million annually, based on an assumption that a passenger carrying CMV generates annual revenues of $150,000. This estimate compares reasonably to the estimated average annual revenue per power unit for the trucking industry ($172,000). A lower estimate was used because buses generally do not accumulate as many vehicle miles traveled (VMT) per power units as trucks[37], and it is assumed therefore that they would generate less revenue on average. The analysis concluded that passenger carriers with 47 PUs or fewer ($7,000,000 divided by $150,000/PU = 46.7 PU) would be considered small entities. The Agency examined its registration data and found that 96% of, or just over 19,000, interstate passenger carriers have 47 PUs or fewer.

The Agency seeks comment on other ways to minimize the impact on small entities. FMCSA is often contacted with public inquiries about EOBR devices, and will continue to address these questions. Following the pattern of previous rulemakings, the Agency will conduct outreach once a final rule is issued. The Agency notes that all registered motor carriers are subject to this rule. This includes small non-profits. This does not include small governmental jurisdictions.

---

35 The 2000 TTS Blue Book of Trucking Companies, number adjusted to 2008 dollars for inflation.

36 U.S. Small Business Administration Table of Small Business Size Standards matched to North American Industry Classification System (NAICS) codes, effective August 22, 2008. See NAICS subsector 484, Truck Transportation.

37 FMCSA Large Truck and Bus Crash Facts 2008, Tables 1 and 20; http://fmcsa.dot.gov/facts-research/LTBCF2008/Index-2008LargeTruckandBusCrashFacts.aspx (accessed January 4, 2011).

9.5 Reporting, Recordkeeping, and Other Compliance Requirements.

FMCSA believes that implementation of the proposed rule would not require additional reporting, recordkeeping, or other paperwork-related compliance requirements beyond what are already required in the existing regulations. In fact, the proposed rule is estimated to result in paperwork savings, particularly from the elimination of paper RODS. Furthermore, the carriers would experience compensatory time-saving or administrative efficiencies as a result of using EOBR records in place of paper RODS. The level of savings would vary with the size of the carrier implementing the systems (larger carriers generally experience greater savings).

Under current regulations, most CMV drivers are required to fill out RODS for every 24-hour period. The remaining population of CMV drivers is required to fill out time cards at their workplace (reporting location). Motor carriers must retain the RODS (or timecards, if used) for 6 months. FMCSA estimates the annual recordkeeping cost savings from this proposed rule of about $688 per driver. This is comprised of $486 for a reduction in time drivers spend completing paper RODS and $56 submitting those RODS to their employers; $116 for motor carrier clerical staff to handle and file the RODS; and $30 for elimination of expenditures on blank paper RODS for drivers. Two of the options discussed in the NPRM extend the EOBR mandate to carrier operations that are exempt from the RODS. Paperwork savings will not accrue to drivers engaged in these operations.

Under the Paperwork Reduction Act of 1995 (PRA) (44 U.S.C. 3501 et seq.), Federal agencies must obtain approval from the OMB for each collection of information they conduct, sponsor, or require through regulations. This NPRM proposes regulatory changes to several parts of the FMCSRs, but only those applicable to part 395, "Hours of Service of Drivers," would alter or impose information collection requirements. The information collection requirements of this NPRM would affect OMB Control Number 2126-0001, which is currently approved through August 31, 2011, at 181,270,000 burden hours.

OMB requires agencies to provide a specific, objective estimate of the burden hours imposed by their information collection requirements (5 CFR 1320.8(a)(4)). This NPRM proposes a compliance date 3 years after the date of publication of the final rule to allow regulated entities a reasonable opportunity to satisfy its requirements. The PRA limits estimates of paperwork burdens to a 3-year period; during the initial 3 years following publication of a final rule in this matter, the requirements of part 395, including information collection requirements, would remain unchanged. Consequently, the Agency estimates the paperwork burden of this proposal to be 181,270,000 burden hours, as currently approved by OMB. At an appropriate time, the Agency will provide notice and request public comment on the paperwork burden of part 395 after the initial 3-year period of this rule; at the present time, the Agency believes that the regulatory changes proposed by this NPRM will ultimately affect a net reduction in the paperwork burden of OMB Control Number 2126-0001.

9.6 Federal Rules that May Duplicate, Overlap, or Conflict with the Rule

The Agency did not identify any Federal rules that duplicate, overlap, or conflict with the rule.

9.7 Steps to Minimize Adverse Economic Impacts on Small Entities

Of the population of motor carriers that FMCSA regulates, 99% are considered small entities under the SBA's definition.[38] Because small businesses are such a large part of the demographic the Agency regulates, providing exemptions to small business to permit noncompliance with safety regulations is not feasible and not consistent with good public policy. The safe operation of CMVs on the Nation's highways depends on compliance with all of FMCSA's safety regulations. Accordingly, the Agency will not allow any motor carriers to be exempt from coverage of the proposed rule based solely on a status as a small entity.

FMCSA analyzed an alternative 5-year implementation schedule that would have provided a longer implementation period for small businesses. However, the estimated cost of compliance for motor carriers, including small businesses, did not decrease from the 3-year "baseline" proposed implementation period. Furthermore, a considerably longer implementation period could compromise the consistency of compliance-assurance and enforcement activities, and thereby diminish the rule's potential safety benefits. Therefore, the Agency's proposal includes

[38] (482,000 property carriers + 19,000 passenger carriers) ÷ 504,000 total carriers = 99.4%

a single compliance date for all motor carriers that would be subject to the new rule's requirements.

However, the Agency recognizes that small businesses may need additional information and guidance in order to comply with the proposed regulation. In order and to improve their understanding of the proposal and any rulemaking that would result from it, FMCSA proposes to conduct outreach aimed specifically at small businesses. FMCSA would conduct Webinars and other presentations as needed and upon request, at no charge to the participants. These would be held after the final rule has published and before the rule's compliance date. To the extent practicable, these presentations will be interactive. Their purpose will be to describe in plain language the compliance and reporting requirements so they are clear and readily understood by the small entities that will be affected. The technical requirements the EOBR device and support systems used by small businesses must be identical to those established in the April 5, 2010 final rule, as amended (75 FR 17208; amended at 75 FR 55488, Sept. 132010)), codified in Appendix A to Part 395. This section establishes the minimum performance standards for the devices.

Today's rule would likely become effective no earlier than 2014, four years after the technical specifications were published in EOBR I, and two years after the first 1x10 remedial directive carriers will have been required to use the devices. EOBRs are expected to reduce business costs related to HOS Compliance, and can be used to increase other business-related efficiencies and reduce costs.

EOBRs can lead to significant paperwork savings that can in part or fully offset the costs of the devices. The Agency, however, recognizes that these devices entail a significant up-front investment than can be burdensome for small carriers. At least one vendor, however, provides free hardware and recoups the cost of the device over time in the form of higher monthly operating fees. The Agency is also aware of lease-to-own programs that allow the carriers to spread the purchase costs over several years. Nevertheless, the typical carrier would likely be required to spend $1,500-$2,000 per CMV to purchase and install EOBRs, and several hundred dollars per year for service fees. This estimate is higher than the estimate used in the April 2010 EOBR rulemaking for two primary reasons.

This proposed mandate would be permanent and also would require EOBRs to be installed and used in more than 20 times as many CMVs than were estimated to be affected by the April 5, 2010, final rule. Therefore, the Agency cannot assume that an adequate number of the lower-cost devices would be available to meet the needs of that larger market. Current revenue data from the manufacturer of the device cited in the April 2010 final rule indicate that its market share is relatively low.

A second reason for using a higher cost for this analysis is that, in response to motor carrier customer demand, EOBR suppliers have expanded the functionality of their products and services. Hours-of-service recording and monitoring are functions commonly offered as part of comprehensive fleet management systems, rather than in stand-alone devices. Many motor carriers are recognizing the potential operational benefits they can gain from the use of fleet management systems, and the marketplace is responding with products and services tailored to motor carriers of all sizes. However, the Agency is not dismissing the possibility that "stand-alone" EOBRs, providing only hours-of-service recording and reporting (similar to the first AOBRDs in the 1980s), may be offered for sale or lease at a lower cost than devices with other functionalities in addition to HOS compliance. The Agency requests comments and data about EOBR cost.

Based on direct experience with the devices and conversations with vendors, the Agency believes these devices are extremely durable and can be kept operational for many years. In addition to purchase costs, carriers would also likely spend about $40 per month per CMV for monthly service fees.

10 Unfunded Mandates Reform Analysis

The Unfunded Mandates Reform Act of 1995 requires Agencies to evaluate whether an Agency action would result in the expenditure by State, local and tribal governments, in the aggregate, or by the private sector, of $140.8 million or more (as adjusted for inflation) in any one year, and if so, to take steps to minimize these unfunded mandates. This rule would not result in the expenditure by State, local and tribal governments, in the aggregate, of $140.8 million or more in any one year, nor would it affect small governments, as they are excluded from this rule. As table 25 shows, this rulemaking would result in private sector expenditures in excess of the threshold for all of the proposed options. Gross costs, however, are expected to be more than offset in savings from paperwork burden reductions.

Table 25: Annualized Net Expenditures by Private Sector (millions)

	Option 1: RODS	Option 2: RODS+	Option 3: All
Total EOBR Cost	$1,586	$1,643	$1,939
Total Paperwork Savings	$1,965	$1,965	$1,965
Net EOBR Cost	-$379	-$322	-$26

Appendix A Derivation of Carrier, Driver, and CMV Counts

FMCSA used two recently conducted rulemaking analyses and data for years 2007 through 2009 from the Motor Carrier Management Information System (MCMIS) for its estimates of carriers, drivers, and CMVs. Estimates of about 500,000 active carriers and 4,000,000 CMV drivers were developed for the Drivers of CMVs: Restricting the Use of Cellular Phones (hereafter "cell phone") proposed rule.[39] The RIA prepared for the 2010 HOS NPRM estimated 1,472,000 LH or over-the-road (OTR) tractors and 1,619,000 LH or OTR drivers, the latter estimate derived by having applied an industry average of 1.1 drivers per CMV.[40] The estimate in this RIA of total CMVs was derived by dividing the 4,000,000 driver estimate in the cell phone rule by the 1.1 driver-per-CMV average, resulting in an estimate of 3,637,000 CMVs. SH estimates were derived by subtracting the LH estimates from the totals. The Agency did not develop estimates for the number of LH and SH carriers due to the overlap between the two types of operations, that is, not all carriers specialize by length of haul, and many conduct both types of operations. Separate estimates of the numbers of carriers engaged in LH and SH operations were not needed for the cost and benefit calculations.

Table 26: Estimates of Total, LH, and SH Operations (thousands)

Total			LH		SH (Total -LH)	
Carriers	Drivers	CMVs	Drivers	CMVs	Drivers	CMVs
504	4,000	3,637	1,619	1,472	2,381	2,165

MCMIS data on the type and number of CMVs are generally more accurate than those on drivers. Carriers report both types of information when they register for their DOT numbers on the MCS-150 forms, and are required to update this information at least once every two years. The MCS-150 registration forms contain information on the types of equipment carriers operate and if they haul bulk quantities of hazardous materials. Counts of total CMVs by type of vehicle are believed to be reasonably accurate and can be reconstructed quickly from the MCMIS data.

39 75 FR 80014 (Dec. 21, 2010).
40 See section 2.1.3 and Appendix A of the 2010 HOS NPRM RIA.

Counts of CMVs are also used to parse non passenger carrying, non bulk hazmat operations into three categories: large (greater than 1,000 power units), medium (151 to 1,000 power units), and small (150 or fewer power units). Driver counts do not identify the types of operations, passenger versus property, or the type of cargo that drivers transport. Due to high occupational turnover, driver counts can be fluid, and a particular driver may not drive the same type of vehicle or cargo throughout the year. For these reasons, the Agency simply applied the 1.1 driver-per-CMV estimate for the CMV totals to estimate the drivers working in each type of operation.

Table 27: CMVs by Vehicle Configuration or Carrier Size (thousands)

	Total	Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small
CMVs	3,637	49	181	360	1,691	646	710
Drivers (CMVS×1.1)	4,000	54	199	396	1,860	711	780

Although the counts of drivers by type of operation in the MCMIS data were unsuited to this analysis, the Agency did use information on the number of SH ("within 100-Mile Radius") and LH ("beyond 100-Mile Radius") drivers reported by carriers on the MCS-150 form. Using these data, the Agency constructed estimates of the average fractions of carrier operations by length of haul for each of the groups (table 28). Because it began with estimates of total, LH, and SH operations, FMCSA estimated each of the categories of operations, and then used the small carrier group as a residual to ensure that the sum across all the groups equaled the total, that is, Small = Total – Motorcoach – Other Passenger – Bulk Hazmat – Large – Medium. As a next step, the percentages in table 28 were applied to the figures in table 27 for the final counts of CMVs and drivers by type of operation and length of haul, shown in table 29.

Table 28: Carrier Operations by Length of Haul

	Total	Motor-coach	Other Passenger	Bulk HM	Large	Medium	Small (observed)	Small (adjusted)
LH	40%	50%	20%	60%	30%	50%	40%	51%
SH	60%	50%	80%	40%	70%	50%	60%	49%

Table 29: Final Carrier, CMV, and Driver Estimates (thousands)

		Total	Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small
Total	Carriers	504	10	10	18	<1	2	464
	Drivers	4,000	54	199	396	1,860	711	780
	CMVs	3,637	49	181	360	1,691	646	710
LH	Drivers	1,619	28	40	238	558	356	399
	CMVs	1,472	25	36	216	507	323	365
SH w/ RODS	Drivers	1,787	21	119	119	977	267	284
	CMVs	1,624	19	109	108	888	242	258
SH w/o RODS	Drivers	594	7	40	39	325	89	94
	CMVs	541	6	36	36	296	81	86

Appendix B Forecasts of EOBR and FMS Use

To forecast EOBR and FMS use, the Agency fit a model to the few data points it had on the percentage of CMVs equipped with these devices. The Agency picked 1990 as a starting point: around that year the first AOBRDs were introduced and FMS[41] first came on the market. Those early FMS would have had none of the functionality required for HOS logging as defined in EOBR I, but the Agency assumes that early adopters will have upgraded their FMS to those with fully compliant EOBR functions by the time the rule being proposed here will become effective. The Agency relied on a simple model for technology adoption called a diffusion model. A study by Ryan and Gross (1943)[42] on farmers' adoption of hybrid seed technology is widely recognized as the starting point for modern research into the technological diffusion process. A more formal mathematical analysis of this earlier study was presented by Griliches (1957).[43] The general premise is that the total percentage of new technology adopters will follow a cumulative normal distribution extending over time. Using 1990 as an approximate starting point, the Agency fitted diffusion curves to the 1990 starting point and other available data points on motor carrier technology use. Charts 1 and 2 display those fitted curves.

41 Reference for Business Encyclopedia of Business, 2nd ed. "SIC 4123 trucking except local". http://www.referenceforbusiness.com/industries/Transportation-Communications-Utilities/Trucking-Except-Local.html. Accessed 27 November 2009.
42 Ryan, B. (1943). The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology*. 8(1), p. 15-24.
43 Griliches, Z. (1957) "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica*, 25 (4): 501-522.

Chart 1: Forecast of FMS Use without EOBR Rule

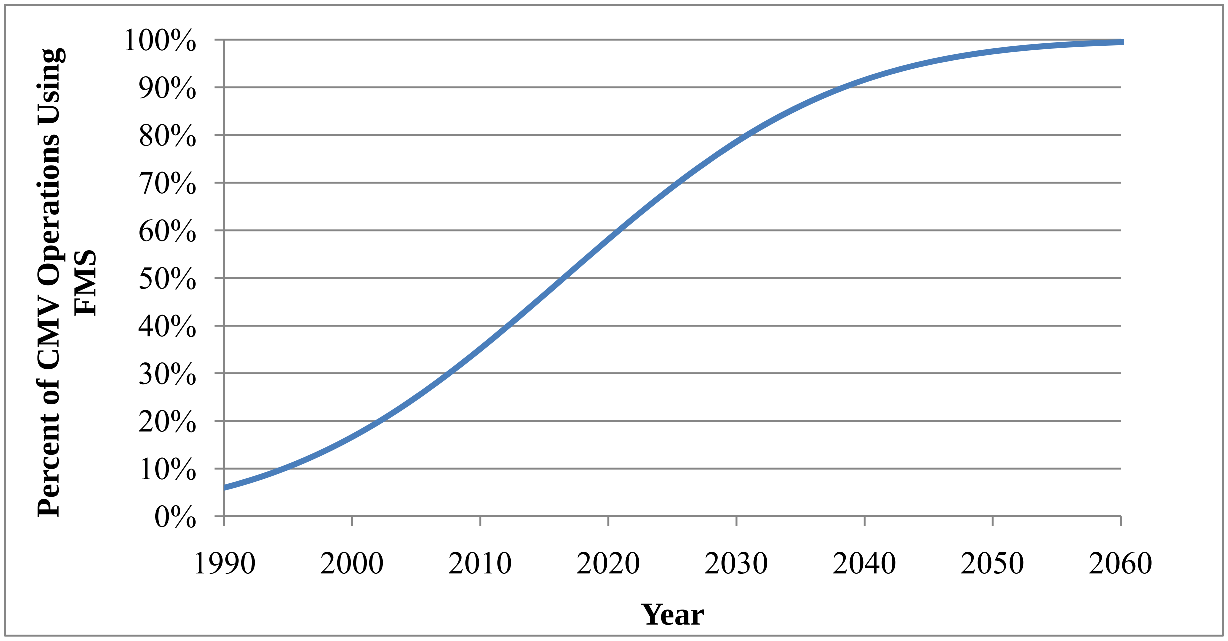


Chart 2: Forecast of Voluntary EOBR Use without EOBR Rule

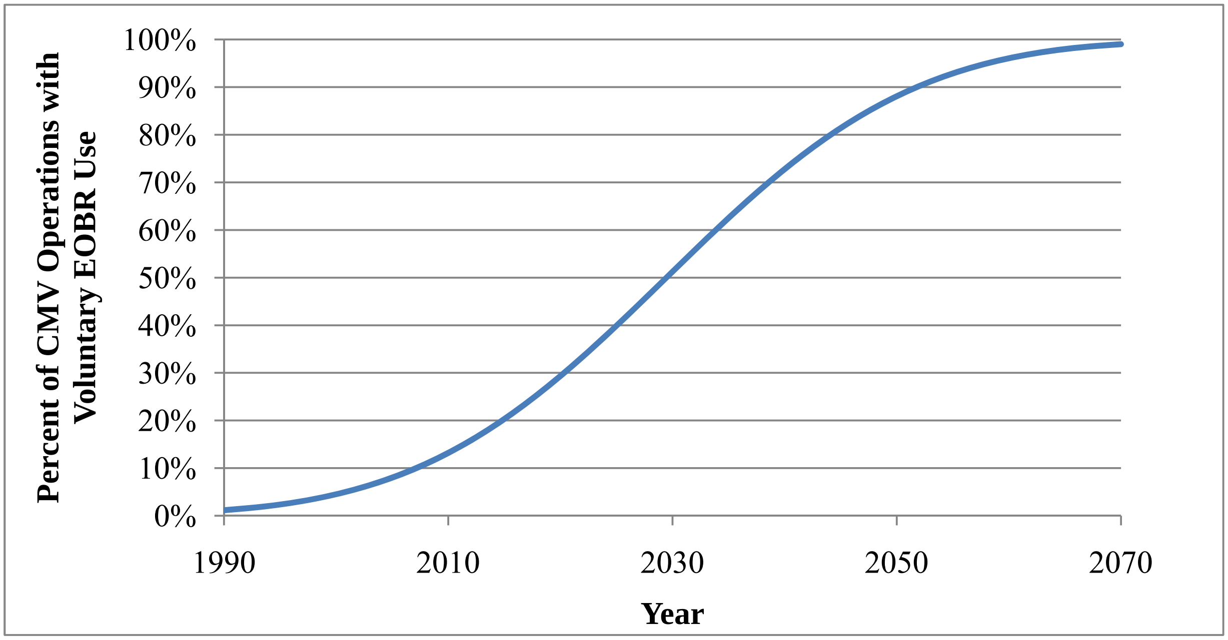


Table 30 shows the percentages for FMS and EOBR used from each of the diffusion model curves and the final estimates of technology adoption used in the analysis. As of 2005, the percentage of SH operations using FMS was about one-third the percentage of LH operations using this technology (8% for SH versus 25% for LH).[44] The Agency does not have sufficient data to estimate separate SH technology adoption curves, and assumes that technology adoption for SH will be one-third that of LH for any point on the diffusion curves. Last, beginning in 2012, the percentage of power units affected by the EOBR I 1X10 remedial directive was added on top of the percentages of EOBR voluntary users.

Table 30: Estimates of FMS and EOBR Use

	FMS Use		EOBR Use		
Year	LH	SH	LH	LH 1X10	SH
1990	6%	2%	1%	0%	0%
1991	7%	2%	1%	0%	0%
1992	8%	3%	2%	0%	1%
1993	8%	3%	2%	0%	1%
1994	9%	3%	2%	0%	1%
1995	10%	3%	2%	0%	1%
1996	11%	4%	3%	0%	1%
1997	13%	4%	3%	0%	1%
1998	14%	5%	4%	0%	1%
1999	15%	5%	4%	0%	1%
2000	17%	6%	5%	0%	2%
2001	18%	6%	5%	0%	2%
2002	20%	7%	6%	0%	2%
2003	21%	7%	6%	0%	2%
2004	23%	8%	7%	0%	2%
2005	25%	8%	8%	0%	3%
2006	27%	9%	9%	0%	3%
2007	29%	10%	10%	0%	3%
2008	31%	10%	11%	0%	4%
2009	33%	11%	12%	0%	4%
2010	35%	12%	13%	0%	4%
2011	37%	12%	14%	0%	5%
2012	40%	13%	16%	10%	5%
2013	42%	14%	17%	10%	6%
2014	44%	15%	19%	10%	6%
2015	46%	15%	20%	10%	7%
2016	49%	16%	22%	10%	7%
2017	51%	17%	24%	10%	8%

44 "Exhibit 1:Estimation of Market Penetration of EOBR-Ready Devices" from the EOBR I RIA.

2018	53%	18%	26%	10%	9%
2019	56%	19%	27%	10%	9%
2020	58%	19%	29%	10%	10%

Appendix C Improvements in HOS Compliance

FMCSA examined CMV roadside inspection data from 2004, the first full year the main provisions of the current HOS rules were in effect, through 2009, the last complete year of data, to assess changes in carrier compliance with the HOS rules, focusing on those violations severe enough to warrant out of service (OOS) orders. Table 31 shows the overall HOS OOS violation rates and the most prevalent types of individual violations (the OOS rate will be less than the sum of the individual categories because an inspection can result in multiple OOS violations). From 2004 to 2009, the overall OOS rate declined about 84 percent. OOS rates for the 11 hour driving limit declined 67 percent, and OOS violations related to missing, incomplete, improper, or fraudulent RODS declined 84 percent. Although there are not enough years of data to determine whether the declines in the HOS violation OOS in 2008 and 2009 are permanent, incomplete inspection data for 2010 are so far showing further declines in the HOS OOS rate as compared to that in 2009. These data represent the Agency's best estimate of the current state of HOS compliance, and although there may be some uncertainty as to whether they are the most robust assessment of baseline non-compliance with the HOS rules, projections of future non-compliance rates would be difficult to construct and would have high degrees of forecast uncertainty.

EOBRs at a minimum will automatically record driving time; insofar as drivers use the devices as required, EOBRs will ensure that drivers have RODS that are complete and contain properly formatted entries. The Agency believes that EOBRs will have the greatest impact reducing 11 hour driving time violations and most of the serious RODS preparation violations. However, because drivers will have to manually record when on-duty, non-driving periods begin and end, EOBRs will have limited effects on improving accurate recording of overall daily on-duty time (14-hour rule violations) or weekly on-duty time (60/7 or 70/8 rule violations). Improvements in overall HOS compliance currently reflect reductions in 11 hour RODS preparation violations and will continue to do so when the majority of CMV operations begin using EOBRs.

Table 31: 2004-2009 HOS OOS Violation Rates

	2004	2005	2006	2007	2008	2009	2004-2009 Improve-ment
Total HOS OOS Violation Rate	4.6%	4.7%	5.3%	4.9%	4.4%	3.9%	84%
Over 11 Hours Driving	1.4%	1.4%	1.4%	1.2%	1.1%	0.9%	67%
Over 14 Hours On Duty	1.3%	1.3%	2.1%	1.9%	1.7%	1.5%	118%
Over 60 Hours/7 Days or 70 Hours/8 Days	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	62%
Missing, Incomplete, Improper, or Fraudulent RODS	3.9%	4.2%	4.4%	4.1%	3.7%	3.3%	84%

Appendix D Improvements in CMV Safety

The ability of EOBRs to reduce CMV crashes is constrained by two factors. The first is the overall number of crashes occurring; irrespective of HOS noncompliance, safety deficiencies have to exist for safety improvements to occur. The second is the prevalence of crashes related to HOS violations, specifically fatigue related crashes. Safety benefits can be estimated as the monetized reductions in crashes that can be anticipated to follow from reductions in fatigue. An accurate indicator to measure safety benefits are reductions in crash risk because eliminating any hour of driving eliminates all increase in crash risk associated with that hour, not just the risk associated with fatigue coded ones. However, the Agency does not have enough data to determine relative crash risk for all types of crashes at each hour. Hence, we consider only risk associated with fatigue-coded crashes. Table 32 shows the changes in the measurements of CMV safety since the safety baseline for the current rules was established in the 2003 HOS RIA. The "2003 Rule" column does not contain year 2003 data, but a four-year average from 1997-2000 to which the Agency's estimate of the cost of CMV crashes available at the time[45] was applied for a measure of total societal damages. To update the overall CMV safety measure, FMCSA compared the 2003 HOS rule figures to the average number of crashes that occurred in the most recent two years for which data are available, 2007 and 2008. As shown in table 32, fatal and injury crashes declined, but the less severe category of property damage only (PDO) crashes increased. In total, the number of crashes has increased slightly, only 3 percent, as compared to the data used in the 2003 HOS rule. The Agency also applied a higher value for the cost per CMV crash which reflects revised cost per crash data,[46] inflation to year 2008 prices, and a higher VSL required by DOT for all of its regulatory evaluations.[47] Combined, these adjustments caused the estimate of the cost per CMV crash to about double. Total monetized damages from CMV involved crashes were 203 percent of the estimate prepared in the 2003 HOS RIA; this adjustment is reflected in row VII of table 7. Although the total number of crashes did not change substantially, the monetary value assigned to those crashes led to a significant increase in the safety benefits attainable by mandating EOBRs.

---

45 Zaloshnja, E., Miller, T., Spicer R. (2000). Costs of Large Truck and Bus Involved Crashes. U. S. Department of Transportation.

46 Zaloshnja, E. and Miller, T. (2006). Unit Costs of Medium and Heavy Truck Crashes, Final Report for Federal Motor Carrier Safety Administration, Federal Highway Administration.

47 http://ostpxweb.dot.gov/policy/reports/080205.htm.

Table 32: 2003-2008 Changes in Measurements of CMV Safety

	2003 Rule (2000$)	Updated Baseline (2008$)					Updated ÷ 2003 Rule
		2007		2008		Total, Annual Average	
		Truck	Bus	Truck	Bus		
Fatal Crashes	4,568	3,733	247	4,204	280	4,232	93%
Injury Crashes	92,000	64,000	11,000	72,000	11,000	79,000	86%
PDO Crashes	329,250	297,000	45,000	317,000	48,000	353,500	107%
Total Crashes	425,818	364,733	56,247	393,204	59,280	436,732	103%
Cost per Crash ($)	75,637					150,000	198%
Total Monetized Societal Damages ($ Millions)	32,208					65,510	203%

In the 2010 HOS RIA, the Agency reassessed the prevalence of CMV driver fatigue in crashes. Past HOS analyses had used an estimate of about 7 percent, which limited the attainable safety benefits from any changes to the HOS rules or improved enforcement of those rules, such as by mandating EOBRs, to at most 7 percent of the total societal damages from CMV involved crashes. Based on data from the Large Truck Crash Causation study and public comments on past HOS rule analyses, the Agency updated its estimate of the prevalence of CMV driver fatigue to 13 percent of crashes, resulting in the attainable safety benefits increasing to 186 percent (13 percent ÷ 7 percent) of the value estimated in the 2003 HOS RIA. This adjustment is reflected in row VIII of table 9.

Appendix E EOBR Effectiveness

There is little research on the effectiveness of EOBRs in reducing crashes and HOS violations. FMCSA examined a study conducted by Cantor et al. of the University of Maryland on the effectiveness of EOBRs in reducing HOS violations and crashes.[48] Data used in this study were from a national survey sponsored by FMCSA on safety technology adoption (which includes but is not limited to EOBRs or AOBRDs) by large motor carriers. The final dataset included information from a total of 386 firms that operated on average 671 CMVs; in terms of CMVs, survey respondents represented about 6 1/2 percent of the estimated total. About 58 percent were for-hire carriers and the range of operations represented about 8 percent local, 44 percent regional, and 41 percent national. Among larger carriers, the Agency believes the survey achieved a representative cross section of the industry. Small and medium carriers, however, are not represented, but the Agency believes that these firms will likely have lower adoption of safety technologies.

The researchers employed Poisson models that treat both HOS violations and crashes as count variables, and regressed these on an EOBR variable measuring the percentage of each carrier's fleet that used the devices and several control variables. The authors developed an impact analysis on the average effect of EOBR usage based on the estimates resulting from their models. Their analysis found that full EOBR adoption could reduce HOS violations 12.4 percent and reduce total crashes, not only fatigue-related crashes, 15.6 percent. While the estimates of positive impacts of the devices are credible, the Agency believes that the magnitude of the crash effects estimated in this study is larger than what one would anticipate from the implementation of this rule, and the magnitude of the reduction in HOS violations much smaller. All carriers in the sample that use EOBRs adopted these devices voluntarily, indicating a proactive commitment to reducing their fatigue-related crashes. Also, EOBRs were likely implemented along with other safety technology, which this study did not control for, and the EOBR usage variable may also capture safety improvements from reductions in other types of crashes not related to HOS violations. For the purposes of this analysis, the Agency focuses strictly on costs

48 Cantor, D.E. et al. (2009). "Do Electronic Logbooks Contribute to Motor Carrier Safety Performance." *Journal of Business Logistics* 30(1), 203-23.

and benefits from electronic HOS logging and monitoring, which likely form a subset of the crashes eliminated by the voluntary adopters in this study.

The Agency relied on a different analysis of EOBR effectiveness that is intended to evaluate the effects of these devices for the typical, unwilling adopter and that maintains analytical consistency with the HOS rule. It estimated the percentage of crashes occurring at illegal drive times (after 11 hours) to construct an upper bound for the safety benefits of EOBR use. It began with the Time on Task (TOT) model developed for the HOS rules, which used a logistic regression to predict fatigue related crashes as a function of driving time: Percentage of Crashes that are Fatigue Related = exp(-4.632 + 0.1226Drive Time + 0.0034Drive Time).2 Next, using data from FMCSA's 2008 Field Survey, the Agency constructed a measure of driver exposure, that is, the percentage of driving occurring, at each hour of drive time.[49] The product of the predicted percentage of fatigue related crashes and exposure yields an estimate of the percentage of total crashes attributable to fatigue distributed over 20 hours of drive time. The Agency estimates that driver fatigue occurs in 13 percent of crashes, and as a final step rescales these results to sum to 13 percent. Last, as shown in table 33, the Agency calculates that total annual societal damages from CMV crashes are $65,510 million. This amount can be allocated to the fatigue related crashes occurring in each hour of drive time. This analysis is presented in Table 32.

Table 33: Predicted Safety Benefits of Eliminating 11-Hour Rule Violations

(a)	(b)	(c)	(d)	(e)	(f)
Driving Hour	TOT Model Prediction, Fatigue Crashes within Driving Hour	Driving Occurring at Each Hour of Drive Time	Fatigue Crashes, Percentage of Total, Distributed over Hours of Drive Time (b × c)	Fatigue Crashes, Percentage of Total, Distributed over Hours of Drive Time, Scaled to Sum to 13 Percent	Societal Damages (millions) (e × $65,510)
1	1.1%	12.8%	0.1%	0.8%	$494
2	1.3%	12.5%	0.2%	0.8%	$550

49 This follows the methodology used in the HOS NPRM, but extends it to 20 hours of drive time.

3	1.4%	11.9%	0.2%	0.9%	$604
4	1.7%	11.4%	0.2%	1.0%	$666
5	2.0%	10.6%	0.2%	1.1%	$721
6	2.3%	9.6%	0.2%	1.2%	$769
7	2.7%	8.6%	0.2%	1.2%	$809
8	3.2%	7.4%	0.2%	1.3%	$837
9	3.9%	6.1%	0.2%	1.3%	$825
10	4.7%	4.6%	0.2%	1.1%	$749
11	5.6%	2.4%	0.1%	0.7%	$478
12	6.9%	0.5%	0.0%	0.2%	$128
13	8.5%	0.4%	0.0%	0.2%	$109
14	10.5%	0.3%	0.0%	0.1%	$96
15	13.1%	0.2%	0.0%	0.1%	$98
16	16.5%	0.2%	0.0%	0.2%	$104
17	20.9%	0.2%	0.0%	0.2%	$114
18	26.6%	0.1%	0.0%	0.2%	$130
19	34.0%	0.1%	0.0%	0.2%	$148
20	43.9%	0.1%	0.0%	0.1%	$87
Sum of Effects for Hours 12 to 20				1.5%	$1,014

According to this analysis, eliminating all fatigue-related crashes that occur during illegal driving times results in a 1.5 percent reduction in total crashes and a monetized safety benefit of $1,014 million. As Table 9 above indicates, the baseline safety benefit related to perfect enforcement of the existing HOS rules is $3,255 million. If the elimination of driving time violations could accrue safety benefits of $1,014 million, then other violations account for the remaining $2,214 million ($3,255 - $1,014) in maximum safety benefits.

To evaluate the effectiveness of EOBRs in improving HOS compliance, the Agency used roadside inspection data from motor carriers under settlement agreements with the Agency to install and use enhanced AOBRDs. The Agency continually monitors inspection data from these carriers. It began by analyzing OOS 11-hour rule violations per inspection. Because multiple categories of OOS HOS violations can be found during a single inspection, the TOT model would have captured the risks of other types of HOS violations that coincide with driving time violations. To attempt to isolate the effects of EOBRs on other violations, these other OOS HOS violations are evaluated only where an 11-hour rule violation had not been found. As shown in table 34, after the carriers began using enhanced AOBRDs, HOS violations dropped significantly; the differences in violation rates were significant at a 99 percent level or higher.[50]

Table 34: HOS OOS Rate Reduction for Carriers Using AOBRDs under Settlement Agreements

					95% Confidence Interval		EOBR Effectiveness at:	
	No EOBR (n=603)	EOBR (n=256)	Diff.	P-Value	Lower Bound	Upper Bound	Lower Bound	Mean
11-Hour Rule	6.5%	2.3%	4.1%	0.01	1.4%	6.8%	22%	64%
14 Hour, Other Rules	21.7%	8.2%	13.5%	<0.01	8.8%	18.2%	41%	62%
Missing, Incomplete, Fraudulent RODS	35.2%	7.0%	28.1%	<0.01	23.2%	33.1%	66%	80%
All Violations	69.2%	19.1%	50.0%	<0.01	43.9%	56.1%	64%	72%

FMCSA's analysis indicates that enhanced AOBRDs can eliminate at least two-thirds of HOS violations. However, the Agency is cautious not to overestimate the effectiveness of the devices, and for this regulatory analysis, prefers to evaluate them at the lower bound of a 95 percent confidence interval, where 22 percent of 11-hour rule violations are eliminated, 41 percent of violations to other time limits are eliminated, and 66 percent of RODS preparation violations, so-called "form and manner" violations, are eliminated. The Agency is uncertain about the degree to which form and manner violations are the result of simple negligence or mask other time limit violations, but believes the latter reason is prevalent enough to justify its adjusting the estimate of EOBR effectiveness upward slightly. As discussed above, about one-third of the safety benefits of enforcing the HOS rules come from the drive time limits, and the other two-thirds from the other provisions. The Agency calculates overall EOBR effectiveness as the weighted

50 The data represent counts of violations per inspection. Therefore a hypothesis test on the differences in values treated as proportions, rather than sample means, was conducted.

average of 11-hour rule and other rule enforcement, or [(22% × 1/3) + (41% × 2/3)] = 34%. The Agency rounds this figure up to 40 percent to account for form and manner violations used to hide time limit violations.

Appendix F Price and Availability of EOBRs

The device examined in the analysis for cost estimates is the Qualcomm MCP-100 FMS that uses terrestrial communications. In past reviews of devices, FMCSA has found Qualcomm devices to be at the top of the cost range of available products. Qualcomm has among the largest market shares of FMS[51], and although its devices are slightly more expensive, devices with costs close to that of the MCP-100 may be the most abundant in the market when the compliance phase-in begins. Qualcomm reports that the MCP-100 currently costs $1675 and requires a $40 per month communication fee, which covers all the device's main features, including HOS monitoring. A Qualcomm sales representative also discussed third party lease-to-own programs that allow carriers to spread the up-front costs of the device over a monthly payment plan. A typical payment plan is $60 per month over 36 months.

FMCSA has limited information on the ability of vendors to produce adequate supplies of EOBRs by the compliance date of the rule. However, there is currently sufficient depth in the market to suggest that vendors will be able to meet demand. The Agency estimates that about one-half of LH operations currently use FMS or EOBRs, and is forecasting that about three-quarters of LH operations will have been using these devices absent this rulemaking. It is also estimated that about 15 percent of SH operations use these devices, and that this will have grown to about 25 percent absent this rulemaking. Vendors are currently able to meet demand, and the Agency believes that they will have already been anticipating growth in EOBR and FMS markets. FMCSA is seeking commentary and information on vendors on their ability to supply EOBRs.

Table 35 present further comparisons of devices costs. A slightly higher cost results if the MCP-100 is evaluated with the thirty-six-month payment plan. The cost of producing devices may decline over time, but the Agency is uncertain, given the surge in demand caused by the compliance date, whether these cost savings will be passed on to purchasers in the near term.

51 Qualcomm reported over $10 billion in sales for 2009. http://www.hoovers.com/company/Qualcomm_Incorporated/rrcyji-1.html. (accessed February 19, 2010).

Table 35: Comparison of EOBR Cost Estimates

	New EOBR Purchase			EOBR-Ready FMS
	EOBR I Device	EOBR II Device	EOBR II Device Lease to Own	
Description of Monthly Costs	$45=($35 for EOBR Service + $10 for Cell Phone Data Service)	$40 Fee for HOS Monitoring	$40 Monthly Fee + $60 per Month Lease for First 36 Months	$8 fee for HOS Monitoring
Monthly Cost Discounted to Beginning of Year (12 Payments Discounted at 7%÷12)	$520	$462	$721	$92
Description of Startup Costs	$35 for Initial Fee	$1675 for Device + $100 for Installation, $500 for Repair	$100 for Installation, $500 for Repair	$0 (Power Units Already Equipped with Hardware)
Startup Costs	$35	$1,775	$100	$0
Repair Costs in 5th and 10th Years		$500	$500	
Annualized Startup Costs	$5	$323	$100	$0
Total Annualized Costs	$525	$785	$821	$92

Appendix G Evaluation of Five-Year Implementation Schedule

The analysis of a five-year implementation plan is complicated by the fact that the Agency has forecast that use of FMS and voluntary adoption of EOBRs will increase over time, thereby reducing the number of carriers, drivers, and CMVs this rule will affect as each year passes. Numerous implementation schedules can be considered and evaluated. The Agency considered requiring EOBRs for all motorcoaches in year 1, other passenger carrying operations in year 2, bulk HM operations and large property carriers in year 3, medium sized property carriers in year 4, and small property carriers in year 5. Passenger carrier and bulk HM operations have the highest potential for societal damages and therefore might reasonably be put first in any new safety rule. For all other property carrying operations, the largest carriers would be subject to an EOBR mandate first because they are best able to absorb the costs of these devices, whereas small business might be disadvantaged by simultaneous implementation, and therefore could be required to install these devices in year five.

Tables 36 and 37 show the number of LH and SH CMVs and drivers that would be affected by the rule during each year.

Table 36: LH and SH CMVs and Drivers, Five-Year Implementation

			Year 1	Year 2	Year 3		Year 4	Year 5
			Motor-coach	Other Passenger	Bulk HM	Large	Medium	Small
LH	I	Drivers	28	40	238	558	356	399
	II	CMVs	25	36	216	507	323	365
	III	EOBR Use	0%	0%	30%	30%	32%	34%
	IV	FMS Use	0%	0%	46%	46%	49%	51%
	V	Drivers w/o EOBRs (I × (1 - III))	28	40	167	391	242	263
	VI	CMVs w/o EOBRs (II × (1 - III))	25	36	151	355	220	241
	VII	CMVs needing new EOBRs (VI ×	25	36	82	192	112	118

		(1 - IV))						
	VIII	CMVs w/ FMS Upgrade (VI × IV)	0	0	69	163	108	123
SH	IX	Drivers	28	159	158	1,302	356	378
	X	CMVs	25	145	144	1,184	323	344
	XI	EOBR Use	0%	0%	7%	7%	7%	8%
	XII	FMS Use	0%	0%	15%	15%	16%	17%
	XIII	Drivers w/o EOBRs (IX × (1 - XI))	28	159	147	1211	331	348
	XIV	CMVs w/o EOBRs (X × (1 - XI))	25	145	134	1101	300	316
	XV	CMVs with New EOBRs (XIV × (1 - XII))	25	145	114	936	252	262
	XVI	CMVs w/ FMS Upgrade (XIV × XII)	0	0	20	165	48	54

Table 37: SH RODS and non-RODS users, Five-Year Implementation

			Year 1	Year 2	Year 3		Year 4	Year 5
			Motor-coach	Other Passenger	Bulk HM	Large	Medium	Small
SH w/o RODS	XVII	Drivers w/o EOBRs (XIII * 25%)	7	40	37	303	83	87
	XVIII	CMVs w/o EOBRs (XII * 25%)	6	36	34	275	75	79
	XIX	CMVs with New EOBRs (XVIII × (1 - XII))	6	36	29	234	63	66
	XX	CMVs w/ FMS Upgrade (XVIII × XII)	0	0	5	41	12	13
SH w/ RODS	XXI	Drivers w/o EOBRs (XIII - XVII)	21	119	110	908	248	261
	XXII	CMVs w/o EOBRs (XIV - XVIII)	19	109	100	826	225	237

	XXIII	CMVs with New EOBRs (XV - XIX)	19	109	85	702	189	196
	XXIV	CMVs w/ FMS Upgrade (XVI - XX)	0	0	15	124	36	41

These counts of drivers and CMVs are applied to evaluate the annualized incremental costs of benefits of each option in each year, that is, the monetized values associated only to those operations added to the EOBR mandate in each year. These amounts are then summed to total annualized costs and benefits.

G.1 Derivation of Option 1 Costs and Benefits, Five-Year Implementation

Tables 38, 39, and 40 show the steps used to calculate the costs and benefits of option 1 under a five-year implementation schedule.

Table 38: Drivers and CMVs Affected under Option 1, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk HM	Large	Medium	Small	
I	LH Drivers	28	40	167	391	242	263	1,131
II	LH EOBRs, New	25	36	82	192	112	118	565
III	LH EOBRs, FMS Upgrades	0	0	69	163	108	123	463
IV	Non RODS SH Drivers	0	0	0	0	0	0	0
V	Non RODS SH EOBRs, New	0	0	0	0	0	0	0
VI	Non RODS SH EOBRs, FMS Upgrade	0	0	0	0	0	0	0
VII	RODS SH Drivers	21	119	110	908	248	261	1,667
VIII	RODS SH EOBRs, New	19	109	85	702	189	196	1,300
IX	RODS SH EOBRs, FMS Upgrade	0	0	15	124	36	41	216
X	EOBRs, New Purchases	44	145	167	894	301	314	1,865

	(II+V+VIII)							
XI	EOBRs, FMS Upgrades (III+VI+IX)	0	0	84	287	144	164	679

Table 39: Costs and Benefits of Option 1, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk HM	Large	Medium	Small	
XII	Annualized EOBR Cost	$785	$734	$575	$575	$509	$446	
XIII	Annualized FMS Upgrade Cost	$92	$86	$75	$75	$64	$54	
XIV	Total EOBR Cost (X×XII+XI×XIII) (millions)	$35	$106	$102	$536	$162	$149	$1,090
XV	LH Compliance Costs per CMV	$261	$226	$194	$194	$163	$135	
XVI	SH Compliance Costs per CMV	$79	$68	$59	$59	$49	$41	
XVII	Total Compliance Costs ((II+III)×XV+(V+VI+VIII +IX)×XVI) (millions)	$8	$16	$35	$117	$47	$42	$265
XVIII	Total Costs (XIV+XVII) (millions)	$43	$122	$137	$653	$209	$191	$1,355
XIX	Paperwork Savings per RODS Driver	$688	$596	$511	$511	$431	$356	
XX	Total Paperwork Savings ((I+VII)×XIX) (millions)	$34	$95	$142	$664	$211	$187	$1,332
XXI	LH Safety Benefits per CMV	$805	$698	$598	$598	$505	$417	
XXII	SH Safety Benefits per CMV	$29	$25	$21	$21	$18	$15	
XXIII	Total Safety Benefits ((II+III)×XXI+(V+VI+VIII +IX)×XXII) (millions)	$21	$28	$93	$230	$115	$104	$590
XXIV	Total Benefits (XX+XXIII)	$54	$123	$234	$894	$326	$291	$1,922
XXV	Net Benefits (millions)	$12	$1	$97	$241	$117	$99	$567

Table 40: Costs and Benefits of Option 1 Alternate Baselines, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small	
XXVI	Additional Net Benefits per LH CMV Baseline 2	$80	$69	$59	$59	$50	$41	
XXVII	Additional LH Net Benefits Baseline 2 ((II+III)×XXVI) (millions)	$2	$2	$9	$21	$11	$10	$55
XXVIII	Total Net Benefits Baseline 2 (XXV+XXVII)	$14	$3	$106	$262	$128	$109	$622
XXIX	Additional Net Benefits per LH CMV Baseline 3	$136	$118	$101	$101	$85	$70	
XXX	Additional LH Net Benefits Baseline 3 ((II+III)×XXIX) (millions)	$3	$4	$15	$36	$19	$17	$94
XXXI	Total Net Benefits Baseline 3 (XXV+XXX) (millions)	$15	$5	$112	$277	$136	$116	$661

G.2 Derivation of Option 2 Costs and Benefits, Five-Year Implementation

Tables 41, 42, and 43 show the steps used to calculate the costs and benefits of option 2 under a five-year implementation schedule.

Table 41: Drivers and CMVs Affected under Option 2, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small	
I	LH Drivers	28	40	167	391	242	263	1,131
II	LH EOBRs, New	25	36	82	192	112	118	565
III	LH EOBRs, FMS Upgrades	0	0	69	163	108	123	463
IV	Non RODS SH Drivers	7	40	37	0	0	0	84
V	Non RODS SH EOBRs, New	6	36	29	0	0	0	71

VI	Non RODS SH EOBRs, FMS Upgrade	0	0	5	0	0	0	5
VII	RODS SH Drivers	21	119	110	908	248	261	1,667
VIII	RODS SH EOBRs, New	19	109	85	702	189	196	1,300
IX	RODS SH EOBRs, FMS Upgrade	0	0	15	124	36	41	216
X	EOBRs, New Purchases (II+V+VIII)	50	181	196	894	301	314	1,936
XI	EOBRs, FMS Upgrades (III+VI+IX)	0	0	89	287	144	164	684

Table 42: Costs and Benefits of Option 2, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small	
XII	Annualized EOBR Cost	$785	$734	$575	$575	$509	$446	
XIII	Annualized FMS Upgrade Cost	$92	$86	$75	$75	$64	$54	
XIV	Total EOBR Cost (X×XII+XI×XIII) (millions)	$39	$133	$119	$536	$162	$149	$1,139
XV	LH Compliance Costs per CMV	$261	$226	$194	$194	$163	$135	
XVI	SH Compliance Costs per CMV	$79	$68	$59	$59	$49	$41	
XVII	Total Compliance Costs ((II+III)×XV+(V+VI+VIII+IX)×XVI) (millions)	$9	$18	$37	$117	$47	$42	$270
XVIII	Total Costs (XIV+XVII) (millions)	$48	$151	$157	$653	$209	$191	$1,409
XIX	Paperwork Savings per RODS Driver	$688	$596	$511	$511	$431	$356	
XX	Total Paperwork Savings ((I+VII)×XIX) (millions)	$34	$95	$142	$664	$211	$187	$1,332
XXI	LH Safety Benefits per CMV	$805	$698	$598	$598	$505	$417	
XXII	SH Safety Benefits per CMV	$29	$25	$21	$21	$18	$15	
XXIII	Total Safety Benefits ((II+III)×XXI+(V+VI+VIII+IX)×XXII) (millions)	$21	$29	$93	$230	$115	$104	$592
XXIV	Total Benefits (XX+XXIII)	$55	$124	$235	$894	$326	$291	$1,924
XXV	Net Benefits (millions)	$7	-$27	$78	$241	$117	$99	$515

Table 43: Costs and Benefits of Option 2 Alternate Baselines, Five-Year Implementation

		Year 1	Year 2	Year 3		Year 4	Year 5	Total
		Motor-coach	Other Passenger	Bulk Hazmat	Large	Medium	Small	
XXVI	Additional Net Benefits per LH CMV Baseline 2	$80	$69	$59	$59	$50	$41	
XXVII	Additional LH Net Benefits Baseline 2 ((II+III)×XXVI) (millions)	$2	$2	$9	$21	$11	$10	$55
XXVIII	Total Net Benefits Baseline 2 (XXV+XXVII)	$9	-$25	$87	$262	$128	$109	$570
XXIX	Additional Net Benefits per LH CMV Baseline 3	$136	$118	$101	$101	$85	$70	
XXX	Additional LH Net Benefits Baseline 3 ((II+III)×XXIX) (millions)	$3	$4	$15	$36	$19	$17	$94
XXXI	Total Net Benefits Baseline 3 (XXV+XXX) (millions)	$10	-$23	$93	$277	$136	$116	$609

G.3 Derivation of Option 3 Costs and Benefits, Five-Year Implementation

Option 3 merely adds the SH operations that are exempt from RODS to year 5 of the Option 2 implementation schedule. As shown in table 44, EOBR use in these types of operations results in no paperwork reduction and very small safety benefits. The addition of these operations results in an incremental annualized net benefit of -$174 million.

Table 44: Drivers and CMVs Affected, Costs and Benefits of Option 3, Five-Year Implementation

		a	b	c	d	e	f
		Option 2 Total	Large	Medium	Small	Incremental Total (b+c+d)	Total (a+e)
I	Non RODS SH Drivers (thousands)	84	303	83	87	473	557
II	SH Non RODS CMVs (thousands)	76	275	75	79	429	505
III	FMS Use		17%	17%	17%	17%	
IV	Non RODS SH EOBRs, New (thousands)	71	228	62	66	356	427
V	Non RODS SH EOBRs, FMS Upgrade (thousands)	5	47	13	13	73	78
VI	Annualized EOBR Cost		$446	$446	$446	$446	
VII	Annualized FMS Upgrade Cost		$54	$54	$54	$54	
VIII	Total EOBR Cost (millions)	$1,139	$104	$28	$30	$163	$1,301
IX	SH Compliance Costs per CMV		$41	$41	$41	$41	
X	Total Compliance Costs (millions)	$270	$11	$3	$3	$18	$288
XI	Total Costs (millions)	$1,409	$115	$32	$33	$180	$1,589
XII	SH Safety Benefits per CMV		$15	$15	$15	$15	
XIII	Total Safety Benefits (millions)	$592	$4	$1	$1	$6	$598
XIV	Net Benefits	$515	-$111	-$30	-$32	-$174	$341
XV	Total Net Benefits Baseline 2 (millions)	$570				-$174	$396
XVI	Total Net Benefits Baseline 3 (millions)	$609				-$174	$435

Appendix H Derivation of Cost and Benefits in the HOS Rule Analyses

Most of the content of this Appendix has been taken verbatim from the RIAs prepared for the 2003 and 2005 HOS rules. This appendix provides detail about FMCSA's methodology for estimating costs and benefits. FMCSA has not undertaken a comprehensive survey of drivers to measure the level of noncompliance with the HOS rules since enactment of the 2003 HOS rule. The Agency does not attempt to directly measure the costs and benefits of the increased HOS compliance that is expected with the adoption of EOBRs. Instead, FMCSA starts with the level of noncompliance that was found when drivers were surveyed prior to 2003. Then the Agency replicates portions of the analysis that was performed to estimate costs and benefits of the changes in the 2003 and 2005 rules, to account for the changes in the HOS rules and changes in drivers' compliance with the rules. Most of the content of this appendix has been taken from the RIAs prepared for the 2003 and 2005 rules.

H.1 Basis for 2003 Rule and Derivation of Pre-2003 Status Quo

This section summarizes the survey data and analytical techniques used to evaluate the baseline level of non-compliance with the HOS rules. Survey data provided information on drivers' actual schedules, which were than evaluated against schedules that fully complied with the pre-2003 and 2003 HOS rules. Simulated adjustments were made to any schedules that were found to be non-compliant to bring them to the minimal level of compliance. These adjustments were then translated into a redistribution of hours for a given driver and across drivers to estimate compliance costs and safety benefits.

The status quo level of compliance was derived from a simulation of driver work and rest schedules calibrated with data from two driver surveys. After this status quo was established, FMCSA determined what changes to driver schedules would have to occur should 100 percent of non-compliant drivers move toward full compliance with the pre-2003 HOS rules, and then what changes would occur if it were the 2003 HOS rules that drivers were complying with. Results for costs and benefits for the pre-2003 baseline and the effects of the 2003 rules are the starting points for the compliance cost and benefits calculations estimated in this rule.

H.1.1 Survey Data Used in Status Quo

University of Michigan Trucking Industry Program (UMTIP) Driver Surveys (1997-1999), by Dale Belman *et al.*, with the University of Michigan Institute for Social Research

The first wave of the UMTIP data collection effort resulted in 573 long surveys completed by truck drivers at 19 mid-western truck stops between July and October of 1997. The second phase of the driver survey, conducted between summer 1998 and spring 1999, used the same methodology and essentially the same questions at 12 truck stops and increased the sample size to over 1,019 valid observations. Truck stops were chosen based on the number of overnight parking spaces available, which gives a measure of traffic volume. The probability sampling technique employed ensures that the selected truck stops match the distribution of overnight parking spaces by both state and size category. A potential respondent was interviewed if he or she reported being a truck driver, possessed a Commercial Drivers License (CDL) and was driving a tractor trailer at the time of the interview.

The variables of interest contained in the UMTIP data set included hours spent sleeping, working and driving in the 24 hours leading up to the interview, hours worked in the last pay period,[52] and detailed variables concerning the timing and/or duration of activities during the last completed trip (for example, waiting for a dispatch, loading/unloading, or driving). For descriptive statistics and cross-tabs, FMCSA used sample weights to account for sampling bias due to the size of the truck stops selected as survey locations.[53]

In cooperation with the authors of the UMTIP driver survey, FMCSA studied customized statistical outputs for particular subsets of the population surveyed. These subsets were designed to match, as closely as possible and where appropriate, the industry segments determined to reflect the most relevant profile for the present regulatory impact analysis. In particular, this data set provided several useful variables on driver type (owner-operator, employee, union, non-union, teams), industry segment (for-hire, private carriage, truckload and less-than-truckload),

[52] Drivers' responses pertaining to pay period were standardized to 7 days.
[53] Weights were constructed and used according to the procedures in Belman, D., Monaco, K., and Brooks, T. (1998). "Let it Be Palletized: A Portrait of Truck Drivers' Work and Lives," University of Michigan Trucking Industry Program.

range of operations (local, regional, LH) and size of firm, which enabled comparative analyses of many different sub-groups of drivers. For comparison with other data sets, it was useful to study miles driven in the past year and miles driven on a "typical run."

The UMTIP driver survey provides a representative picture of certain segments of the regional and LH OTR truck driver population. The survey team did not intend to capture every aspect of the trucking industry; rather, it was the express intent of the authors to sample regional and LH OTR truck drivers. For example, the authors clearly state that local pickup and delivery drivers are underrepresented. Analysis of their data further indicates that those SH drivers are not a representative sub-sample of the SH population. The survey design addressed the potential for bias by applying randomization techniques to the choice of truck stops, the choice of potential respondents, the day of the week, and the time of day. Subsets of the driver population, to the extent possible, were analyzed separately to ensure that dissimilar subsets were not grouped together. Advantages of the UMTIP driver survey are that it captures the portion of the driving population that will be most affected by the proposed regulations, it offers a rich range of information about its subjects, and its limitations are transparent.

"Effects of Sleep Schedules on Commercial Motor Vehicle Driver Performance," 2000, by Balkin *et al.* (Walter-Reed Army Institute of Research)

The Walter Reed Commercial Motor Vehicle field study gathered sleep patterns via wrist actigraphy and self-reported sleep logs from 25 LH and 25 SH drivers over two to three weeks. The data was entered into the Walter Reed Sleep Performance Model. Participants drivers were recruited through flyers at truck stops and through word-of-mouth and were required to hold a commercial drivers license (CDL). SH and LH drivers were differentiated based on whether they were able to return home at the end of work periods to sleep.

The variables of interest in the Walter Reed study were the date of observation, the time spent on-duty and off-duty each day, and the time of day and duration of each sleep period. This study represents the most accurate information available regarding truckers' exact sleep routines by time of day. This study does not suffer from problems of other datasets that underestimate the proportion of drivers with extreme schedules because they do not sufficiently differentiate among types of truckers or their differing work schedules over the past 7 days by aggregating truckers' schedules were homogeneous over time and across groups. Moreover, with exception of Walter Reed, most studies ask subjects for their subjective view of how much they are sleeping, incremented in one-hour units, and do not differentiate between time in bed versus actual sleep. The strength of the WR study resides in the precise nature of its sleep measurements and the fact that they were carried out over a relatively long period of time.

H.1.2 Driver Schedule Simulation Methods and Results

UMTIP provides insufficient raw data to completely enumerate driver schedules over time. For instance, the UMTIP surveys ask drivers about hours worked over the last 24 hours rather than for a full week or for averages over time. The Walter Reed Field Study provided more information across days but is a small sample that was not randomly drawn and was insufficient to determine whether work/sleep schedules shift under current or other proposal options. FMCSA gathered descriptive statistics describing the distribution of schedule types from these studies in order to model 25-day schedules representative of those found in the real world.

In order to model representative schedules, the Agency first estimated the distribution across individuals of average number of hours worked per day using the average number of hours worked in a 24-hour period for LH OTR drivers excluding team drivers[54] from UMTIP. The average number of hours worked is required because the relationship between truckers' schedules and sleep is estimated and available only for sleep with hours on-duty. For modeling hours worked per day, a large distribution of average number of hours worked per day was generated, 100 random numbers, with mean and standard deviation values taken from the UMTIP and Walter Reed data, to represent a distribution of average number of hours worked per day. The random numbers are drawn from a normal distribution with a mean value equal to the mean number of hours worked per 24-hour period for LH OTR drivers from UMTIP (11.37 hours per day). The standard deviation of the random numbers is equal to the standard deviation across LH drivers in the Walter Reed Field Study of their average number of hours worked per

[54] Team drivers are less likely to be affected by the rule changes, and were not modeled.

day (1.88 hours).[55] Rather than model 100 separate schedules with only slight differences in average length of work day, the analysis groups them into four bins representing average work day lengths around 9, 11, 13, and 15 hours on-duty on average in a 24-hour period (excluding full days off-duty). These bin values are chosen to divide the distribution such that the middle two values (11 and 13) represent about a third of the distribution under current compliance levels, with the remainder divided about equally between the other two values.[56] This provides the average number of hours worked per 24-hour period worked for the current HOS rules under current compliance (status quo scenario).

Next, average number of hours worked per 24-hour period is used to simulate the number of hours worked per eight-day work period under the pre-2003 HOS rules. This is derived from the frequency distribution from UMTIP of number of days worked in the last seven-day pay period.[57] Interviews with industry experts indicate that most OTR LH drivers follow an eight-day work schedule. In order to make this distribution based on seven-days apply to the pre-2003 compliance baseline, the UMTIP distribution is scaled up from days worked in seven days to days worked in eight days. Because the mean, median, and modal OTR driver worked five days in the seven-day period, it is assumed that, from each group, five of every seven would work another day in an eight-day period.[58] The majority of drivers in the resulting distribution worked five to eight of the last eight days. Those who work four or fewer days in eight are not expected to be affected by changes in HOS rules. The analysis is simplified by reducing the number of schedules to model by combining into one bin those who worked four or fewer days within the eight-day period. This group, modeled as working three days in eight, represents 12 percent of the trucker population. Table 45 displays the original distribution of workweek lengths as well as

[55] This figure excludes days in which the driver was on-duty for fewer than two hours. The UMTIP was preferred for the average number of hours worked per day due to its larger sample size combined with its more random sampling approach.

[56] Nine hours is approximately the average number of hours worked in 24-hours for truckers modeled as having worked up to 10.5 or fewer hours on average. Eleven hours is approximately the average number of hours worked in 24-hours for truckers modeled as having worked 10.5 up to 12 hours on average. Thirteen hours is approximately the average number of hours worked in 24-hours for truckers modeled as having worked 12 up to 14 hours on average, and 15 hours is approximately the average number of hours worked in 24-hours for truckers modeled as having worked 14 or more hours on average.

[57] This distribution is based on only those OTR drivers who reported fewer than 24 hours of combined work and sleep.

[58] There is no evidence of a negative correlation of number of days worked across weeks. For this reason, it is assumed that the number of days worked in the seven-day period covered in the survey represents the average for the respective proportion of the trucker population.

the rescaled and simplified distributions.

Table 45: Work Week Length for UMTIP and Modeled Drivers

	# Days per Week							
Driver Distribution	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
UMTIP 7-Day Distribution	1%	3%	5%	13%	35%	24%	21%	0
Distribution Rescaled to 8 Days	0%	1%	3%	7%	19%	31%	23%	15%
Simplified Distribution	0%	0%	12%	0%	19%	31%	23%	15%

No information is available in UMTIP to estimate directly the proportion of the driver population by both hours worked in 24 hours and the number of days worked. The proportion of drivers who worked on average around nine, 11, 13, or 15 hours in 24-hours is multiplied by the proportion who worked three, five, six, seven, or eight days in an eight-day schedule. This does not account for possible negative correlation between these two variables, but although this is no evidence of a strong negative relationship.[59] The matrix of proportions of truckers working various hours-per-day and days-per-eight has been termed the "driver schedule proportion matrix" and any individual cell within the matrix a "driver proportion cell." The driver schedule proportion matrix is generated first to reflect current compliance levels with HOS rules. This matrix is shown for the status quo in table 46. The percentages in the cell that represents three days of work in an eight-day period and nine hours of work in 24 is simply the product of 12 percent and 14 percent, or 2 percent.

Table 46: Driver Schedule Proportion Matrix for Status Quo

			Days Work / 8 Days							
Hrs Work/ 24 Hrs	Modeled Hrs/24 Distribution	Simplified Hrs/24 Distribution	1	2	3	4	5	6	7	8

[59] Walter Reed field study LH driver data revealed a small negative correlation of –0.05 between hours worked and days worked in a seven-day period. This would translate into a difference of less than a third of a day shorter workweek for those averaging 15 hours of work per day than those averaging 9 hours per day.

7	1%	0%	--	--	--	--	--	--	--	--
8	3%	0%	--	--	--	--	--	--	--	--
9	10%	14%	--	--	2%	--	3%	4%	3%	2%
10	14%	0%	--	--	--	--	--	--	--	--
11	20%	34%	--	--	4%	--	7%	11%	8%	5%
12	15%	0%	--	--	--	--	--	--	--	--
13	18%	33%	--	--	4%	--	6%	10%	8%	5%
14	9%	0%	--	--	--	--	--	--	--	--
15	6%	19%	--	--	2%	--	4%	6%	4%	3%
16	4%	0%	--	--	--	--	--	--	--	--

The proportion matrix was adjusted to show fully compliant schedules under the different numbers of hours worked per week allowed under the pre-2003 and 2003 HOS rules. Driver proportion cells were truncated to reflect daily and weekly limits allowed under current HOS rules. That is, if a group of drivers work too many hours per day or week, those drivers are added to a cell that complies with HOS rules. Driver proportion cells that allow too many hours per day are carried down to the cell with the next lower number of hours that meets the daily limits. If the total number of hours per week worked for that driver proportion cell remains above that allowed under a given HOS rule option, hours worked per day are reduced within the same number of days per eight-day period by shifting the proportion in that cell to the cell with the next lower number of hours per day working. If the cell already is in the nine hours of work per 24-hours cell and still is over the threshold, the proportion of hours in that cell is shifted to a cell in which drivers work fewer days per week.

H.1.3 Rolling Work and Sleep Schedules

The modeled runs from a dispatching simulation are used to predict the extent to which, under the pre-2003 and 2003 HOS rules, drivers' primary sleeping time (and, thus, their whole sleep-work cycle) steadily moves, or rolls, over a series of days or remains fixed over time.

H.1.3.1 Dispatching Simulation

The following table summarizes the results of the dispatch simulations. The numbers in the cells in the table are index measures that reflect relative productivity of drivers and are different for the for-hire and private cases. In the for-hire case, the index reflects both number of loads moved and length of haul. Changing HOS rules affects both the number of loads carried and the distances covered by a for-hire, truckload company. If such a company can make longer hauls with a given set of resources, it is likely that it will; longer moves for the same tonnage mean more revenue. In the real world, a company might use fewer resources to carry the same number of loads the same distance in response to less restrictive HOS rules. Either response would reflect the same productivity gain. Simulation analyses of for-hire operations use a fixed level of resources, so the output vary with a change to the HOS rules.

The for-hire index is a composite, weighted one-third according to loads moved per vehicle and two-thirds according to distance moved per vehicle. Productivity measures based on delivered orders per driver per week and miles per driver per week can differ somewhat if the length of haul differs under different options. After reviewing the factors that would cause the length of haul to vary, and the relative contributions of driving to non-driving activities to producing value for shippers, FMCSA developed a composite measure of productivity that weights miles per driver per week twice as heavily as orders per driver per week. This weighting scheme, which was not intended to be precise, was based roughly on the ratio of driving time to non-driving time for a LH truckload shipment.

Selection of private-carriage scenarios posed some problems. One can postulate a set of basic patterns for private-carriage operations, but there is no empirical basis for allocating shares of private-carriage activity among various patterns. Nor is it possible to specify a set of patterns and assert that they account for all, or almost all, of private movement. The analysis focused on just two private scenarios, the "national one-to-few" case and the "regional one-to-many." The national one-to-few case could be a manufacturer shipping from one factory to a few regional-hub distribution centers (DCs) from which large numbers of stores or other DCs are served. The regional-hub DCs might be owned by the manufacturer or by its customers. The one-to-many case may be thought of as one of those regional DCs, shipping on to stores and/or lower-tier DCs as the case may be. In the private cases, output is fixed and variation in the level of resources used to produce that output is captured. Most of that variation takes the form of more or less intensive use of the same set of tractors and drivers. The index reflects the number of loads a driver could deliver in a standardized, fully employed week.

Table 47: Relative Driver Productivity from Dispatch Analysis

For-hire scenarios	Pre 2003 Rules—full compliance	Pre-2003 Rules—status quo	2003 Rules
Short regional	100	112	109
Long regional	100	115	112
LH	100	115	114
Private scenarios			
Regional one-to many	100	105	109
National one-to-few	100	110	115

Estimates of total vehicle miles of travel for truckload and private carriers and numbers of drivers, presented elsewhere, are used to convert these productivity changes into costs (or benefits) of rule changes. It would be incorrect, however, to use these index numbers directly for that purpose. Not all companies have operations that are always pressing against HOS limits; many do not, as indicated by anecdotal evidence and from the findings from the UMTIP driver survey of hours actually worked. The impacts on for-hire TL were scaled back to 46 percent of the result from direct application of these indices and to 35 percent in the case of private carriage. The difference in these percentages simply reflects the fact that TL operations are more likely to be pushing against the HOS rules than are private operations.

H.1.3.2 Results of Rolling Work and Sleep Schedule Analysis

The total change in time of day between the beginning and end of a working week schedule at which an OTR driver begins his or her sleeping break period was calculated. For example, if a driver begins a route at 8 am on the first day of the route and ends at 4 am on the last day of the route before an extended (multiple-day) break, the schedule is calculated to have rolled backwards by four hours. The threshold at which a schedule qualifies as having work-sleep cycles that rolled is a difference of at least two hours over a route for a backward-rolling schedule and three hours over a route for a forward-rolling schedule. Preliminary analysis suggested that less than two-hour change in sleeping time over a driving route was insufficient to result in a significant change in modeled schedules. Because initial tests of the model indicated that a schedule that rolls forward adds about two-thirds of the incremental crash probability as a schedule rolling backwards, the forward-rolling threshold was set to an equivalent to three hours.

The likelihood of rolling was analyzed separately for the pre-2003 rules relative to full compliance and the 2003 rules, and for regional and LH operations. The number of hours a schedule rolls was also measured separately in order to down-weight schedules that roll for fewer hours than modeled.

For the current rule fully enforced, the analysis found three of 13 regional schedules and seven of 11 LH to shift. The majority of these were rolling backwards. The regional schedules rolled on average two hours and the LH over ten hours over the driving period. These driving periods varied in their length depending on the limits for each proposal and trip lengths for the driver types. FMCSA assumed that the proportion of OTR drivers is split evenly between regional and LH companies and combine the calculated proportion of regional and LH drivers whose schedules roll into an overall weighted average. That is, even though it is not expected that all of the drivers with sleeping times that roll to shift by a total of 10 hours, the modeling uses a weighted proportion that would be equivalent to the proportion whose sleep periods would shift backwards by ten hours. For the current rule fully enforced, the result is a weighted average of 34 percent of drivers rolling backwards an average of 10 hours (given a five-day route). For the 2003 rules, two of eight regional schedules and seven of ten LH roll backwards.[60]

Table 48: Generation of Proportion of Schedules that Roll

	Pre-2003 Rules, Fully Enforced		2003 Rules, Fully Enforced	
Data element	**LH**	**Regional**	**LH**	**Regional**
# of schedules	11	13	10	13
# of schedules that roll	7	3	7	2
% rolling	64%	23%	70%	15%
# of hours roll	10	2	3	2
% rolling (relative to rolling 10 hours)*	64%	5%	21%	3%
% of total population	50%	50%	50%	50%
Overall relative % rolling*	34%		12%	
*This percentage is relative to a hypothetical option in which all schedules roll by 10 hours.				
The number of hours schedules roll forward are treated as equivalent to half that of rolling back.				

60 This includes two schedules rolling backwards nearly two hours.

H.2 Compliance Costs

This section summarizes the results of applying the analysis of driver schedules to costs of achieving full compliance with HOS rules. Additional drivers (and CMVs) will be have to be added to shift work away from over-utilized drivers, which entail additional labor, overhead, and capital costs. The analysis also examined the total labor pool available to the motor carrier industry, not just the driver population, and concluded that there was sufficient numbers of workers available to shift into CMV driver jobs. Given the current under-employment in blue collar occupations, the Agency believes this conclusion still holds.

Compliance costs with the HOS rules are those costs associated with changes that carriers will need to make to their operations to achieve full compliance with the HOS rules. Non-compliance is the result of over-utilization of both drivers and CMVs beyond what is allowed under the HOS rules. Assuming carriers maintain the same level of work, additional drivers and equipment will have to be acquired to complete these loads without exceeding the HOS limits.

H.2.1 Labor Cost Changes

This section discusses the issues related to the truck driver labor supply and the methodology used for the labor cost changes. Compliance with HOS rules are expected to result in changes in labor productivity for truck drivers, leading to changes in driver labor demand. The analysis uses the changes in labor productivity obtained from simulations of trucking routes for the various options and translates them to dollar impacts based on the labor supply relationships for truck drivers.

Issues related to the truck driver wage equation, as a function of job and employee characteristics are discussed first, followed by a discussion of the labor supply elasticity for truck drivers. Components of the indirect labor costs that are associated with driver wage costs are also analyzed to complete the discussion on various aspects of the labor cost changes.

H.2.1.1 Estimate of Driver Wage Function

To analyze the labor costs of the different options, the Agency examined the relationship between hours worked and wages earned for truck drivers. The issue of individual driver wages is important because it is one dimension of the cost of the HOS regulations. As hours of work are shifted from drivers who currently work very long hours to newly hired drivers, the cost implications for carriers depends on the employment costs per additional hour of work by existing drivers relative to the costs for new hires.

H.2.1.1.1 Data, Methodology, and Results

The primary data source for the analyses carried out in the following section is the Current Population Survey (CPS), a household based survey conducted by the BLS every month. This 2003 HOS RIA uses annual CPS data compiled by the National Bureau of Economic Research (NBER) that give earnings and hours worked for a randomly chosen sample. FMCSA combine annual data from 1995 to 2000 and model the wage equation for non-union truck drivers only.

The wage equation was estimated for truck drivers based on their demographic information and job characteristics. It was hypothesized that the wage earned by truck drivers depends on their hours worked[61], along with their occupational experience, and dummy variables to capture whether they are high school graduates, married, sex, race, whether they are in the for-hire industry, as well as dummies to control for year and regional effects. The details of all the variables used in the regression, including descriptive statistics and the estimated coefficients are presented in table 49.

Table 49: Regression Results and Descriptive Statistics for Truck Driver Wage Relationship – 1995-2000

Variable	Coefficient	Mean	S.D.	Min	Max
Natural Log Hours Worked	4.12	3.78	0.149	2.4	4.09
	(5.68)				
Natural Log Hours Worked Squared	-0.398	14.32	1.14	5.74	16.76
	(-4.2)				
High School Diploma Earned	0.122	0.784	0.412	0	1
	(13.01)				

61 The square of the number of hours worked captures a nonlinear effect of hours on wages.

Variable	Coefficient	Mean	S.D.	Min	Max
Occupational Experience (Age-Years of Ed.-6)	0.023	21.28	11.93	1	71
	(20.5)				
Experience Squared (Age-Years of Ed.-6)^2	-0.0004	595.1	591.24	1	5041
	(-17.97)				
Married	0.076	0.634	0.482	0	1
	(9.115)				
Gender	0.186	0.962	0.191	0	1
	(9.46)				
Race (0=White; 1=Non-White)	-0.027	0.14	0.347	0	1
	(-2.414)				
For Hire Trucker	0.115	0.36	0.48	0	1
	(14.34)				
Constant	-0.393	---	---	---	---
	(-0.28)				

Notes: t-statistics in parentheses
Number of observations = 11,017
Regression model includes region and year control dummies

All the variables of interest have the expected signs and most are statistically significant (except for some of the region and year control dummies)[62]. Of particular importance are the coefficients associated with the two hours worked variables and the distribution of wages implied.

Table 50 presents predicted wages for different levels of weekly hours worked for the sample on non-union truck drivers only. Based on the total wage relationship, the model predicts that the average 50 hour/week driver earns $28,307, a 60 hour/week driver makes $33,588 and a 70 hour/week driver makes $38,022 annually.

Table 50: Predicted Annual Wages for Different Hours/Week

Hours/week	Predicted Annual Wage
40	$ 22,149
45	$ 25,336
50	$ 28,307
55	$ 31,058

62 The R-squared of the model is low (27 percent) but consistent with the evidence in the literature - see for e.g., Rose (1987), Hirsch (1988).

60	$ 33,588
65	$ 35,907
70	$ 38,022
75	$ 39,947
80	$ 41,692

Chart 3 shows the implied relationship for the total annual wages and Chart 4 shows the average and marginal wages as a function of the hours worked.

Chart 3: Total Wage Curve for Non-Union Drivers

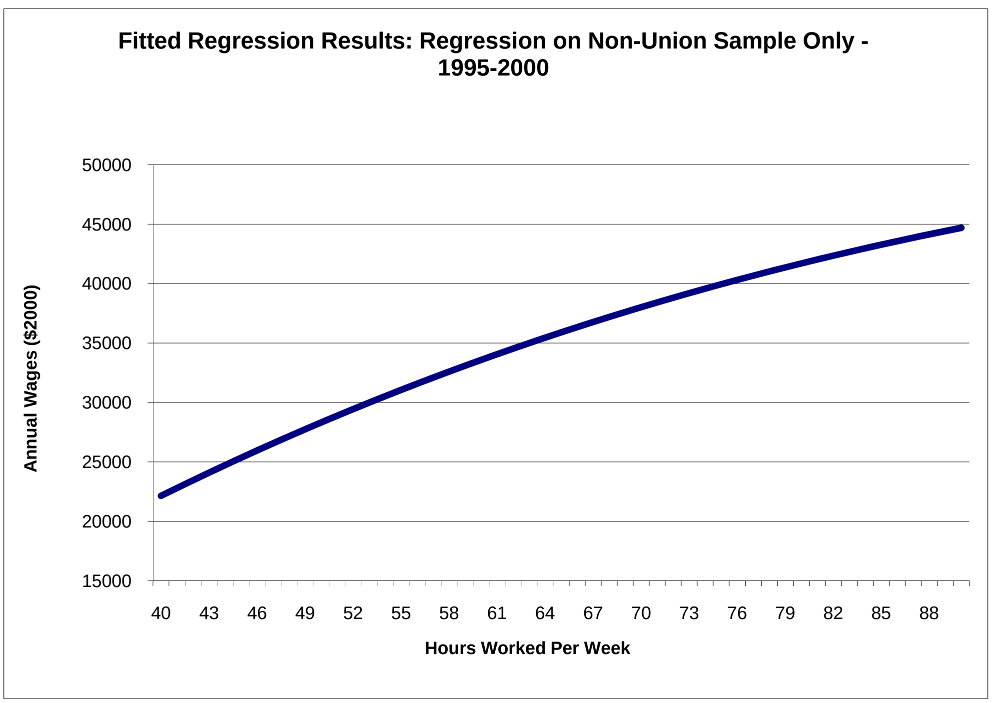
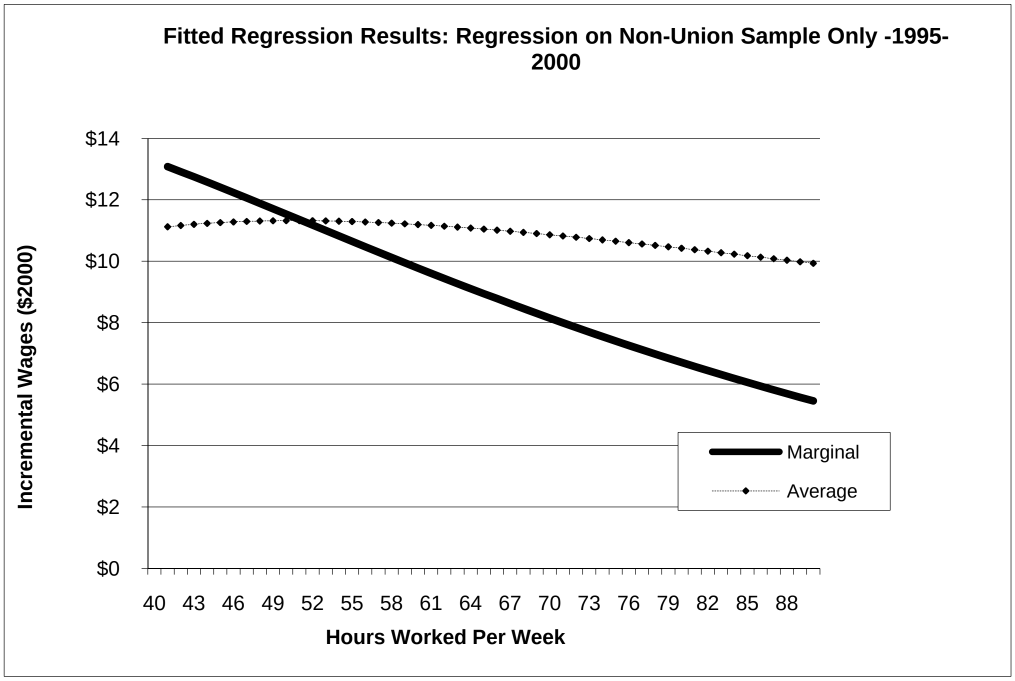


Chart 4: Marginal and Average Wage Curves for Non-union Drivers



The results indicate that the total annual wages for drivers is an increasing function of hours worked that increases at a decreasing rate. This implies that the marginal cost to the firm of an additional hour of driver labor diminishes constantly as the hours of work increases. The specific shape of the total wage curve also ensures that the average wage curve is below the marginal wage for a significant part of the distribution.

The downward slope of the marginal cost curve implies that as the number of hours worked by drivers under the HOS rules are curtailed, the cost savings to companies from cutting down hours of service from drivers is less than the increase in cost due to the hiring of new drivers, that is, **giving an hour of work to a new driver costs more than the savings from taking an hour of work away from an over utilized driver who would exceed the HOS limits**. Another implication of the slope of the marginal wage curve is that every hour of driver labor does not cost the same for the trucking company. This is because of the “non-standard” labor-leisure choice faced by truck drivers. While they are on the road, they are willing to work an extra hour for a lower marginal wage (and cost to the firm), to maximize their earnings potential, in part because the value of leisure time out on the road is low. As drivers work more and more hours, the shape of the marginal wage curve implies that the cost to the firm for the extra hours declines gradually.

H.2.1.2 Supply of Drivers

Another aspect of the labor costs of the different HOS options is related to the issue of the labor supply curve in the market for truck drivers. The shape of the labor supply curve determines the impact that changes in labor demand would have on the wage rates for truck drivers, and this is expressed as the elasticity of labor supply. As discussed, there is evidence in the literature to suggest that trucking is a very competitive industry with relatively free entry and exit and that its market labor supply curve is quite elastic. This is because trucking is considered a low-skill job with relatively low fixed costs. A small change in labor demand from additional drivers needed for full compliance with the HOS rules will not lead to any substantial changes in wage rates.

H.2.1.2.1 Previous Studies

Rose (1987) contends that the truck driver labor supply curve, especially for the non-union TL sector should be highly elastic. This is because "truck driving is a low-skill occupation with considerable turnover." She also discusses the fact that there is a large pool of drivers outside of the regulated interstate trucking industry who perform the same type of job – owner-operators, private carriage drivers and delivery drivers. She argues thus that the labor supply curve should be highly elastic for this occupation as a whole. Hirsch (1988) also makes the same argument that truck driver labor supply is likely to be highly elastic, given the fact that it is considered a low-skilled job. Engel[63] (1998) argues that the high turnover rate in trucking, especially in the TL sector, indicates that this occupation has a highly elastic labor supply curve and provides an easy entry to new truck drivers. The author further argues that these high rates of turnover also indicate that trucking is a job that is difficult to perform over extended periods. There is evidence in the literature that the trucking industry, especially the TL sector, suffers from significant driver shortage. The details about how this can potentially impact the issue of market labor supply are discussed below.

[63] Cynthia Engel. "Competition Drives the Trucking Industry". Monthly Labor Review, April 1998.

Other studies that looked at the issue of labor supply elasticity in general (not for trucking only) have come up with estimates ranging between 2 and 5. (See for e.g., Lettau (1994), Eberts and Stone (1992)). These studies introduce a spatial dimension to the analysis by looking at local labor markets and therefore are not directly comparable to the analysis here. Nevertheless, these estimates provide a "benchmark" for labor supply elasticity values. Lettau[64], for example, argues that empirical studies that look at local area labor demand-labor supply relationships, find that "an area's elasticity of labor supply is between 2.0 and 5.0." Eberts and Stone[65] use a recursive model to identify the labor supply and demand relationships in local labor markets using CPS data. They find a labor supply elasticity of 4.9 using a five-period lag structure.

H.2.1.2.2 Evidence from Industry Data

Analysis of historical employment data on truck drivers confirms the view held by experts on this industry that the market labor supply for truck drivers is relatively elastic. Table 51 shows the pattern of employment and annual earnings of truck drivers in the economy from 1983 to 2000, based on CPS data. Although driver employment has grown close to a million from 1983 to 2000 (a growth rate of about 40 percent), growth in real wages for drivers has not been nearly that dramatic. In fact, real wages, in 2000 dollars, have grown less than one-half of a percent during the same period.

Table 51: Economy-Wide Truck Driver Employment and Real Wage Levels

Year	Employment	Real Wage (2000$)
1983	2,195,000	30,642
1984	2,373,000	30,878
1985	2,414,000	30,687
1986	2,452,000	30,813
1987	2,543,000	30,810
1988	2,608,000	31,190
1989	2,616,000	31,037
1990	2,627,000	30,866
1991	2,684,000	30,463

64 Michael K. Lettau. "Wage Adjustments in Local Labor Markets: Do the Wage Rates in all Industries Adjust?". Office of Economic Research, Bureau of Labor Statistics. May 1994. Abstract available at: http://www.bls.gov/ore/abstract/ec/ec940070.htm

65 Randall W. Eberts and Joe A. Stone. "Wage and Employment Adjustment in Local Labor Markets". W.E. Upjohn Institute, 1992.

Year	Employment	Real Wage (2000$)
1992	2,712,000	28,709
1993	2,804,000	28,943
1994	2,815,000	29,846
1995	2,861,000	29,549
1996	3,019,000	29,831
1997	3,075,000	30,014
1998	3,012,000	31,236
1999	3,116,000	31,083
2000	3,088,000	30,759

These data support the idea that employment growth for this occupation has not been "significantly impeded by wage movements".

H.2.1.2.3 The Pool of Available Truck Drivers

Wage elasticity for new drivers should ideally be considered in the context of potential truck drivers. Since hiring new drivers would mean shifting or attracting workers from other competing sectors to trucking, the Agency analyzed the existing labor pool for blue-collar workers to see where the new drivers could come from. Table 52 gives the number of blue-collar workers in some of the industries that could supply additional truck drivers needed to comply with the new rules.

Table 52: Employment Levels for Blue-Collar Occupations (thousands)

Occupational Categories	2000	1995	1990	1985
Mechanics and repairers, except supervisors	4,652	4,173	4,221	4,209
Construction trades, except supervisors	5,153	4,372	4,545	4,143
Extractive occupations, including oil well drillers, explosive and mining occupations	84	90	111	141
Precision Production occupations, including metalworking, woodworking, food prodn. and textile, apparel and furnishings	1,665	1,686	1,691	1,709
Operators, fabricators, and laborers	18,319	18,068	18,071	16,816
Fabricators, assemblers, and hand working occupations	2,070	2,059	1,978	1,833
Farm occupations, except managerial	847	862	964	1,064
Related agricultural occupations (except Supervisors)	1,094	1,024	1,014	765
Forestry and logging occupations (except	89	116	123	96

Occupational Categories	2000	1995	1990	1985
Supervisors)				
Transportation and material moving occupations (except Supervisors and Truck Drivers)	2,382	2,209	2,165	2,057
Handlers, equipment cleaners, helpers, and laborers (except Supervisors)	5,429	4,976	4,973	4,431
Janitors and cleaners	2,233	2,071	2,222	2,049
Public transportation attendants	127	94	100	65
Baggage porters and bellhops	42	43	39	20
Total Other Blue Collar	44,186	41,843	42,217	39,398
Truck Drivers	3,088	2,861	2,627	2,414

Source: Current Population Survey

The data in the above table indicate that truck drivers account for about 5 to 6 percent of a total blue-collar population.[66] Most of the occupations listed above can be considered similar to truck driving in terms of attracting people. This is one reason to believe that there is a large labor pool of blue-collar workers from which to attract potential new truck drivers as a result of the HOS options. This fact, coupled with the historical trends on wage movements, suggests that changes in labor demand would not lead to substantial wage effects due to the high labor supply elasticity.

Some analysts believe the high turnover rates in this industry are not driven by a shortage of drivers. According to a study done by the Upper Great Plains Transportation Institute (UGPTI)[67] in 1990, and quoted in a report on "What Matters to Drivers"[68] published in 1997, the trucking industry does not suffer from a "shortage of drivers" to hire from. The study claims the fact that this industry has been able to sustain such high driver turnover rates over the years is an indication that the problem is not one of labor shortage, but a lack of human resource strategy to take advantage of the available driver pool.

Also, the truck driver population in the U.S. under the current conditions is predominantly middle-aged white males. The average age of drivers in the CPS sample is 39 years (for both males and females), with 96 percent of the population being male. However, according to a

[66] The definition of blue-collar workers is broader than that used by BLS to include occupations that can potentially supply new truck drivers.

[67] Griffin, G.C. and Rodriguez, J.M. (1990). "The Determinants of Job Satisfaction of Professional Drivers," *Journal of the Transportation Research Forum*, 2, pp. 453-464.

[68] See Penneau, B. and Smits, R. (1997). *What Matters to Drivers*, J. J. Keller & Associates, Inc., December.

study done by The Gallup Organization[69], females, non-whites (or minorities) and those that have less than 15 years of experience most likely see trucking as a good occupational choice. There is a growing segment of the labor force that has remained untapped to increase the pool of drivers. Improving the working conditions of drivers and making their job characteristics consistent with other competing occupations would be one way to attract this previously unused portion of the labor force.

H.2.1.2.4 Turnover and its Impact on Driver Labor

Another issue that is related to this and could have a potential impact on labor supply is that of turnover. Evidence suggests that this industry, particularly the TL sector, has been plagued by very high rates of turnover.[70]

The Gallup study argues that between 1994 and 2005, the industry will need to hire an additional 403,000 drivers/year (even before new HOS). Of these, about 320,000 (or 80 percent) would be because of "churning" or internal turnover, drivers leaving one company to go to another, because of their dissatisfaction with the present job and pay. Another 34,000 (or 8 percent) would be needed to account for growth in the industry. And the remaining 48,000 (or 12 percent) would be needed because of attrition, retirement and external turnover.

The study also notes five specific job attributes that can predict overall job satisfaction for truck drivers:[71]

Steadiness of work (i.e., consistent driving assignments)
Genuine care of managers for their drivers
Pay
Support from company while on the road, and
Number of hours of work.

Any improvement in the work schedules of drivers that makes it comparable to other competing

69 See "Empty Seats and Musical Chairs: Critical Success Factors in Truck Driver Retention". Prepared by The Gallup Organization for ATA Foundation. October 1997.

70 Turnover rates are the highest in the TL sector – close to 100 percent—which also has the worst pay structure – see Belzer (1995).

71 See "Empty Seats and Musical Chairs: Critical Success Factors in Truck Driver Retention", Prepared by the Gallup Organization for the ATA Foundation, October 1997, page 4.

occupations could reduce driver turnover. Pay structure is also important. Since pay is also listed as an important reason for the lack of satisfaction, any changes in the rules that results in a reduction in pay for drivers could increase driver turnover. Thus the net effect of better work schedules and lower overall wages is unknown.

Based on the issues discussed above and the evidence from previous literature and data on truck driver labor supply, the Agency assume a labor supply elasticity of 5 to measure the impact on wages as a result of a change in demand for drivers. An elasticity of 5 is consistent with the view held by industry analysts that trucking is a fairly low-skill, easy entry job. Although there seem to be very limited research on truck driver's market labor supply models that are directly relevant for the 2003 HOS analysis, an elasticity measure of 5 is reasonable. Changes in labor demand due to compliance with HOS rules should not have large impacts on wage rates.

H.2.1.3 Summary of Labor Cost Assumptions

Using the methodology discussed above, labor costs of compliance with HOS rules are calculated separately for LH and SH. Using the labor productivity changes for these segments as inputs, FMCSA calculated the changes in the driver population that would be needed to maintain the same VMT. Then, using the relationships derived from the labor supply curve for individual truck drivers, as well as for the market labor supply, the avoided (from reducing hours of over utilized drivers) and new (from giving hours to new drivers) labor costs and the overhead.

Table 53: Summary of Labor Assumptions

	LH	SH
Current Driver Population	1,500,000	1,500,000
Labor Supply Elasticity	5	5
Overhead Labor Cost Proportional to Driver Labor	4.0%	4.0%
New Driver Fringe Share	31%	31%

H.2.2 Non-Wage Costs

A change in the number of drivers required to conduct trucking activity requires a complementary change in the fleet size and supporting infrastructure. FMCSA identified methods for estimating the cost of new power units, trailers, and parking spaces, and maintenance and insurance costs of this equipment based on a review of the literature and relevant databases, as well as on the conclusions of its industry experts. It was assumed that no new docking facilities or change in mileage-based costs occurs since no direct change in the number of deliveries or in VMT is assumed, that is the amount of total work conducted by the trucking industry is held as fixed.

H.2.2.1 Trucking Equipment

The method used to estimate the change in the number of tractors and trailers incorporates two countervailing impacts from the change in labor productivity. The first is the obvious change in the number of trucks associated with the incremental change in the number of drivers. The second has to do with the fact that a change in the number of tractors and trailers, under an assumption of no direct change in overall fleet VMT, changes the life of the entire fleet of tractors and trailers, including the life of newly purchased trucks. For example, consider the case of lower labor productivity requiring more drivers and, hence, tractors and trailers. The existing fleet is now driving less to maintain the same VMT, meaning that the average life of each truck is longer. On average, this will translate into lower vehicle replacement based on the change in the number of trucks relative to the initial fleet.

For purposes of illustration, the preceding example will be worked through a representative case in which 10,000 new drivers are hired by trucking companies in response to lower labor productivity, where the initial fleet size is 1,500,000 drivers. Table 54 summarizes the key assumptions used in the analysis. FMCSA assessed and incorporated a number of assumptions made by National Economic Research Associates (NERA)[72] (2001).

The change in motor vehicle expenditures has two implications for the economy that are estimated for purposes of conducting the regional economic analysis. First, the direct

[72] Mark Berkman, Jesse David, Michael Liu, and Alison Pan (2000). "A Review of the Federal Motor Carrier Safety Administration's Economic Analysis for its Proposed Hours of Service Standard." Prepared for the American Trucking Association by National Economic Research Associates (NERA). August 3.

expenditures on equipment are estimated based on the starting year of the policy, the anticipated reaction time by trucking firms, and the anticipated life of assets adjusted for the change in fleet size. Second, the assumption is made that firms will not simply bear the swings in capital costs in each year. Instead, firms will finance the costs over the amortization schedule at a reasonable weighted-average cost of capital.

The money to cover these transactions is assumed to come from personal consumption in the regional economic framework. In year 1 of an amortization schedule, consumers provide the cash to cover the change in purchases of new vehicles, net of the first year's principal and interest payments. In subsequent years, consumers receive the remaining principal and interest payments associated with the original loan in the first year. The principal and interest costs represent an increase in the production costs facing trucking-related sectors in the economy.

Table 54: Assumptions Used to Model Motor Vehicle Equipment Costs

Variable	Units	Name	Assumption	Source
Ratio of Tractors to Drivers	Ratio	Ratio_TD	0.75	NERA[73]
Ratio of Trailers to Tractors	Ratio	Ratio_TT	1.00	FMCSA
Cost of New Tractor	$Nominal	Tractor_Cost	$95,000	FMCSA/NERA[74]
Cost of New Trailer	$Nominal	Trailer_Cost	$20,000	FMCSA/NERA
Amortization Period	Years	Truck_Amort	5	FMCSA
Cost of Capital (% Return on Assets)*	Percent	Truck_Cap	14.00%	FMCSA
Phase In Period	Years	Truck_Phase	2	FMCSA
Initial Ratio of Trailers to Trucks	Ratio	Initial_RTT	2.50	NERA[75]
Average Tractor Life	Years	Tractor_Life	7	NERA
Average Trailer Life	Years	Trailer_Life	10	FMCSA

*Pre-tax revenue requirement based on weighted-average cost of capital assuming a debt-to-equity ratio of 1 (50% debt/50% equity), a pre-tax bond rate of 8%, and a 20% pre-tax equity rate

Returning to the example, the steps involved in estimating the changes in the demand for motor

---

73 NERA evaluated ratios of trucks to drivers based on estimates of 1.14 from an ATA Driver Comparison Study (August 2000), an ATA survey of members at 1.18, and a study by Belzer, Michael, *Hours of Service Impact Assessment*, University of Michigan Transportation Research Institute, March 5, 1999.

74 NERA evaluated truck valuations and expected lives based on information from Martin Labbe Associates and an ATA report of costs between $60,000 and $150,000 per truck. The Agency revised up to $95,000 per tractor based on discussions with its industry experts.

75 NERA's estimate based on ATA's *Motor Carrier Annual Report* (1998) reporting 737,339 owned and leased trailers and semi-trailers and 294,658 owned and leased truck-tractors. The Agncy examined the *2000 TTS National Motor Carrier Directory* database that revealed ratios in the 1.95 to 2.30 range.

vehicle equipment are as follows (t is used to represent time by year and MM for millions):

Step 1: Estimate the Number, Timing, and Cost of New Tractors and Trailers

New Tractors = Ratio_TD * New Drivers = 0.75 * 10,000 = 7,500
New Trailers = Ratio_TT * New Tractors = 1.00 * 7,500 = 7,500
For t = 0 to Truck_Phase, New $Tractors_t$ = New Tractors/Truck_Phase = 7,500/2 = 3,750
For t = 0 to Truck_Phase, New $Trailers_t$ = New Trailers/Truck_Phase = 7,500/2 = 3,750
Tractor $Cost_t$ = New $Tractors_t$ * Tractor_Cost = 3,750 * $95,000/1MM = $356.25 MM
Trailer $Cost_t$ = New $Trailers_t$ * Trailer_Cost = 3,750 * $20,000/1MM = $75.00 MM

Step 2: Estimate the Change in Asset Life of Tractors and Trailers

Adj. Tractor Life = Tractor_Life * [1 + New Tractors / (New Tractors + Initial Tractor Inventory)] = 7 * [1 + 7,500 / (7,500 + 1,500,000)] = 7.034829 Years
Initial Trailer Inventory = Initial Tractor Inventory * Initial_RTT = 1,500,000 * 2.5 = 3,750,000
Adj. Trailer Life = Trailer_Life * [1 + New Trailers / (New Trailers + Initial Trailer Inventory)] = 10 * [7,500 / (7,500 + 3,750,000)] = 10.01996 Years

Step 3: Estimate the Replacement Timing and Cost for New Tractors and Trailers

Tractor Costt+INT(Adj. Tractor Life) = Tractor Costt = $356.25 MM
Trailer Costt+INT(Adj. Tractor Life) = Trailer Costt = $75.00 MM

Step 4: Estimate the Change in Existing Annual Fleet Replacement

Δ Annual Tractor Repl. = Initial Tractor Inventory*[(1/Tractor_Life)-(1/Adj. Tractor Life)] = 1,500,000 * [(1/10)-(1/10.01996)] = -1,061 Tractors/Year
Δ Annual Tractor Repl. Cost = Δ Annual Tractor Repl. * Tractor_Cost = -1,061 * $95,000 = -$100.79 MM/Year
Δ Annual Trailer Repl. = Initial Trailer Inventory*[(1/Trailer_Life)-(1/Adj. Trailer Life)] = 3,750,000 * [(1/10)-(1/10.01996)] = -747 Trailers/Year
Δ Annual Trailer Repl Cost. = Δ Annual Tractor Repl. * Tractor_Cost = -747 * $95,000 = -$14.94 MM/Year

Step 5: Estimate Capital Payments for Each Year's Change in Investment Over Time

For each year, calculate aggregate net change in Capital Cost required across Steps 1 to 4

Annuitization Factor = [Truck_Cap] / [1-(1/((1+Truck_Cap)^Truck(Trailer)_Amort))] = 29.128%
Capital Payment = Annuitization Factor * Capital Cost (associated with a given year's investment – need to aggregate capital payments across multiple years' investments according to the amortization life and year)
Capital Payment$_{t=1}$ = ($326.25 MM + $75.00 MM - $100.79 MM - $14.94 MM)*29.128% = $83.168 MM/Year for 5 Years

H.2.2.2 Parking Space Construction and Maintenance

A change in the number of tractor-trailer sets will require that additional parking spaces be available at terminals. The construction and maintenance of new parking spaces requires both an up-front capital expenditure in the first year followed by annual maintenance costs in subsequent years. The capital expenditures will be capitalized and amortized as a cost to the trucking sector with financing assumed to be substituted for personal consumption as with equipment expenditures. Unlike trucks, no off-setting change in the life of existing parking spaces occurs, because the life of a parking space is expected to be longer than the 10-year horizon under consideration in this analysis.

The assumptions used in the analysis are documented in table 55. Information on parking space requirements for tractor-trailer sets was taken from the National Association of Truck Stop Owners (NATSO) and for auto parking spaces from International Parking Institute (IPI). Maintenance costs for auto spaces were assumed to occur at the same ratio as truck space maintenance to capital cost.

Not all new tractor-trailer sets will be at the terminal at any given point in time, where Terminal_Max summarizes the proportion of additional spaces to sets. In addition to parking spaces for new tractor-trailer sets, additional spaces must be constructed for new drivers to park at truck stops, rest areas, or terminals while en route. The ratio of new drivers parking at work to new tractor-trailer sets is accounted for in variable Terminal_TD. The installation and maintenance costs are estimated based on the following steps.

Table 55: Assumptions Used to Model Parking Space Construction & Maintenance Costs

Variable	Units	Name	Assumption	Source
Ratio of Tractor/Trailers Per Acre	Ratio	TPA_Ratio	18.00	NATSO[76,]
Ratio of Tractors to Drivers	Ratio	Ratio_TD	0.75	NERA
Max. # of New Trucks at Terminal	Percent	Terminal_Max	75%	FMCSA
Capital Cost Per Acre for Trucks	$Nominal	TPA_Cost	$100,000	NATSO
O&M Cost Per Acre for Trucks	$Nominal	TPA_OM	$10,000	NATSO
Drivers Parking at Terminal	Percent	Terminal_TD	75%	FMCSA
Capital Cost Per Space for Autos	$Nominal	APS_Cost	$1,500	IPI[77]
O&M Cost Per Space for Autos	$Nominal	APS_OM	$150	FMCSA
Cost of Capital (% Return on Assets)*	Percent	Truck_Cap	14.00%	FMCSA
Amortization Period	Years	Pkg_Amort	10	FMCSA
Average Life of Parking Spaces	Years	Pkg_Life	20	FMCSA

*Pre-tax revenue requirement based on weighted-average cost of capital assuming a debt-to-equity ratio of 1 (50% debt/50% equity), a pre-tax bond rate of 8%, and a 20% pre-tax equity rate

Step 1: Estimate the Number of Parking Spaces Required

1.1.1. New Tractor-Trailer Spaces = New Drivers * Ratio_TD * Terminal_Max = 10,000 * 0.75 * 75% = 5,625
1.1.2. New Auto Spaces = New Tractor-Trailer Spaces * Terminal_TD = 5,625 * 75% = 4,219

Step 2: Estimate the New Tractor-Trailer Set Capital & Maintenance Costs

1.1.3. TT Set Pkg. Capital Cost = New Tractor-Trailer Spaces * TPA_Cost / TPA_Ratio = 5,625 * $100,000 / 18 = $31.25 MM in Year 1
1.1.4. TT Set Pkg. Maint. Cost = New Tractor-Trailer Spaces * TPA_OM / TPA_Ratio = 5,625 * $10,000 / 18 = $3.125 MM in Years 2+

Step 3: Estimate the New Auto Parking Capital & Maintenance Costs

1.1.5. Auto Pkg. Capital Cost = New Auto Spaces * APS_Cost = 4,219 * $1,500 = $6.328 MM in Year 1

76 Costs per space based on Scott Imus, National Association of Truck Stop Owners, http://www.natso.com/for_members/government_downloads/truckparking_solutions2001.doc: Assume 18:1 ratio of tractor/trailer sets per acre, $100K construction costs per acre, and $8,000-$10,000 per year in annualized maintenance costs; translates to $5,555 in capital costs and $555 per year in maintenance costs per tractor/trailer set. These values are consistent with estimates of incremental, rest-area pull-off parking space construction costs of $5,000-$7,000 per space based on information derived from truck stop operators and a national rest area database in U.S. DOT, Federal Highway Administration (1996). "Commercial Driver Rest & Parking Requirements: Making Space for Safety – Final Report." Report No. FHWA-MC-96-0010, May, Table III-2, p. 97.

77 The International Parking Institute states that, "Surface facilities can be built for $1,500 per space in most cases." http://www.parking.org/main/faq.htm; http://wwww.fsfarchitects.com/ExtGuide.htm estimates the ratio of spaces per acre at 80:1 to 100:1 at a cost of approximately $1,000 per space. It was assumed that 10 percent of construction was maintenance.

1.1.6. Auto Pkg. Maint. Cost = New Auto Spaces * APS_OM = 4,219 * $150 = $0.6328 MM in Years 2+

Step 4: Estimate Capital Payments

1.1.7. Calculate aggregate net change in Capital Cost required across Steps 1 and 2 in Year 1
1.1.8. Annuitization Factor = [Truck_Cap] / [1-(1/((1+Truck_Cap)^Truck(Trailer)_Amort))] = 19.171%
1.1.9. Capital Payment = Annuitization Factor * Capital
1.1.10. Capital Payment$_{t=1}$ = ($31.25 MM + $6.328 MM)*19.171% = $7.204 MM/Year for 10 Years

H.2.2.3 Insurance

Additional tractor-trailer sets have value whether they are on the road or not. Though incremental insurance costs are predominantly associated with changes in the VMT, a portion of the insurance cost is associated with the intrinsic value of the change in the capital stock represented by the change in the number of tractor-trailer sets. NERA estimated a value of $2,549 per new driver per year in insurance costs based on ATA data, and the 2003 HOS rule analysis used this estimate.[78] Industry experts estimated that perhaps 25% of this cost is associated with the intrinsic value of the truck, and is therefore a fixed cost per CMV. The remainder is assumed to be variable with changes in VMT. FMCSA assumed that no direct change will occur in the variable portion of insurance costs since overall VMT is assumed to remain the same. The end result is a change of $637.25 per driver per year, or, $6.3725 million per year.

H.2.2.4 Maintenance

Analogous to the issue of insurance, additional tractor-trailer sets require some regular maintenance whether they are on the road or not. Though incremental maintenance costs are predominantly associated with changes in the VMT, a portion of the maintenance cost is associated with regular safety inspections and other routine, scheduled maintenance represented by the change in the number of tractor-trailer sets. Industry experts estimated a value of $8,500 per new tractor-trailer per year in maintenance costs and that perhaps 25% of this cost is

---

[78] Based on data from Motor Carrier Financial and Operating Statistics, 1998.

associated with fixed maintenance costs per truck. The remainder is assumed to be variable with changes in VMT. The portion of the maintenance cost associated with new trucks is negated by changes in VMT in the rest of the fleet to yield no direct net change in VMT, and, hence, no change in the variable portion of maintenance costs. The end result is a change of $2,125 per truck per year, or $21.25 million per year.

H.2.2.5 Recruitment

The need for more or fewer drivers will have an impact on recruitment costs associated with the hiring of new drivers. Rodriquez, et al. (1998),[79] surveyed 15 LH, for-hire trucking firms to determine the average costs associated with driver turnover, or churn. The study estimated an average cost to firms of $5,423, as summarized by cost category in the first three columns of table 56. The Agency excluded the costs and profits from idle equipment and the production loss due to churn since equipment costs are explicitly modeled and VMT is assumed to remain constant. It also assumed that 75% of the advertising and staff labor costs are based on fixed annual budgets, where only 25% is variable based on the change in number of new drivers to be recruited. Firms are likely to have exhausted the most important marketing channels to them given the high industry churn rate. Administrative support (Staff Labor) is assumed to be characterized by a high degree of automation, with the 25% assumption used to cover the fact that some back-office recruiting labor was included in this category by Rodriquez, et al. The rest of the costs are assumed to be fully variable with a change in the number of new drivers. The result is an incremental cost of $1,610 per hire as compared to the average of $5,423 based directly on the survey results.

Table 56: Cost of Driver Churn

Average Costs Per Firm	Total Cost	Per Hire*	25% Per Hire	% Fixed
Advertising	$446,000	$340	$85	75%
Staff Labor	$1,063,000	$811	$203	75%

[79] *The Costs of Driver Turnover*, Upper Great Plains Transportation Institute, North Dakota State University, April 2000. Average values for churn-related costs ranged from $6,400 to $8,600 per hire, with an average of $8,234 per hire. However, ICF evaluated the averages as reported in the study for each cost category and the average number hires to determine the value of $5,423 per hire. Values in other surveys reviewed by NERA ranged from $2,000 to $20,000.

Testing Fees	$193,000	$147	$147	0%
Recruitment Fees	$580,000	$442	$442	0%
Orientation Fees	$323,000	$246	$246	0%
Training Fees	$543,000	$414	$414	0%
Referral/Sign On Bonus	$94,000	$72	$72	0%
Costs for Idle Equipment	$2,313,000	$1,764		
Lost Profits Due to Idle Equipment	$705,000	$538		
Production Loss Due to Turnover	$849,000	$648		
Totals	$7,109,000	$5,423	$1,610	

*Based on survey average of 1,311 hires per firm from Rodriquez, *et al.* (1998).

The cost per driver is multiplied by the change in the number of drivers in the first year. In subsequent years, the cost per hire is multiplied by the change in the number of new drivers times the assumed churn rate for drivers. Estimates of churn rates vary from 25% to over 100% depending on the survey. The 2003 HOS RIA employed the churn rate of 25% assumed by NERA (2001).[80] The cost in Year 1 is $1,610 * 10,000 drivers, or $16.10 million. The cost in subsequent years is equal to $16.10 times the churn rate of 25%, or $4.02 million per year.

H.3 Safety Benefits

This section estimates the safety benefits from reducing fatigue in over-utilized drivers by bringing them into minimal compliance with the HOS rules.

H.3.1 Background on Driver Fatigue, Sleep and Truck-Involved Accidents

This review draws on existing literature to describe the function of sleep and the established relationship between sleep, fatigue, shift work and performance, and CMV accidents. For the purposes of this review, fatigue is defined as the decreased ability to perform induced by a lack of adequate sleep, approximately 8 hours per 24-hour period. The review does not intend to duplicate other major literature reviews performed on the subject of sleep, fatigue and truck-involved accidents.[81] Rather, it is a targeted summary of key issues related to the analysis

---

[80] NERA claims this is a conservative assumption based on survey data indicating 25% churn per *quarter* for TL and 4% for NTL carriers, or ~75% annually across all driver types (*Trucking Activity Report*, June 2000, ATA). FMCAS also reviewed a compendium of surveys compiled by J.J. Keller & Associates ("What Matters to Drivers", Neenah, WI, 1997) which generally confirms the range of estimates cited by NERA.

[81] See Freund, D. 1999. An Annotated Literature Review Relating to Proposed Revisions to the Hours of Service Regulation for Commercial Motor Vehicle Drivers. OMCS, Federal Highway Administration.

conducted for this study.

H.3.1.1 The Function and Physiology of Sleep

Sleep is an integral part of human functioning and longevity. Not getting enough sleep leads to drowsiness and impaired concentration for the subsequent non-sleep period.[82] Too little sleep also leads to impaired memory and physical performance and reduced ability to perform on cognitive tasks. Without sleep, neurons may become so depleted in energy or so polluted with byproducts of normal cellular activity that they begin to malfunction. During sleep, the body also increases its protein production, enabling the repair of damaged cells, damaged from such external elements as ultraviolet rays or stress. Sleep is crucial to this process of cell repair and to the promotion of uncompromised performance during non-sleep periods.

H.3.1.1.1 The Stages of Sleep

Until the 1950s, sleep was regarded as a dormant, passive part of daily life. After this time, however, sleep became to be recognized as a dynamic process with multiple states of brain activity. There are five different stages of sleep, as measured through brain activity. These five stages are:

Stage 1 – Sleep Onset
Stage 2, 3 and 4 – non Rapid Eye Movement (non-REM) Sleep
Stage 5 – Rapid Eye Movement (REM) Sleep

The brain passes through stages 1, 2, 3 and 4 (non-REM sleep) and then into stage 5 (REM sleep). The time spent in each stage varies depending on the stage and depending on the number of sleep cycles (progression through stages 1, 2, 3, 4 and REM sleep) completed in the sleep period. Approximately 50 percent of total sleep time is spent in stage 2, 20 percent in REM sleep and 30 percent in the remaining stages.

Stage 1 is the shortest phase, comprised of drifting in and out of sleep. People are easily

[82] The information in this section and in the next section on sleep is from a National Institute of Health website http://www.ninds.nih.gov, unless otherwise noted.

awakened during this phase. This is also the phase where one experiences "hypnic myoclonia" where the sensation of falling is often felt. In stage 1, the body has slow muscle activity and eye movement. In stage 2, the stage in which most sleep time is spent, eye movement stops. The brain's electrical activity decreases and short bursts of rapid brain waves occasionally appear. Stage 2 is the first stage of the non-REM sleep stages. Stages 3 and 4 (called deep sleep) are also non-REM sleep stages and are characterized by very slow brain waves.

REM sleep is the next stage. This is often referred to as the "active" sleep stage. The slowed brain waves begin to accelerate, breathing becomes more rapid, irregular and shallow, eye movement begins, heart rate increases and blood pressure rises. This lighter stage of sleep is where most dreaming occurs. As the sleep period progresses, the REM sleep stage increases in length where towards the end of the sleep period, an individual may spend up to one hour in REM sleep and experience very involved dreams.

The complete sleep cycle usually takes 90 to 110 minutes. The first sleep cycles of each sleep period contain relatively short REM periods and long periods of deep sleep. As the night progresses, REM sleep periods increase in length while deep sleep (stages 3 and 4) decreases. By the end of a "normal" sleep period (defined here as approximately 8 hours), almost all sleep is spent in Stage 2 and REM sleep.

H.3.1.1.2 Physiology of Sleep

Most sleep experts agree that adults need between six and ten hours of sleep per 24-hour period, with most people requiring approximately 8 hours of sleep per day.[83] Sleep most naturally occurs at night, due to the human body's circadian rhythm. Circadian, or daily, rhythms operate on approximately a 24-hour cycle and are responsible for natural peaks and lulls in hormonal secretions, a heightened sense of fatigue during different parts of the day – particularly in the early morning hours and the late afternoon – and the coordination and timing of other internal bodily functions, including body temperature and sleep. Sunlight and other time cues help to set and maintain circadian cycles.

[83] Pilcher, J.J., Huffcutt, A.I., 1996. Effects of sleep deprivation on performance: a meta-analysis. Sleep, 19, 318-326.

Body temperature fluctuates in accordance with other bodily fluctuations of the circadian cycle and influences the timing of sleep and sleep onset. During a single day, the body's temperature rises and falls a number of times. Body temperature rises in the early morning hours, declines in the late afternoon, rises in the evening and declines later at night. People prefer to go to bed during certain phases in the temperature cycle over others, preferring phases when the circadian temperature cycle is at the nadir (lowest point).[84] When body temperature is on the rise, the body has a greater propensity to awaken.[85] Body temperature is on the rise in the morning hours, when people on regular night sleep schedules tend to wake up. It logically follows that it is more difficult to fall asleep during these morning hours (because body temperature is rising, not falling).

The sleep/wake cycle shows that the degree of sleepiness depends on the oscillating circadian rhythm and declining linear function (increased degree of sleepiness) based on the length of time spent awake.[86]

H.3.1.2 Significance of the Timing of Sleep

The timing of sleep matters. Sleep duration is greatest after evening bedtimes and shortest after morning bedtimes.[87] The duration of sleep has also been found to be shorter the later in the morning sleep begins.[88] The shorter sleep duration after a morning bedtime might seem somewhat counterintuitive as a morning bedtime is often the result of sleep postponed (i.e. longer period elapsed since last period of sleep). However, this decrease can be explained by the strong influence of the circadian rhythm on sleep duration, which makes it more difficult to sleep during daytime hours than it is during nighttime hours.

A number of studies have shown that duration of sleep is influenced by the time of day of sleep.

---

[84] Czeisler, C.A., Weitzman, E.D., Moore-Ede, M.C., Zimmerman, J.C., Knauer, R.S., 1980. Human sleep: its duration and organization depend on its circadian phase. Science 210, 1264-1267.

[85] Gillberg, M., Akerstedt, T., 1982. Body temperature and sleep at different times of day. Sleep.

[86] Akerstedt, T., Gillberg, M., 1982. Displacement of the sleep period and sleep deprivation. Human Neurobiology 1: 163-171.

[87] Akerstedt, T., Gillberg, M, 1981. The circadian variation of experimentally displaced sleep. Sleep 4: 159-169.

[88] Akerstedt, T., Gillberg, M., 1982. Displacement of the sleep period and sleep deprivation: implications for shift work. Human Neurobiology 1, 163-171.

A survey found that night workers, who by default must sleep in some part, or entirely, during the day, slept three hours less than the recommended eight hours required to prevent sleep debt.[89] Another study found that night workers (shift starting around 2200 or 0000) slept on average 3.3 hours less than their day-working counterparts (shift starting around 0800), sleeping 4.3 hours and 7.6 hours respectively.[90] These data demonstrate that people who rely on daytime sleep for a significant part of their rest are experiencing less total sleep.

H.3.1.3 Sleep Deprivation and Sleep Debt and Impact on Performance

Sleep deprivation occurs when an individual sleeps two or more hours less than the optimal amount during any one sleep episode, eight hours being the standard optimal amount subject to significant variation by individual. Sleep deprivation over a series of sleep periods leads to sleep debt, the accumulated sleep loss over the course of time.[91] The discussion in this section presents the results of a number of studies and the implications of sleep deprivation and sleep debt on performance based on the available literature.

Sleep deprivation and sleep debt have a number of consequences for performance. Sleep deprivation over a couple of days leads to slower response times and decreased initiative.[92] After one sleepless night, cognitive performance may decrease 25% as compared to the performance of non-sleep deprived individuals.[93] After the second sleepless night, performance on cognitive tasks may decrease to nearly 40% the potential level. A meta-analysis found that people who are chronically sleep deprived, that is, have substantial sleep debt, performed at the 9th percentile of

---

89 Caldwell, J.L., Gilreath, D.S., 2000. A survey of subjective sleep length of shift workers based on time of day of sleep onset. Presented at the 14th Annual Meeting of the Associated Professional Sleep Societies.

90 Akerstedt, T., Gillberg, M., Torscall, L, Froberg, J., 1980. Oregelbunndna arbetstider: Sammanfattning av en undersokning av turlistetidsarbetande lokforare. Reports from the Laboratory for Clinical Stress Research, No 132. In Akerstedt, T., Gillberg, M., 1982. Displacement of the sleep period and sleep deprivation: implications for shift work. Human Neurobiology 1, 163-171.

91 Jha, A.K., Duncan, B.W., Bates, D.W., 2001. Fatigue, Sleepiness and Medical Errors, for the Agency for Health Care Research and Quality. Evidence Report/Technology Assessment, No. 43.

92 Koslowsky, M., Babkoff, H., 1992. Meta-analysis of the relationship between total sleep deprivation and performance. Chronobiol Int, 9, 132-136.

93 Krueger, G., ed., 1989. Sustained work, fatigue, sleeps loss and performance: a review of the issues. Work and Stress, 3.

non-sleep-deprived subjects.[94]

Individuals switching from an irregular to regular schedule do not immediately achieve improved fatigue levels. Sleep deprived individuals with irregular sleep schedules (as could be the case with truck drivers) who regularized their sleep schedules but suffered sleep loss in the process experienced an increase in daytime sleepiness and a concomitant deterioration in concentration ratings, immediately after regularizing their sleep schedule.[95]

These findings suggest that routine sleep schedules that allow the individual sleeping an adequate number of hours (approximately 8, varying by individual) during approximately the same time during a 24-hour period facilitate daily functioning at unimpaired performance levels.

H.3.1.4 Fatigue and Work

Workers experience a number of different types of fatigue while on the job. The three major types of fatigue affecting work performance are industrial, cumulative and circadian.[96] These types of fatigue are described below, focusing on the literature relating to truck drivers.

Industrial fatigue results from working continuously over an extended period of time without proper rest, often referred to in the literature as fatigue resulting from time-on-task. For example, a truck driver who has been driving for six hours, without a break, might be subject to industrial fatigue. Some studies have shown performance to decrease as time on task increases.[97] Time-on-task problems could be exacerbated by sleep loss, even in the early stages of the task. One study concluded that for sleep deprived individuals, performance is compromised even at early stages of performance of a monotonous task if the situation is undemanding and boring. This study suggests that the effect of sleepiness becomes immediately evident in the form of

[94] Pilcher, J.J., Huffcutt, A.I., 1996. Effects of sleep deprivation on performance: a meta-analysis. Sleep, 19, 318-326.
[95] Manber, R., Bootzin, R., 1991. The effects of regular wake-up schedules on daytime sleepiness in college students. Sleep Research 20, 284.
[96] Saccomanno, F.F., Yu, M., and Shortreed , J.H., 1995. Effect of driver fatigue on truck accident rates. *Urban Transport and the Environment for the 21st Century*, ed. Sucharov, L.J., Southampton, UK: Computational Mechanics Publications, 439-446.
[97] Dinges, D.F., Kribbs, N.B., 1991. Performing while sleepy: effects of experimentally induced sleepiness. In Monk, T. (ed.) Sleep, sleepiness and performance. New York: John Wiley & Sons.

reduced vigilance.[98,99]

Cumulative fatigue arises from working for too many days on any protracted, repetitive task without any prolonged break. This fatigue results from a lack of alertness brought on by familiarity and boredom with the task at hand. A truck driver could experience cumulative fatigue after driving for 12 hours, taking eight hours off and then driving another 12 hours (driving a total of 24 hours in a 32 hour period).

Circadian fatigue is a function of the circadian rhythm. Fatigue is greatest when approaching or at the nadir of the circadian cycle, where the body is least vigilant. The truck accident rate is much higher during the early morning hours than during any other time of day,[100] supporting the circadian effect hypothesis that accidents are more likely to occur when the human body is least vigilant.[101]

Night and rotating shift workers are especially susceptible to being fatigued on the job.[102,103,104] Permanently assigned graveyard-shift workers sleep between 5.8 to 6.4 hours per day.[105] Rotating shift workers, such as many truck drivers, sleep even less when they work a night shift (5.25 to 5.5 hours). Shift workers experience disturbances in their circadian rhythm, as measured by changes in hormonal levels;[106] they are also less alert during nighttime shifts and perform less well on reasoning and non-stimulating tasks than non-shift workers.[107] Though nightshift work for many workers is regular (the same schedule is kept over time), truck drivers often have irregular schedules which can amplify the effects of circadian, cumulative and industrial fatigue

98 "Vigilance" was measured through a 34-minute visual vigilance test.
99 Gillberg, M., Akerstedt, T. 1998. Sleep loss and performance: no "safe" duration of a monotonous task. Physiol Behav 64(5), 599-604.
100 Harris, W., 1978. Fatigue, circadian rhythm and truck accidents in Vigilance: Theory, Operational Performance and Physiological Correlates, ed. Mackie, R.. New York, NY: Plenum Press, 133-146.
101 See previous section entitled "The Biology of Sleep" for further discussion of the circadian effect.
102 Akerstedt, T., 1988. Sleepiness as a consequence of shift work. Sleep, 11, 17-34.
103 Mitler, M.M., Carskadon, M.A., Czeisler, C.S., Dement, W.C., Dinges, D.F., Graeber, R.C., 1988. Catastrophes, sleep and public policy. Sleep 11 (1), 100-109.
104 Gold, D.R., et al., 1992. Rotating shift work, sleep and accidents related to sleepiness in hospital nurses. American Journal of Public Health 82 (7), 1011-1014.
105 Bonnet, M.H., Arand, D.L., 1995. We are chronically sleep deprived. Sleep 18 (10), 908-911.
106 Akerstedt, T., Levi, L., 1978. Circadian rhythms in the secretion of cortisol, adrenaline and noradrenaline. Eur J Clin Invest 8, 57-58.
107 Akerstedt, T., 1988. Sleepiness as a consequence of shift work. Sleep 11, 17-34; Akerstedt, T., Kecklund, G., Knutsson, A., 1981. Manifest sleepiness and the spectral content of the EEG during shift work. Sleep 14, 221-225.

and increase the risk of fatigue-related accidents.

H.3.1.5 Fatigue and Truck-Involved Crashes

Fatigue increases over the duration of trips, regardless of the driving schedule[108] and total driving time has a significant effect on crash risk though there is variation on the point at which crash risk increases significantly, depending on the study methodology.[109,110] A study of industrial fatigue in truck drivers found that in over 65% of cases, truck accidents took place during the second half of a trip, regardless of trip length.[111] An analysis of Bureau of Motor Carrier Safety data in the 1970s found that about twice as many accidents occurred during the second half of trips than during the first half, regardless of trip duration.[112] Another study found that the risk of accident increased after the fourth hour of driving and peaked after nine hours of driving.[113] These studies are among many finding that industrial fatigue plays a role in predisposing truck drivers to accidents. Determining the magnitude of this effect, however, and ensuring that other factors (such as sleep history and time of day) have been factored out, is quite difficult.

Researchers have long asked how long a person can sustain work effort at different tasks without lengthy breaks, before his/her performance of those tasks becomes unacceptably degraded. There has always been a notion that by itself, sustained performance at a task (Time on Task or TOT) eventually results in a "fatiguing effect" manifesting itself in the form of slower response times or errors of omission. Below is a short literature review of five studies about the time-on-task effect on driving and some concluding remarks.

---

[108] Williamson, A.M., Feyer, A.M., Friswell, R., 1996. The impact of work practices on fatigue in long distance truck drivers. Accident Analysis and Prevantion 28 (6), 709-719.

[109] Lin, T.D., Jovanis, P.P., Yang, C.Z., 1994. Time of day models of motor carrier accident risk, Transportation Research Record 1457, National Academy Press, Washington, DC.

[110] Frith, W.J., 1994. A case control study of heavy vehicle drivers' working time and safety. Victoria, Australia: Proceedings, 17th Australian Road Research Board Conference, Part 5, 17-30.

[111] Mackie, R.R., Miller, J.C., 1980. Effects of irregular schedules and physical work on commercial driver fatigue and performance. Human Factors in Transport Research. London, UK: Academic Press Inc.

[112] Harris, W., 1978. Fatigue, circadian rhythm and truck accidents, in ed. Mackie, R., Vigilance: Theory, Operational Performance and Physiological Correlates. New York, NY: Plenum Press, 133-146.

[113] Kaneko, T., Jovanis, P., 1992. Multiday driving patterns and motor carrier accident risk: a disaggregate analysis. Accident Analysis and Prevention 24 (5), 437-452.

Jones and Stein (1987)[114] attempted to provide "adjusted odds ratios" to different categories of "length of time in driving" (TOT), assigning a baseline value of 1.0 to the relative risk of the likelihood of crashes attributable to a driving time of from 0 to 2 hours; and they presented an increased odds ratio of 1.2 for driving times of from 2 to 5 hours and also 5 to 8 hours of driving time (TOT). The work of Jones and Stein says nothing about projecting odds ratios for driving more than 8 hours, something at the root question of the entire discussion of truck driver HOS.

Lin, Jovanis, and Yang (1993)[115] introduce a time-dependent logistic regression model formulated to assess the safety of motor carrier operations. They describe their model as being flexible, allowing the inclusion of time-independent covariates, time main effects, and time-related interactions. The model estimates the probability of having a crash at time interval t, subject to surviving (not having a crash) before that time interval. Covariates tested in the model in this paper include consecutive driving time, multiday driving pattern over a 7-day period, driver age and experience, and hours off duty before the trip of interest. Although the work of Lin, Jovanis, and Yang has some appeal in the conduct of this study, their methods and modeling are of some concern in that they do not model beyond the 8-9 hours of driving incidents, something which is obviously needed to examine the HOS alternatives.

In their description of nine logistic regression modeling attempts Lin, Jovanis, and Yang state that driving time (TOT) has the strongest direct effect on accident risk. The first 4 hr consistently have the lowest crash risk and are indistinguishable from each other. Accident (crash) risk increases significantly after the fourth hour of driving, by approximately 50% or more, until the seventh hour. The 8th and 9th hours show a further increase, approximately 80% and 130% higher than the first 4 hours.

Campbell (1988)[116] states that there is a steady increase in the probability of accident involvement with the number of hours driving. To look into this, Campbell used data from

---

114 Jones, I.S. & Stein, H.S. (1987). Effect of driver hours of service on tractor-trailer crash involvement. (Proceedings paper). Arlington, VA: Insurance Institute for Highway Safety.
115 Lin, T.D., Jovanis, P.P. & Yang, C-Z. (1993) Modeling the safety of truck driver service hours using time-dependent logistic regression. Transportation Research Record, 1407 1-10.
116 Campbell, K. L. 1988. Evidence of fatigue and the circadian rhythm in the accident experience. Michigan University, Ann Arbor, Transportation Research Institute, Center for National Truck Statistics. 29 p. UMTRI-77933

accident reports filed with the Office of Motor Carriers and extracted the time of day that the accident occurred, the number of hours driving at the time of the accident, and the intended driving period had the accident not occurred. The accidents that were coded as the driver having dozed at the time of the accident were used to determine the time-on-task effect. The problem with this is that not all of the crash data was included and crashes may have been caused by fatigue yet the driver was not dozing at the time. It was concluded that the crossover point in which the proportion of accidents in the latter hours of driving is more frequent occurs around four hours of driving.

O'Neill et al. (1999)[117] studied the operating practices of CMV drivers, as well as the relationship of these practices to driver fatigue. Drivers worked a 14-hour on, 10 hour off schedule driving a simulator for a 5-day week. Two 30-minute breaks and a 45-minute lunch break were taken during the day at regularly scheduled times. The observed recovery effect of the breaks was rather striking. The effects of 6.5 hours of driving were virtually reduced to the starting levels by a 45-minute break (O'Neil et al., 1999). It is important to keep in mind that while this recovery effect is remarkable, it occurred under very strict, adhered to conditions. This effect took place under daytime driving conditions, the 14 hours on/10 hours off driving schedule that allowed for adequate rest, and scheduled breaks. It cannot be said with a reasonable degree of certainty that this recovery effect would occur in the same way under different conditions.

Wylie et al. (1996) [118]studied four different driving conditions to test several driving fatigue questions: a 10-hour "baseline" daytime schedule, a 10-hour "operational" or rotating schedule, a 13-hour nighttime start schedule, and a 13-hour daytime start schedule. The authors concluded that hours-of-driving (TOT) was not a strong or consistent predictor of observed fatigue. Interestingly, there was a positive correlation between driver's self-ratings of fatigue and the number of hours driving within a trip while objective performance did not indicate a positive correlation.

---

[117] O'Neill, Krueger, G.P., Van Hemel, S.B., & McGowan, A.L. (1999). Effects of operating practices on commercial driver alertness. (FHWA-OMC Technical Report No. FHWA-MC-99-140).

[118] Wylie, C.D., Shultz, T., Miller, J.C., Miktler, M.M. & Mackie, R.R. (1996). Commercial motor vehicle driver fatigue and alertness study. (FHWA Technical Report No. MC-97-002). Washington, DC: Federal Highway Administration.

Based on the literature reviewed, the time-on-task effect was not quantified independent of and in addition to the circadian and recovery/decrement recovery factors. Therefore, the TOT effect was not used as a separate factor in the 2003 HOS rule analysis.

Another important and relevant factor is time of day and continuity of sleep. Numerous studies have found an increased crash risk for truck drivers associated with night-time driving.[119,120] In a study of a group of drivers involved in single-vehicle accidents, almost twice as many of their accidents occurred in the early morning hours between midnight and 0800 hours (66%) as during the rest of the day (34%).[121] Accidents and workplace errors from studies concerning road, maritime and industrial operations show a peak at 0300.[122] Additionally, the continuity of sleep is significant. An elevated fatal crash risk was identified for drivers that split the required 8 hours off-duty into two sessions in a sleeper berth.[123]

An arduous work schedule has also been identified as increasing the risk of truck involved accidents.[124] One study found that drivers on a regular 13-hour daytime-start driving schedule slept for 5.1 hours while drivers on a 10-hour daytime start driving schedule slept 5.4 hours.[125] While this study only looked at daytime-start schedules, the relationship between time-off duty and time spent asleep is remarkable. Drivers with 11 hours off spent 5.1 hours asleep (and an additional .4 hours in bed) while drivers with 14 hours off spent 5.4 hours asleep (and an additional .4 hours in bed). The study cites the fact that drivers on the 13-hour schedule were within 10 minutes of their sleep laboratory and thus may have been able to get more sleep than otherwise. The sleep numbers for both groups are likely to be high because each were able to obtain their principal sleep during optimal times of the day (in accordance with the circadian

---

[119] Jovanis, P.P, Kaneko, T., Lin, T.D., 1991. Exploratory analysis of motor carrier accident risk and daily driving patterns. 70th Annual Meeting of Transportation Research Board, Transportation Research Board, Washington, DC.
[120] Lavie, P., 1986. Ultrashort sleep-waking schedule, III. 'Gates' and 'forbidden zones' for sleep. Electroencephalography and Clinical Neurophysiology 63, 414-425.
[121] Harris, W., 1978. Fatigue, circadian rhythm and truck accidents in Vigilance: Theory, Operational Performance and Physiological Correlates, ed. Mackie, R.. New York, NY: Plenum Press, 133-146.
[122] Folkard, S., 1997. Black times: temporal determinants of transport safety. Accident Analysis and Prevention 29 (4), 417-430.
[123] Hertz, R.P., 1988. Tractor-trailer driver fatality: the role of nonconnective rest in a sleep berth. Accident Analysis and Prevention 20 (6), 429-431.
[124] McCartt, A.T. et. Al, 1999. Factors associated with falling asleep at the wheel among long-distance truck drivers. Accident and Analysis Prevention 32,493-504.
[125] Wylie, C.D., Shultz, T., Miller, J.C., Mitler, M.M., Mackie, R.R., 1996. Commercial motor vehicle driver fatigue and alertness study.

rhythm), starting late in the evening and ending early in the morning. It is possible that given the same schedule durations, these drivers could have slept less if conditions were different (e.g., if the schedule necessitated nighttime driving, if the drivers lived (or the sleep center was) further from their daily terminating point).

H.3.1.6 Conclusion

Driving requires sustained attention; it is an inherently fatiguing task in its monotony and repetition.[126] For many commercial motor vehicle drivers, the inherently fatiguing task of driving is compounded by fatigue caused by working long, irregular hours that conflict with natural circadian rhythms.[127] Because of the economic incentives for rapid goods transport, many drivers may be unable to obtain sufficient, sustained, restorative sleep and may subsequently experience sleep deprivation or accumulate a sizable sleep debt. Sleep deprivation and sleep debt, as shown through this review, can lead to an increase in the risk of accidents through impaired performance. This fact supports the need to provide CMV drivers with conditions that make it possible and likely for them to get sufficient sleep, though even ideal conditions could not eliminate all fatigue-related crashes.

H.3.2 Estimates of Motor Carrier Crashes Due to Fatigue

H.3.2.1 Data and Approach to Crash Analyses

The National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) and General Estimates System (GES) databases and the MCMIS Crash File were reviewed for the years 1997 through 2000. They provided the primary basis for crash estimates. Other databases including the MCMIS Census File, National Motor Carrier Directory (NMCD), and Bluebook were used to categorize crashes by motor carrier firm operations so that the resultant crash data could be linked to the industry profile and schedule/risk analyses used to evaluate the potential effects of proposed changes to the hours of service regulations.

---

126 Monk, T.H., Folkard, S., 1979. Shiftwork and performance. Human Factors 21 (4), 483-492.

127 McCartt, A.T., Rohrbaugh, H.W., Hammer, M.C., Fuller, S.Z., 2000. Factors associated with falling asleep at the wheel among long-distance truck drivers. Accident Analysis and Prevention 32, 493-504.

The crash analysis began with an attempt to extract commercial motor vehicle crashes from the three crash data files. Key variables included the state, and date of the crashes; vehicle type and configuration; motor carrier census number; total vehicles, occupants, injuries and fatalities; and driver, vehicle and environmental factors associated with the crashes. The goal was to be able to establish a profile of carriers/vehicles involved in crashes with particular attention placed on the apparent contributing factors or accident causes. There was an attempt made to eliminate "other driver" and environmental factors leading to the crash. This was done to extract truck crashes where the driver would probably be considered not "at fault" from the overall set of crashes. The key issue was to determine the extent to which CMV driver fatigue or associated factors could be reasonably established as a primary contributing factor in the crash.

In conducting such an analysis, it is essential that one recognize the potential weakness in using police accident reports (PARs) as the sole basis for attributing fatigue as a crash cause. The police officers who complete the reports rarely have specialized training in crash investigation or even in completing the forms. One should also note that completing the PAR is no greater than a third priority for officers who are involved in situation assessment, emergency response and victim assistance, and finally controlling and then restoring traffic flow around the crash scene. Additionally, PARs are believed to under- rather than overestimate fatigue involvement in large truck crashes.

Crashes where CMV driver fatigue is cited as a primary contributing factor should be viewed as the "minimum" number of crashes with fatigue as a cause. For this reason, the analysis was conducted to develop a more reasonable estimate of the total number of fatigue-related crashes. An analysis of data for crashes where driver inattention was cited within the PAR was used to apportion part of those crashes as fatigue-related. This conclusion was drawn from a comprehensive report of SH drivers that attributed more than 20 percent of all inattention crashes to driver fatigue.

H.3.2.1.1 Historical Crash Data Summary

In order to develop estimates of the total cost of truck crashes in recent years, the FARS, GES and MCMIS databases were reviewed to derive national summary totals of crashes by type, fatalities, and injuries. Crashes are defined by whether or not they involve fatalities suffered by vehicle passengers or non-occupants (pedestrians), reported injuries where no fatality was involved, or property damage with no fatalities or injuries (property damage only crashes.). The MCMIS database tends to contain more detailed information about the vehicle configuration or cargo carried and is especially useful for determining the identity of the motor carrier involved in a crash. Historically, there has been an undercount of truck crashes noted in the MCMIS database versus FARS. Comparably, there still seems to be a substantial undercount of injury and property damage only (PDO) crashes in MCMIS versus the national estimates derived in the NHTSA GES database. Part of the difference is because MCMIS only records PDO crashes that resulted in a vehicle being towed away, a subset of all PDO crashes.

The FARS database is considered the best source of fatal crash information since it is a census of all fatality involved motor vehicle crashes occurring within the United States. It was used to develop estimates of the total fatal crashes involving trucks, the total fatalities (broken down by truck, other vehicle, or non-occupants) and the numbers of combination and large single unit trucks involved. Data were reported for calendar years 1997 through 2000 and for the average over the four-year period.

National estimates of truck crashes that do not involve a fatal injury were derived from the GES files. Crashes, total injuries and trucks involved were reported for the injury crashes while total crashes and trucks involved were reported for the PDO crashes. The GES estimates are based on a stratified national sample where each crash is assigned a sampling weight according the stratum from which it is reported. The GES estimates are always rounded to the nearest thousand crashes, vehicles, or injuries. These national estimates are provided below.

Table 57: Large Truck Crashes

	1997	1998	1999	2000	average
Fatal Crashes	**4,614**	**4,579**	**4,560**	**4,519**	**4,568**
Total fatalities	5,398	5,395	5,380	5,211	5,346
Truck occupants	723	742	759	741	741
Other vehicle occupants	4,223	4,215	4,180	4,060	4,170
Non vehicle occupants	452	438	441	410	435
Trucks involved	4,917	4,955	4,920	4,930	4,931

	1997	1998	1999	2000	average
Comb trucks involved	3,711	3,747	3,713	3,708	3,720
Single unit trucks involved	1,206	1,208	1,207	1,222	1,211
Single vehicle crashes	847	803	808	802	815
Injury Crashes	**92,000**	**85,000**	**95,000**	**96,000**	**92,000**
Total injuries	131,000	127,000	142,000	140,000	135,000
Trucks involved	96,000	89,000	101,000	101,000	96,750
Comb trucks involved	53,000	51,000	57,000	52,000	53,250
Single unit trucks involved	43,000	38,000	44,000	48,000	43,250
Single vehicle crashes	16,000	15,000	17,000	17,000	16,250
PDO Crashes	**325,000**	**302,000**	**353,000**	**337,000**	**329,250**
Trucks involved	337,000	318,000	369,000	351,000	343,750
Comb trucks involved	197,000	178,000	184,000	179,000	184,500
Single unit trucks involved	141,000	140,000	185,000	173,000	159,750
Single vehicle crashes	95,000	91,000	98,000	104,000	97,000
TOTAL	**421,614**	**391,579**	**452,560**	**437,519**	**425,818**

Source: FARS and GES databases.

H.3.2.1.2 MCMIS Data Analysis

In order to complete the baseline analysis, it was necessary to determine what proportion of truck crashes could be attributed to truck driver fatigue. The MCMIS Crash File for 1997 through 2000 was used. Bus and unknown vehicle type records were eliminated from the database and the "apparent driver condition" variable was used to code the data records for which "fatigue" or "asleep" had been cited as contributing factor in the crash. The "raw" fatigue/asleep crash estimates for 1997 through 1999 was approximately 1.31% of all truck crashes with the number dropping in 2000 to less than 1%. These very low values could seem to indicate a minimal fatigue rate for truck crashes. However, closer examination of the data and direct benchmarking to alternative data sources point to numerous deficiencies in such a simple analysis.

As a matter of policy, the "apparent driver condition" variable has been eliminated from the National Governor's Association (NGA) required list of reportable data elements for commercial vehicle crash reports in the SAFETYNET 2000 (Version 2) reporting system. This was in large part due to historical under-reported and non-reported values for this variable. In 38% of the 2000 data records, the driver condition variable was missing compared to less than 10% of the time in earlier years. In the earlier years, the data field was reported as "unknown" rather than missing in about 7% of all crash records. A problem arises in that "appeared normal" and “unknown” are both coding options, but for analytic purposes, it is difficult to ascertain whether a blank value for this variable should be interpreted as “normal”, “unknown” or “not interpretable”. Previous estimates of driver fatigue associated with truck crashes have been hampered by this serious data quality problem.

A state-by-state examination of the data also showed several systematic problems in the reporting of the driver condition variable. Driver condition was not reported in truck crash data records from the States of Massachusetts, Oregon, South Carolina or Virginia in any of the years of data examined. Additionally, fatigue/asleep was never reported as a factor in truck crashes in the States of Colorado, Michigan, New Mexico or Wisconsin. These data reporting problems result in a logical inconsistency in calculating fatigue involvement rates for truck crashes. If it is impossible to add a fatigue event in the numerator of the national fatigue crash rate, then the data from these States should not be included in the denominator of the rate calculation. The problem grows worse in more recent years with many more States opting to not report apparent driver condition at all. For these reasons, the MCMIS database should not be used to derive estimates of fatigue-involved truck crashes.

H.3.2.1.3 FARS Data Analysis

As an alternative to using the MCMIS data, FARS truck crash data for the years 1997 through 2000 were reviewed. The FARS database contains information for crashes involving at least one associated fatality in the involved truck, in another vehicle, or a pedestrian. The FARS database has been used as a benchmark for the MCMIS database fatal crashes since the requirement for motor carrier self-reporting of crashes was ended in the early 1990’s. The FARS database has historically been held in high regard because of the NHTSA protocols for editing and coding the data elements within the data records.

In order to use the FARS database for analysis of fatigue related truck crashes, several key issues have to be examined. Is it reasonable to extend fatigue–related crash estimates from fatal crashes to injury and property damage only crashes? Since the FARS database contains data elements for reporting up to four driver factors, how should these multiple responses be handled? Are there data reporting issues for the FARS dataset comparable to those encountered in the MCMIS data set?

The FARS database is limited to crashes involving a traffic fatality. By definition, these crashes are more severe since the fatal outcome has a higher social or economic cost than would a comparable crash resulting in (perhaps minor) injuries or damages to property only. Fatal crashes certainly have other characteristics that separate them from injury only or PDO crashes, especially those factors associated with speed and type of impact. In truck crashes, the "other vehicle" occupant is almost six times more likely to die in the crash than a truck occupant, so it is not clear to what extent fatal truck crash characteristics can be reasonably generalized to injury or PDO crashes.

This question is difficult to answer with the data available. A review of MCMIS fatigue involved crashes by crash type reveal that there was an historical trend of fatigue being reported in fatal crashes more than in injury and property damage only crashes. The overall data reporting problems for MCMIS fatigue crash rates also present interpretation problems for this feature of the data. Data for the year 2000 should not be used since the apparent driver condition variable had already stopped being used. However, for 1999 and 1998, fatigue involvement in fatal crashes did exceed that reported in injury crashes or PDO crashes.

Another estimate of the relative prevalence of fatigue in the three types of crashes could be drawn from the GES data. The GES database serves as a very good source of national estimates of total crashes and for crashes with certain characteristics (such as number of occupants or injuries, or by vehicle type). However, some specific details of the crash cannot be estimated very reliably. Derived from state databases of police accident reports, the GES suffers from some of the same faults as the MCMIS. There may be only one (if any) of the driver condition variables included in the reports and fatigue may not always be a coded or reported factor. In the 2000 database, however, fatigue was cited as a contributing factor in 1.46% of all the fatal crashes, 0.94% of the injury only crashes and 0.65% of the PDO crashes. These percentages were drawn from the raw non-weighted sample. Additionally, the data were not edited for missing values or adjusted for any other factors related to the data reporting in the files.

With such small percentages reported in the MCMIS and GES databases, there is some uncertainty in concluding that FARS data for fatigue involvement in crashes can be extended to the injury and PDO crashes. In real terms, the differences are negligible. In percentage terms the differences could be viewed as substantial. However, the FARS database contains the most detailed and highest quality data. There is also evidence that the historical underreporting of fatigue involvement in FARS would tend to provide conservative estimates regardless.

Since the FARS database contains four different fields for reporting driver factors contributing to the crash, there was some initial concern that this could introduce an upward bias in the reporting of fatigue involvement in crashes. For the years 1997 through 2000 this appears not to be the case. In most all of the cases where fatigue was cited as a factor and there were other factors cited, the fatigue code tended to occur first in the list. Additionally, it was reported with a factor that would not confound the results reported in this analysis. The two most common other factors reported were “ran off road” and “inattention”. These accounted for a large proportion of the multiple factors cases.

Finally, from the standpoint of data quality, some factors ought to be considered when viewing the FARS data to assure that cases are not included in the denominator of the rate calculations, unreasonably biasing the estimates downward. Examination of the individual data records indicated that there are several sets of crashes that it seems unreasonable to consider in calculating the fatigue involvement rate. For one set of crashes, many of the key variables (vehicle configuration, body type, harmful events, driver charges, impact details, etc.) are coded as “9’s”, which means unknown or unreported. In all of these cases the driver contributing factors are coded as “99”. In another set of data records, the individual crashes can be matched back to the MCMIS file where the contributing factors are missing because of state data reporting systems and procedures. These appear in the FARS database with driver factors coded as “0’s”. Eliminating these records from the analysis set was a prerequisite to calculating the proportion of crashes with motor carrier fatigue as a contributing factor.

The final step in completing this analysis was to examine each fatal crash involving a large truck and use the factors cited to determine whether “fault” was attributed in the crash. Crashes were categorized as whether the “other” (non-truck) driver was determined to be at fault and whether the truck driver was determined to be at fault. Two other values for these variables were also considered and reported below. If inclement weather was cited that is so reported. If no fault was assigned for the crash, that was also reported. One should note that since weather conditions and multiple drivers may interact to provide multiple responsible conditions or persons, the percentages for fault attribution could add up to more than 100%. In all of the years of reported data, that is the case. One important fact to note from these attribution data, is that the "other driver" was deemed to be at fault almost twice as often as the truck driver.

The fatigue attribution for the FARS crash data is shown in table 58. The edited data provide us with an estimate of between 6.60% (2000) and 8.21% (1999) for the period examined. These fatigue numbers were adjusted further to account for a systematic phenomenon noted by Hanowski in his study of SH drivers.[128] In that study, fatigue was determined to be a contributing factor in 20.8 percent of the incidents where the driver was judged to be at fault due to inattention. When at fault, their PERCLOS (percent eyelid closure) values prior to the incidents were significantly higher than for other types of critical incidents.

Table 58: Fatigue-Related Fatal Crashes

	1997	1998	1999	2000	Average
MCMIS raw	1.34%	1.31%	1.31%	0.75%	1.18%
MCMIS (adjusted)	1.65%	1.65%	1.80%	1.47%	1.64%
FARS fatigue	7.14%	7.04%	8.21%	6.60%	7.25%
FARS inattention	4.19%	4.08%	4.47%	4.59%	4.33%
FARS fatigued inattention	0.87%	0.85%	0.93%	0.90%	0.89%
FARS all fatigue	**8.01%**	**7.89%**	**9.14%**	**7.55%**	**8.15%**

Source: MCMIS and FARS.

Table 58 also shows the proportion of crashes in which inattention was cited as a major contributing factor. The final fatigue figures provided use the total fatigue cited crashes plus 20.8% of the inattention caused crashes to establish the final estimate of crashes that can be reasonably regarded as due to truck driver fatigue.

[128] Hanowski, R., Wierwille, W., Gellatly, A., Early, N., and Dingus, T. *Impact of Local/SH Operations on Driver Fatigue: Final Report,* FMCSA, FMCSA No. DOT-MC-00-203, NTIS No. PB2001-101416INZ, Washington, D.C., Sept. 2000.

H.3.2.2 Estimates of Crashes by Large Truck Firm Operations Type

To estimate the relative involvement of large trucks in crashes by operations type, crash records must contain specific information about the trucks involved. Crashes can be classified by the operations of the vehicles or firms involved using either the actual characteristics of the trip in which a crash occurred or the identity of the motor carrier involved, assuming that the firm identifying number can be matched to a data source in which motor carriers are classified by their operations.

The most commonly cited crash databases do not contain trip-specific characteristics. The ideal information for determining whether a crash occurred in long- versus SH operations would be the starting and intended ending point of the trip in which the crash occurred. The calculated distance between those two points would provide with certainty the ability to classify the trip according to any specified cut-off point selected for differentiating between LH and SH operations.

A very good indicator for determining if a truck crash occurred in SH operations may be the vehicle or equipment type. Dump trucks, garbage trucks and concrete mixers are rarely involved in LH operations. To a lesser extent, cargo tanks are somewhat restricted to SH use. Flatbed trucks, straight trucks, and vans or enclosed boxes are widely used in both long- and SH operations. This group comprises a substantial population of the cargo body types noted in truck crashes.

An alternative method for determining the operations of the crash involved truck is to associate the individual vehicle with a firm and then research the primary operations type for the whole firm. The TTS Blue Book database of 2,681 motor carriers provides two key indicators for specifying operations type, and also provides the USDOT motor carrier identification number for these carriers. Average length of haul for trips made in the year and the freight revenues from long and short distance transportation are reported in the database. The average length of trip variable can be used directly to classify carriers. A calculated proportion of revenue derived from short distance operations could also be used to classify carriers. There are 2,481 firms in the TTS database with sufficient information to be able to classify them as long or SH. With these data, the motor carrier identification number can be used to match firm records to the MCMIS and (to a lesser extent) FARS crash files. There were 32,342 different firms with a fatal, injury or property damage only crash reported in the MCMIS database during 2000, so the TTS data alone cannot provide a very good match for ascertaining operations type. The 2,481 firms with data can account for 2,016 matched crash records in the year 2000.

Another possible criterion for establishing the operations of a motor carrier is the primary commodity being carried. The Blue Book database has one field for each carrier indicating the commodity hauled. The TTS National Motor Carrier Directory lists the top four commodities being carried, while the MCMIS motor carrier census lists up to 30 different commodities that each firm may carry. There are a number of commodities that are very clearly associated with SH carriage (cement, garbage, tank petroleum products, coal/coke, ores, grain, livestock, et al). These products are associated with special equipment used (as mentioned above), are hauled by train when moving long distances or have some other characteristic that makes long distance carriage untenable or uneconomical. The relative number of long and SH firms carrying any one of the 24 different commodity groups in the Blue Book data provides a very good benchmark for the potential classification of data in the motor carrier census. A discriminate analysis of the Blue Book data revealed that a substantial number of firms could be classified as long or SH based on the primary commodity that they carry. Petroleum tank products, dump trucks, agricultural commodities, film products and local cartage operations are predominantly listed by firms otherwise classified as SH. Firms handling refrigerated solids, refrigerated liquids and household goods were primarily classified as LH.

A final set of characteristics could be used to classify carriers by long and SH operations. The number of power units owned or leased or number of drivers employed divided by the total miles driven per year provides a measure of the utilization rate of these resources. Other data from the Blue Book indicate that the low mileage per power unit (or driver) firms tend to be involved in SH carriage. Low end and high end cut-off points were established for these variables and the carriers at the extremes were classified according to these utilization variables. Since mileage, drivers, and equipment details are available for a large proportion of the firms listed in the USDOT motor carrier census, this analysis was conducted for all 889,381 carriers in the database. Based on a review of the Blue Book data, a logical cut-off point of 30,000 or fewer miles per year per driver or power unit was established for defining SH trucking firms and a cut-off point of 60,000 or more miles per year per driver or power unit was established for defining LH trucking firms. Firms with average driver and vehicle usage between 30,000 and 60,000 miles per year were left unclassified.

The results of these three analyses were combined to develop the overall estimates of short and LH involvement in the 103,055 truck crashes in the 2000 MCMIS Crash database. The crash data cargo body criterion was given the highest priority in the classification, followed by the Blue Book average trip length, chief commodity, and utilization, finally incorporating the MCMIS Census file commodity and utilization information. Once a crash was classified by one of these methods the methods following it in the priority list were not used. For the MCMIS commodity and utilization tests, consistency checks were used to assure that there was no conflict in classification using the different methods. If a conflict was detected, then the carrier was left unclassified. Approximately 70% of the fatal crashes and 65% of the injury and property damage only crashes could be classified as long or SH using this procedure.

Table 59 shows the numbers and proportion of crashes in calendar year 2000 broken out by long- or SH firms. The raw percentages have been adjusted to reflect the relative involvement of long and SH operations noted. This allocation scheme assumes that the unclassified crashes should be distributed proportionally to the LH and SH groups. For 2000, there was an approximate 60% to 40% split between LH and SH operations involvement in fatal and property damage only crashes. LH operations were associated with approximately 55% of the injury only crashes. These estimates can be used with the baseline crash numbers derived from FARS and GES to establish the historical baseline of crash involvement for the two different types of motor carrier operations. From that one can estimate the relative benefits of crash reduction due to differing hours of service proposals.

Table 59: Division of Crashes by Length of Haul

	Fatal	**Injury Only**	**PDO**
LH	1,961	17,327	18,890

	Fatal	Injury Only	PDO
raw %	42.9%	36.0%	37.5%
Adjusted %	**61.8%**	**55.0%**	**59.0%**
SH	1,210	14,169	13,118
raw %	26.5%	29.4%	26.1%
Adjusted %	**38.2%**	**45.0%**	**41.0%**
Unclassified	1,398	16,646	18,336
raw %	30.6%	34.6%	36.4%
Total	4,569	48,142	50,344

Source: MCMIS Crash Data, 2000

H.3.3 Sleep Models

Sleep models are used to analyze the major processes underlying sleep regulation. They also provide a conceptual framework for the analysis of sleep data. As pointed out in the sleep literature, sleep regulation involves three processes: (1) the homeostatic process[129] which increases during wakefulness and decreases during sleep; (2) the circadian process which depends on the circadian oscillator controlling temperature and alertness rhythms; and (3) the ultradian process which determines the NREM/REM (Non Rapid/Rapid Eye Movement) periodicity.[130]

Over the past two decades, quantitative models have been developed to describe human sleep regulation. Most current mathematical models of alertness include a homeostatic component and circadian component.[131] Sleep models also account for the regulation of the alternation between non-REM sleep and REM sleep. In one class of models, an ultradian oscillator regulates the alternation of non-REM and REM sleep. In the second class of models the alternation between non-REM sleep and REM sleep is governed by homeostatic processes related to non-REM sleep and REM sleep itself.[132]

---

129 The homeostatic process is often referred to as Process S. The homeostatic process triggers an increase in the demand for sleep after a period of prior wakefulness. It reflects the extent to which the need for sleep has been satisfied.

130 Borbely A.A., Achermann P. (1992), "Concepts and Models of Sleep Regulation: An overview", *Journal of Sleep Research,* 1(1), pg. 63

131 Jewett ME, Dijk D-J, Kronauer RE, Czeisler CA. (1996), "Homeostatic and circadian components of subjective alertness interact in a non-additive manner", *Journal of Sleep Research 1996; 25: 555.*

132 Dijk D-J, Czeisler CA., "Bimodal distribution of REM sleep latency during forced desynchrony: model implications", *Journal of Sleep Research 1996; 25: 122.*

H.3.3.1 Variation among Models

Sleep models differ on how the various components interact with each other. Some models assume an additive interaction between the circadian and homeostatic components of alertness while later studies provide evidence of a nonadditive interaction.[133] Jewett et al (1999)[134] developed mathematical models in which levels of subjective alertness and cognitive throughput are predicted by three components that interact with one another in a nonlinear manner. These components are: (1) a homeostatic component (H) that falls in a s-shaped manner during wake and increases at a decreasing rate that asymptotically approaches a maximum during sleep; (2) a circadian component (C); and (3) a sleep inertia component (W) that increases at a decreasing rate after awakening.

Sleep models also vary depending on the model's purpose. More recently, efforts have been made to develop sleep models that can quantify the relationship between sleep, circadian rhythm and performance. The models use sleep data as input and they yield predicted alertness as well as performance on monotonous tasks. Some models include an identification of levels at which the risk of performance or alertness impairment starts, as well as prediction of sleep latency and time of awakening of sleep episodes. Examples of this new generation of sleep models include the following: the Fatigue Audit InterDyne model (FAID), the Circadian Alertness Simulator (CAS) and the Walter Reed Sleep Performance Model (WRAIR-SPM).

H.3.3.2 Walter Reed Sleep Performance Model

The Walter Reed Sleep and Performance Prediction Model (WRAIR-SPM) was conceived in the late 1980s by Colonel Gregory L. Belenky, US Army, and members of his research staff at the U.S. Army's Walter Reed Army Institute of Research (WRAIR). The WRAIR-SPM is a quantitative model that was initially designed to predict the performance of soldiers during extended operations.

---

133 Dijk, DJ. et al. "Circadian and sleep/wake dependent aspects of subjective alertness and cognitive performance", *Journal of Sleep Research 1992, 1:112117.*

134 Jewett, M.E., Kronauer, RE., (1999). Interactive mathematical models of subjective alertness and cognitive throughput in humans, Journal of Biological Rhythms 1999;14(6):588-97.

During the 1990's, WRAIR's sleep researchers refined the model based on data obtained from studies of sleep loss per se as a determinant of cognitive performance. They focused on the effects of total and partial sleep deprivation on a wide range of psychological and cognitive performance tests. The cognitive task performances selected from the WRAIR Performance Assessment Battery (PAB) include those that tap into brain functions representative of those involved in doing military command and control tasks (e.g., serial addition/subtraction, logical reasoning, choice reaction time and pattern recognition tasks).

Further attempts to refine the model in the mid-1990s led to debates about whether expected performance decline during complete sleep deprivation periods were linear, or degraded in a step-wise function over time for successive days of military operations. The step-wise cognitive performance degradation function (Angus & Heslegrave, 1985)[135] indicates that performance was relatively constant until about 18 hours of non-stop work which is similar but not the same as time-on-task). After 18 hours of non-stop work, performance drops by 25% from baseline, and remains at a constant level until about 30 hours of continuous work. At this point, it drops by another 15-20%, and subsequently begins to deteriorate to 30% of baseline over three days in sustained performance tasks.

In order to extend and validate the parameters of the WRAIR-SPM, the FMCSA and other government agencies sponsored a large-scale laboratory confinement study to determine the effects of four sleep/wake schedules on alertness and performance. The Sleep Dose-Response study (SDR) examined the effects of one week's restricted sleep (three, five, seven, or nine hrs per night) on the performance of 66 CMV driver subjects. Multiple measures of performance, including psychomotor vigilance tasks (PVTs) and driving performance measures, were taken while drivers did a sequence of 45-minute drives on a low-fidelity desk-top truck driving simulator (Balkin, et al., May 2000). This study resulted in numerical estimation of parameters for the WRAIR Sleep Performance Model, and elucidated the relationships among several sleep-related performance measures.

Prior to the sleep dose-response (SDR) simulator study by Balkin et al., Belenky and the WRAIR

[135] Angus, R.G. & Heslegrave, R.J. (1985). Effects of sleep loss on sustained cognitive performance during a command and control simulation. Behavior Research Methods, Instruments, & Computers, Vol. 17, No.1, pp 55-67.

team originally based their prediction model (originally called SPM-96 and framed around only young healthy males) on its ability to predict a person's performance on the serial addition/subtraction task from the WRAIR-PAB (Thorne et al., 1985)[136]. The SDR truck simulator study added experience with a more diverse population of subjects. With this information, they refined the WRAIR-SPM model and they began to base the prediction algorithms around the Dinges Psychomotor Vigilance Task, a simple reaction time test (Balkin et al., 2000). Generally, the PVT reaction time scores are used as indications of a secondary task measurement to indicate the level of "alertness" remaining, the reservoir of alertness still there in the subject while being subjected to continuous performance demands over time.

After the SDR study with truck drivers in the simulator, the WR-SPM gradually became a four-process model. The timing and duration of a person's sleep and wakefulness periods over several days constitutes a sleep/wake history. Four separate functions are used to relate sleep/wake history to level of cognitive performance capacity, including (a) a wake function, (b) a sleep function, (c) a "delay of recuperation" function, and (d) a sleep inertia function.

Because the parameter values for the latest WRAIR-SPM were estimated using normalized Response Time on the Psychomotor Vigilance Task as the performance metric, and given the wide acceptability of PVTs as a "standard" by which many sleep deprivation and performance studies are measured, the next section will be devoted to describing the main features of the psychomotor vigilance task.

H.3.3.3 Psychomotor Vigilance Task

The Psychomotor Vigilance Task is a test of behavioral alertness developed by David Dinges and John Powell in the mid-1980s at the University of Pennsylvania (UPENN) Hospital. The PVT was designed to evaluate the ability to sustain attention and respond in a timely manner to salient signals (Dinges & Powell, 1985).[137] It was also designed to be free of a learning curve or

---

[136] Thorne, D. R., Genser, S. G., Sing, H.C. & Hegge, F.W. (1985). The Walter Reed performance assessment battery. Neurobehavioral Toxicology and Teratology, Vol. 7, pp 415-418.

[137] Dinges, D.F. & Powell, J.W. (1985). Microcomputer analyses of performance on a portable, simple reaction time task during sustained operations. Behavior Research Methods, Instruments & Computers, Vol. 17, No. 6, 652-655.

influence from acquired skills, such as aptitude or education, and to be highly sensitive to an attentional process that is fundamental to normal behavioral alertness.

PVT performance has been demonstrated to be highly sensitive to detecting changes in behavioral alertness associated with numerous work settings, such as medical house staff jobs, night shift workers, drowsy drivers, transoceanic pilots. PVT performance is also sensitive to bodily states, such as those of partial and total sleep-deprived subjects, truck drivers with sleep apnea, sleepy elderly subjects, and to exposure to various ingested chemical substances, such as caffeine, modafinil, and alcohol.

In the study of operating practices in a high-fidelity truck simulator, O'Neill et al. (1999)[138] examined two weeks of day-time driving (0700-2130 hrs) that entailed simulated driving tests of 12 hours per day on a 14 hours on duty and 10 hours off duty work schedule. Ten-minute PVT tests were administered three times per day (at 0645, 1330 and 2100 hrs) during a five-day driving workweek, and four times per day on the drivers' weekend off recovery days (0900, 1300, 1700 and 2100 hrs). PVT data were reported in the form of median and mean reciprocal response times, and number of lapses, combined on a graph. The authors found that PVT scores were sensitive to partial and full sleep deprivation, thus underscoring the value of properly designed work-rest schedules.

The PVT is acknowledged as being one of the most consistently reliable research tools for the study of operator alertness, fatigue and/or drowsiness. The PVT test of simple choice reaction time is backed by almost two decades of experience and historical data. It has been used widely by the research community in many studies e.g. Balkin, (2000)[139]; O'Neill et al. (1999); Hartley et al., (2000)[140] and Krueger, (2002).[141]

---

[138] O'Neill, Krueger, G.P., Van Hemel, S.B., & McGowan, A.L. (1999). Effects of operating practices on commercial driver alertness. (FHWA-OMC Technical Report No. FHWA-MC-99-140.)

[139] Balkin et al. Effects of sleep schedules on commercial motor vehicle driver performance. Washington, DC: US Dept. of Transportation, Federal Motor Carrier Safety Administration, Report No. DOT-MC-00-133, May 2000.

[140] Hartley, L., Horberry, T., Mabbott, N. & Krueger, G.P. (2000). Review of fatigue detection and prediction technologies. Melbourne, Australia: Australian National Road Transport Commission Technical Report, Sept. 2000.

[141] Krueger G.P, & Van Hemel, S.B. (2001). Effects of loading and unloading cargo on commercial truck driver alertness and performance. Federal Motor Carrier Safety Administration FMCSA Technical Report No. DOT-MC-01-107 (May 2001).

H.3.3.3.1 Model Calibration

Balkin et al. (2000) described the WRAIR-SPM as "a series of empirically derived mathematical relationships describing the continuous decrement of cognitive performance during wakefulness, restoration of cognitive performance during sleep, and cyclic variation in cognitive performance during the course of the day."

Wakefulness was assumed to diminish cognitive performance capacity by a simple linear decay function Ct = Ct-1 - κw, where Ct is the cognitive performance capacity at time t, and κw is the performance depletion occurring in the interval t-1 to t.

Sleep was assumed to restore cognitive capacity utilizing an exponential growth function. For a subject going to sleep once cognitive capacity reached zero and remaining asleep for a period of time t, cognitive capacity would equal 100 * (1 - e-c2*t).[142] In this representation, the coefficient c2 is the sleep recovery time constant.

The third component of the model is the circadian phase modulating function (M) which has both a circadian (24-hour) and ultradian (12-hour) component. To reflect the 24-hour circadian and 12-hour ultradian components, M is expressed as an additive double cosine function:

$$M = 1 + c_3 * \cos((2\pi / 24) * t + c_4) + c_5 * \cos((2\pi / 12) * t + c_6)$$[143]

where c3 and c5 represent the amplitude parameters for the cosine functions c4 and c6 represent phase shift parameters from midnight (the beginning of a day). In the WRAIR-SPM, predicted performance at a given time (t) is expressed as the product of the Current Cognitive Capacity (C) and the Modulating function (M).

H.3.3.3.2 Inputs

The software model enables users to enter sleep/wake schedules in which the subject follows the

142 FMCSA, "The effects of sleep schedules on commercial motor vehicle driver performance", May 2000. pp. 3-9.
143 Ibid.

exact same pattern over a period, or to enter a schedule where the subject's sleep pattern varies from day-to-day. The model has the capacity to evaluate schedules that cover up to 100 days. The following are the major input components to the WRAIR-SPM model.

H.3.3.3.3 Sleep/Wake History

The first major input to the model is sleep/wake history. The sleep/wake history represents the timing and duration of sleep and wakefulness periods over a period of days. In the WRAIR-SPM, four functions are used to relate sleep/wake history to cognitive performance capacity level (CPCL). These four functions, and a brief description of their relationship to cognitive performance are as follows:

Wake/Decrement Function – The wake/decrement function describes how cognitive performance declines during periods of continuous wakefulness.

Sleep/Restoration Function – The sleep/restoration function describes the rate at which cognitive performance capacity accrues during sleep.

Delay-of-Recuperation Function – The delay-of-recuperation function was incorporated into the model to exhibit the time lag between the wake/decrement function and the sleep/restoration function at the beginning of sleep. This delay is set at five minutes in the model, the time assumed to transition into recuperative sleep.

Sleep Inertia Function – The sleep inertia function accounts for the gradual restoration of normal performance and alertness upon awakening (approximately 20 minutes).

H.3.3.3.4 Time of Day (Circadian Phase)

The second input is the circadian phase, which is based on time of day. This component accounts for the empirical data showing that CPCL oscillates between a five and twenty percent peak to trough over a 24-hour period. Reflecting the influence of circadian and ultradian rhythms on performance, performance is lowest in early morning hours, and increases across the day (except for a dip in the afternoon), and peaks in the evening hours, prior to sleep onset.

H.3.3.3.5 Output

Based on the user input of a sleep/wake schedule, the model will generate graphical and tabular outputs. The tabular data presents minute-by-minute reports of the subject's sleep/wake status at the particular time and level of predicted performance. The level of predicted performance is reported numerically on a scale ranging from zero (0) to one hundred (100).

H.3.3.3.6 Model Limitations

The model does not differentiate between "awake and working" versus "awake and resting" times. One might think that the former would take a greater toll on one's performance level capacity for subsequent periods in the day. In addition, it does not explicitly take into account the interaction of physical and mental exhaustion and it does not recognize any time-on-task effects separate from the general cognitive depletion and circadian functions.

H.3.4 Estimating Sleep Profiles

The modeling uses actigraph data from the Walter Reed field study to predict sleep in a 24-hour period based on time on duty in 24 hours. The Walter Reed field study provides the most accurate measure of actual sleep (rather than reported sleep) as well as its relationship to time worked. Because the dataset follows a panel of people across time, the appropriate model is a random-effects cross-sectional time series model for panel datasets.[144] Diagnostic tests indicate the appropriateness of a random effects model.[145]

The data suggest the most appropriate functional form is a cubic regression equation (third-order polynomial), particularly given the interest in accurately reflecting hours of sleep for those working longer hours.[146] This relationship between time sleeping and time on-duty is then used

---

144 Theory suggests that the individual differences are random disturbances drawn from some general distribution rather than that each person has a fixed effect shifting the equation up or down, that is, residuals do not vary by individual. In order to run the model appropriately, it was assumed that all days are sequential even if one day's observation was missing or was dropped due data problems.

145 A Hausman test did not reject the null model that the fixed and random effects models are equivalent at a 5 percent alpha level, although it did at a 10 percent level. The coefficients and standard errors found using the random effects model, however, differ only slightly from either using a fixed effects model or pooling the dataset (coefficients only) as if the data points were all independent individuals. This indicates that misspecification is not likely to have affected results. For instance, the fixed effect regression equation results in predictions for sleep vary by no more than five minutes from the random effects model.

146 The data show non-linear tendencies, and a quadratic equation provides predictions that fall out of the realm of that possible (more than 24 hours of activity per day) for people who report a large number of hours on duty.

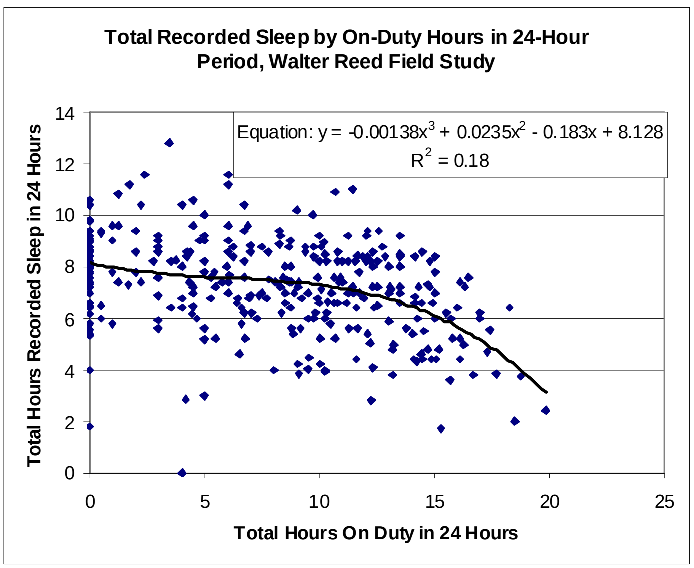
to predict sleep given modeled numbers of hours on duty.[147]

Table 60: Predicted Hours of Sleep in 24-Hour Period by Selected Hours On Duty

Hours On Duty	Predicted Hours Sleep
0	8.13
6	7.57
8	7.45
10	7.25
12	6.91
14	6.35
16	5.52
18	4.34
20	2.75

Source: Walter Reed Field Study.

Chart 5: Relationship of Sleep to Time Off



Because of the interest in this study of accurately reflecting schedules for people who work a large number of hours, the functional form is cubic so that it more closely matches the data especially if a driver is modeled as having worked a large number of hours. The equation estimated is $y = 8.12800 - 0.18272\,x + 0.02335x^2 - 0.00138x^3$. The R-square is reasonable given the number of data points available.

[147] FMCSA attempted to compare the relationship between hours of sleep and time on-duty found from the Walter Reed Field Study with that found from the two waves of the UMTIP data. It was expected that the relationship would be larger for UMTIP because it provides self-reported time sleeping rather than actiwatch monitoring of actual sleep. Another qualification is that the UMTIP did not require drivers to verify time on duty by logging on duty periods or referring to their log books. Because there were problems with the accuracy of the UMTIP data, they were used only as a check on the magnitude of predicted difference in hours slept due to different hours on duty. A regression using these data produces less reliable estimates, with a slope rising from eight hours of sleep in the last 24 with zero hours on duty to over 9.5 hours of sleep when working six hours in the last 24. The downward slope for hours worked above ten was somewhat steeper than that resulting from the Walter Reed data.

Source: Walter Reed Field Study

H.3.5 Estimating Change in SH Crashes using Model Schedules

Daily schedules were modeled for SH drivers to input into the Sleep Performance spreadsheet to predict differences in incremental crash risks for a baseline with full nights of sleep, actual compliance with current HOS rules, current HOS rules under full compliance, and the three proposed options. Research on schedules for SH drivers is more limited than for LH drivers. The literature indicates that these schedules are noted for their more regular pattern of work even if length of the work day varies

Daily schedules for SH drivers were modeled using information on typical SH schedules from the Virginia Tech Field Study and Virginia Tech Focus Groups. General lessons from these sources were confirmed with industry representatives involved in SH operations. Column 2 of Virginia Tech Focus Groups' table 4 (p. 8) outlines typical daily patterns for local beverage truck drivers. The general pattern begins with an early start to the work-day beginning with pre-trip inspections and paperwork. The trip to the first delivery stop is about 15 to 30 miles followed by delivery and paperwork activities. This is followed by a series of shorter driving times (about three miles according to the table) among subsequent route stops and delivery and paperwork activities of roughly constant length. The route ends with a trip back to the facility followed by assisting in reloading or paperwork. The Virginia Tech Focus Groups' table 14 (p. 77) lists average number of deliveries for beverage and snack delivery drivers as just over 11 per day. Figure 25 in the Virginia Tech Focus Groups (p. 75) indicates that the average SH driver in the focus groups spent 29 percent of their non-break time driving.[148]

All SH drivers are modeled as arriving at work at 7:00 am, the median response to time of day they start work. They are modeled as having awoken a half-hour before arriving at work. Sensitivity tests indicated that modeling the drivers as arriving at work 75 minutes after awakening made minimal differences. Following the information discussed above, SH drivers are modeled as performing non-driving work for their first half hour on duty, followed by a half

[148] This indicates that the driving hours limitations in the 2003 rules would not constrain SH drivers. This average response of 29 percent of a work-day spent driving is somewhat less than that suggested by the Virginia Tech Field Study question asking "What percentage of work time is driving?" The modal response in the field study was 50% (answers were restricted to <50%, 50%, >50%, 100%.)

hour of driving to arrive at their first delivery stop and a half-hour of non-driving work at the first stop.[149] Drivers' last half hour is modeled as non-driving work. For the remaining hours on-duty for SH drivers, time is modeled as a repeating pattern of alternating deliveries such that even numbered deliveries begins with a quarter-hour of driving followed by three-quarters of an hour of non-driving work and odd deliveries begins with a quarter-hour of driving followed by a half-hour of non-driving work. These lengths were chosen such that SH drivers drive just over 30 percent of the day for average workdays of 10.3 hours in length.[150] Because FMCSA is interested primarily in the differences in crash risk among the proposals, the exact number of deliveries or length of time spent on each aspect of a driver's duties is less important than the even distribution of driving throughout the day.

This general pattern of daily schedules is applied to 25-day schedules.[151] The series of schedules are adapted such that the SH drivers do not work on the sixth and seventh day of the week to reflect the typical regular work week schedules found in the industry.[152] For a given night, the amount of sleep is modeled based on the calculated relationship between sleep and time on-duty.[153] Sleep was modeled for SH drivers as ending a half-hour before leaving for work. The time sleep begins varies according to the amount of total time (within a quarter hour) of estimated sleep. A 25-day working schedule was input from every fourth driver into the Sleep Performance spreadsheet for each of the proposal options as well as for the current compliance level. The schedules for each proposal vary only by the threshold at which individual work days are truncated.[154] The resulting incremental crash incidence calculation for each scenario is subtracted from a baseline crash increment. This baseline increment represents the model's estimated crash risk increment from five-day work week schedules of 8 hours of sleep with

149 These time lengths were based partially on the approximate number of miles driving for each segment in Appendix J divided by 20 mph speeds in city between deliveries and by 40 mph from the terminal to the first stop.

150 This is the average length of work day according to the Virginia Tech Field Study and the average length of work day modeled under current compliance levels. The Virginia Tech Focus Group drivers provide a slightly longer average shift length of 10.89 hours.

151 This is done by inputting the daily driving schedule pattern as an equation conditional on length of day and varying the 25-day schedule as an input.

152 Representatives involved in the SH industry indicated that most SH operations are based on a regular five-day work week. Similarly, the majority of local pick-up and delivery respondents in the UMTIP survey indicated they worked five-days in the past seven day pay period.

153 There was no evidence found that the relationship between amount of sleep nightly and number of hours on duty should vary between LH and SH drivers.

154 Additional drivers are not modeled explicitly under the simplifying assumption that replacement drivers will work and drive similar day lengths as the dataset average.

driving spread throughout the day.[155] Given the assumptions in the baseline, the model provides a baseline crash increment of –1.72 percent, just slightly below the 0 percent expected theoretically. Because this baseline is subtracted from the increment for the 2003 rules, its size does not affect the results, which are presented at the end of the following section.

H.3.6 LH Schedule Models

H.3.6.1 Spreadsheet LH Crash Increment Calculations

After generating each rolling and non-rolling schedule modeled for each driver proportion cell, FMCSA calculated crash risk increments by entering the schedules into the Sleep/Performance spreadsheet. Results for driver schedules with stable working and sleeping patterns are displayed in table 61.

Table 61: Modeled LH Crash Increment Results, Stable Work/Sleep Pattern

Hours Work / Day	Days Work / Week				
	3	5	6	7	8
9	10%	14%	16%	18%	20%
11	13%	18%	20%	23%	26%
13	14%	21%	24%	28%	32%
15	23%	34%	41%	48%	57%

Source: RoutePro Simulations

H.3.6.2 Weighting Crash Increments, Productivity and Proportion Fatigue-Related

The crash risk increments calculated above are multiplied by the percentage of drivers found in each cell in the driver schedule proportion matrices. The resulting value is subtracted from the baseline crash increment under schedules with eight hours of regular sleep for an interim crash increment score for the pre-2003 compliance status quo, pre-2003 rule with full compliance, and 2003 rule with full compliance.

These interim crash increments are adjusted for the differences in productivity found through

155 Driving is spread throughout the day in order to get an appropriate baseline that reflects an average of any time of day driving.

these calculations from the productivity found in generating the cost estimates. Crash risk estimates are scaled up or down using the ratio of productivity found in the cost analysis to that found in the crash risk analysis. The results are multiplied by the proportion of truck crashes in which fatigue may have played a role. Only truck crashes in which truck driver fatigue is considered to have potentially played a role are included in this proportion. The productivity adjustments and the raw fatigue-related crash increments calculated across all cells in a driver proportion matrix are shown in table 62.

Table 62: Raw LH Crash Increment and Productivity Adjustment

Scenario	Raw Crash Increment vs Baseline	Productivity Adjustment Factor
Pre 2003 Status Quo	11.5%	0.0%
Pre 2003, Fully Enforced	8.4%	5.7%
2003 Rules	7.0%	0.0%

The final step discussed in this section is to convert the raw crash increment into the percentage of crashes that are related to fatigue, starting with the incremental crashes for each option that occur due to fatigue (raw fatigue increment). This number does not represent fatigue-related crashes as a proportion of all crashes, which ultimately is the proportion of interest. To calculate this proportion, termed the fatigue-related percentage, the raw fatigue increment is divided by the sum of the fatigue increment and the baseline of crashes before the fatigue increment. The baseline percentage of crashes before adding the fatigue increment is simply 100 percent. The sum of the raw fatigue increment plus the baseline percentage of total crashes is the raw fatigue increment plus 100 percent. The percentage of fatigue-related crashes, therefore, is the raw crash increments divided by 100 percent plus the raw crash increment or (raw increment)/(100 percent + raw increment).[156]

For the pre 2003 status quo scenario, the raw crash increment of 11.5 percent is divided by 100 percent plus 11.5 percent or 11.5 percent /(100 percent +11.5 percent) = 10.3 percent. The result

[156] As an example for clarification, suppose for the status quo that the fatigue increment were 100 percent. That is, in this hypothetical example, fatigue causes as many crashes in the status quo as would occur without driving under fatigued conditions. Fatigue, however, would not cause 100 percent of all crashes – only half. This percentage is calculated by dividing 100 percent by 100 percent + 100 percent, or 100 percent/200 percent = 50 percent.

of these calculations are shown in table 63, which also presents the equivalent fatigue-related crash results from the analysis of SH operations described above.

Table 63: Crash Increment and Fatigue-Related Crashes

	Scenario	Pre-2003, Full Compliance	2003 Rules	Pre-2003 Status Quo
LH	Raw Crash Increment vs. Non-Fatigued Baseline	8.4%	7.0%	11.5%
	Fatigue-Related Crashes	7.8%	6.5%	10.3%
SH	Raw Crash Increment vs. Non-Fatigued Baseline	3.6%	3.5%	3.7%
	Fatigue-Related Crashes	3.4%	3.4%	3.6%

H.3.6.3 Calibration of SP Results to Empirical Fatigue Crash Estimates

Because the SP spreadsheet is based on predictions of changes in simulated crashes rather than real-world experience, it cannot be used directly to estimate the percentage of crashes attributable to fatigue. Instead, that percentage was estimated independently. To ensure that they map well to the real world, the spreadsheet results need to be adjusted so that the scenario representing the status quo corresponds to this independent estimate of fatigue-related crashes.

The SP spreadsheet projected the fatigue-related crash percentage (relative to what would be expected for non-fatigued drivers) of 10.3 percent for LH operations and 3.6 percent for SH operations. The percentage of fatigue-related crashes is projected to be just under three times as great for LH as for SH operations. This difference is not surprising, given that SH drivers are much more likely than LH drivers to work during the day, sleep at home at night, and are less likely to be pushed to work extremely long hours. Previous research supports this general conclusion. For trucks on trips of 500 miles or more, the relative risk is even higher, at 2.35."[157]

LH operations account for 61.8 percent of fatal truck crashes, 55 percent of injury-only truck

---

[157] Preliminary Regulatory Evaluation and Regulatory Flexibility Act Analysis, Hours of Service NPRM, Federal Motor Carrier Safety Administration, April 2000, p. 28.

crashes, and 59 percent of property-damage only crashes. Weighting by the number of crashes in each category, it was found that LH operations accounted for 58.2 percent of all crashes, with SH operations accounting for the remaining 41.8 percent. Fatigue accounted for 8.15 percent of all fatal truck crashes. Combining these percentages with the SP spreadsheet results showing fatigue-related increments of 3.6 percent and 10.3 percent for SH and LH operations respectively indicates that all of the estimates can be reconciled if the SP spreadsheet estimates are multiplied by an appropriate factor. This factor was found by setting up the following equation for X, the factor by which the SP spreadsheet estimates are to be multiplied:

$$41.8\% * 3.6\% * X + 58.2\% * 10.3\% * X = 8.15\%$$

Rearranging terms and solving, $X = 8.15\%/(41.8\%*3.6\%+58.2\%*10.3\%)$

$$= 8.15\%/7.45\% = 1.0917.$$

Thus, the SP spreadsheet can be calibrated to yield the 8.15% overall fatigue-related crash risk if the SP spreadsheet estimates of the crash increments are multiplied by 1.0917, producing fatigue-related increments of 3.9 and 11.2 percent for SH and LH respectively. Calibrating the estimates of the percentage of fatigue-related crashes for all of the options by multiplying by 1.0917 results in the estimates presented in table 64.

Table 64: Percentage of Crashes Attributable to Fatigue

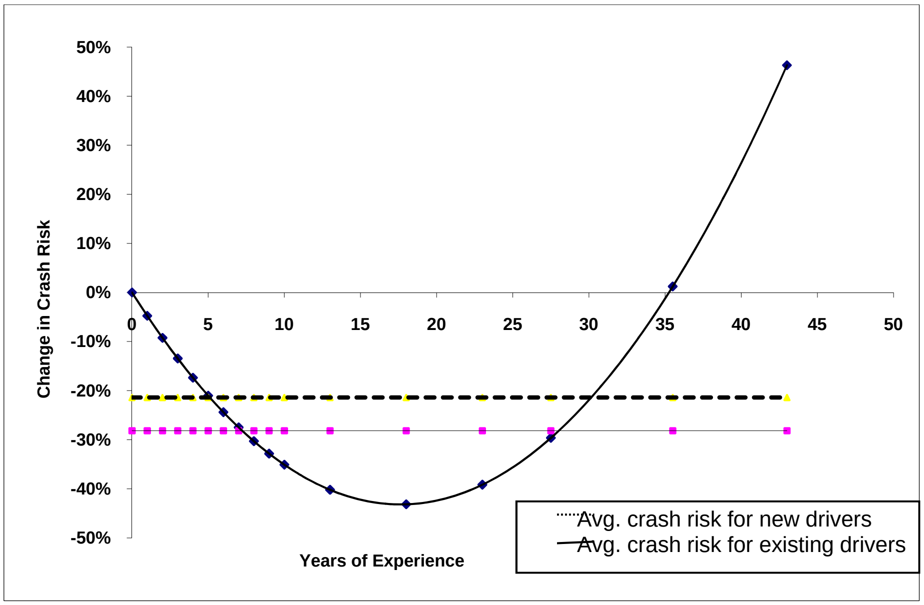
		Pre-2003 Rules	2003 Rules
LH	**Uncalibrated**	7.8	6.5
	Calibrated	8.5	7.1
SH	**Uncalibrated**	3.4	3.4
	Calibrated	3.8	3.7

H.3.7 Risks Associated with New Drivers

A secondary impact of the proposed HOS options would be to change the number of relatively inexperienced drivers that operate in the trucking industry. Since there is evidence in the literature linking experience with accident rates, any changes in the number of inexperienced drivers would correspondingly change the overall accident rates for all drivers under the HOS options considered.

Calculations for the changes in crash rates for new drivers were performed using data from the UMTIP driver survey and the discrete time proportional crash hazards model estimated for drivers based on that data.[158] Using the regression coefficients for experience and its squared term from that model, and data on driving experience from Abrams, *et al*. (1997),[159] a crash risk as a function of driving experience was estimated. Chart 6 shows that relationship.

Chart 6: Effect of Experience on Crash Risk



The function above indicates a 28 percent average reduction in crash risk for existing drivers over their lifetime of driving. Given the coefficients on years of experience and its squared term, FMCSA also estimated a 10-year weighted average change in accident rates for new drivers. The 10-year time horizon was chosen to be consistent with the time period used in this analysis for the costs and benefits calculations.

158 See Michael Belzer, *et al*. "Pay for Safety: An Economic Alternative for Truck Driver Safety", FMCSA, January 2002.

159 See C. Abrams, T. Schultz, C.D. Wylie. "Commercial Motor Vehicle Driver Fatigue, Alertness, and Countermeasures Survey." Sponsored by U.S. Department of Transportation, Federal Highway Administration. August 1997.

The weights used for this calculation are based on the distribution of experience levels for new drivers. According to conversations with industry analysts, approximately 85 percent of new drivers come in without any driving experience outside of their training and the remaining 15 percent is estimated to have an average 4 years of driving experience.

There is evidence that suggests that the high turnover rates, especially in the TL segment, have been driven by the nature of the hours of service,[160] among other factors. Conversations with industry experts on driver retention suggest that the proposed new rules could have a positive impact on turnover to the extent that they make the work schedules in this profession similar to some of the other blue-collar occupations. Experts also feel that the industry does not have adequate human resource programs to retain drivers, leading to the highest turnover rates within the first 12 months of tenure. If HOS compliance could bring about any reductions in drivers leaving trucking, it could reduce the need for hiring new inexperienced drivers[161] and change the composition of the new driver pool such that it is on average more experienced. Moreover, according to some industry experts, there is a growing tendency among trucking companies to only hire new drivers with some experience. This trend can also increase the average level of experience for the new drivers, as well as change the composition of drivers with or without experience in the analysis. Because data are not available on reduction in turnover because of the proposed new rules or fraction of the companies that only hire new drivers with some experience, FMCSA looked at a case in which only 50 percent of the new drivers come in with no experience and the rest with 4 years of experience. The Agency also looked at an extreme case where 99 percent of the new drivers have no experience. The results of this analysis are presented in table 65.

---

[160] See Gallup Organization study: "Empty Seats and Musical Chairs: Critical Success Factors in Truck Driver Retention", 1997, and discussion of these issues in detail in Chapter 6.

[161] What is also worth mentioning is that tenure seems to be a bigger problem for TL companies, more than inexperience. Driver retention rates are very low and improving HOS can have a positive impact on that.

Table 65: Estimated Crash Risk Changes for HOS Rules

Percentage share of new drivers with		Total change in crash risk under			
		2003 Rules		Pre-2003 Rules	
No Experience	4-year Experience	LH	SH	LH	SH
50%	50%	-0.10%	0.06%	-0.21%	-0.02%
85%	15%	-0.26%	0.14%	-0.55%	-0.05%
99%	1%	-0.33%	0.18%	-0.68%	-0.06%

Analysis of UMTIP and Abrams, *et al*, data.

Note that negative crash risk percentages imply that in that market segment, there is actually a reduction in overall crash risk because of a decrease in labor demand (or increase in labor productivity) from the HOS rules.

The main conclusion from the table given above is that although the Agency did not expect an increase in crash rates if there is a need to hire new drivers, the relative increases in their crash risk probabilities are not that alarming. The table also suggests that the increase in crash rates for new drivers is not very sensitive to the composition of experience levels for new drivers, in that the changes in crash risks from the top row of the table to the bottom are generally much smaller than one percentage point whereas the risk reductions provided by the options are on the order of several percent. This analysis used row 2, the 85 percent – 15 percent division, to calculate the changes in dollar benefits.

H.3.8 Value of Crash Reductions

The total damages from all large truck crashes can be found by multiplying the total number of crashes by the average damage imposed per large truck crash. The average value of damages per crash shown in table 66, $75,637, is based on research for the Department of Transportation.[162] Multiplied together, the total number of crashes and the value of damages per crash yield total annual damages of over $32 billion.

[162] Zaloshnja E., Miller T., Spicer R. (2000), "Costs of Large Truck-and-Bus Involved Crashes", p. 22, Table 11.

Table 66: Calculation of Total Value of Large Truck Crashes by Year

	Average per Year
Fatal Crashes	4,568
Injury Crashes	92,000
Property Damage Only Crashes	329,250
Total Large Truck Crashes	425,818
Average Damages per Large Truck Crash	$75,637
Total Damages from Large Truck Crashes (millions)	$32,208

Source: "Costs of Large Truck- and Bus-Involved Crashes," Zaloshnja *et al*., table 10.

This total value of damages can be divided between LH and SH operations using the breakdowns of crashes by length-of-haul and severity. Dividing the total number of crashes of each severity level into LH and SH yields the total number of crashes for each length of haul. Multiplying these totals by the average value per crash yields an approximate value of damages from all LH and SH crashes. These estimates are only approximate because the damages per crash differ by crash severity, and the breakdown of crashes by length of haul differs according to the severity of the crash.

The last line of table 67 shows the effect of excluding two groups of LH drivers from the calculation of benefits. It is not expected that drivers in these two relatively small groups – team drivers (for both private fleets and for-hire carriers) and the LH drivers in LTL carriers – to have their work schedules significantly affected by changes in the HOS rules. The changes in fatigue-related crashes estimated to result from the options would not apply to these drivers or to the crashes that involve them. The damage estimates for LH crashes are reduced by 14.6 percent, which is the estimate of the percentage of LH VMT accounted for by these drivers.

Table 67: Division of Crashes and Crash Damages by Length of Haul

	LH %	SH %	LH Crashes	SH Crashes	Total
Fatal Crashes	61.8	38.2	2,823	1,745	4,568
Injury Crashes	55.0	45.0	50,600	41,400	92,000
Property Damage Only Crashes	59.0	41.0	194,258	134,993	329,250
Total Large Truck Crashes	58.2	41.8	247,681	178,137	425,818
Average Damages per Large Truck Crash			$75,637	$75,637	$75,637
Total Damages (millions)			$18,734	$13,474	$32,208
Total Damages, Excluding Largely			$15,999	$13,474	$29,472

	LH %	SH %	LH Crashes	SH Crashes	Total
Unaffected LH Drivers (Team and LTL LH)					

Table 68: Damages Attributable to Fatigue by Option

		Pre-2003, Full Compliance	2003 Rules	Status Quo
LH	Percentage of Crashes Attributable to Fatigue	8.5%	7.1%	11.2%
	Total Damages of Fatigue-related Crashes (millions)	$1,361	$1,138	$1,791
SH	Percentage of Crashes Attributable to Fatigue	3.8%	3.7%	3.9%
	Total Damages of Fatigue-related Crashes (millions)	$506	$492	$528

H.4 Results of 2003 HOS Rule Analysis

Table 69 shows the results for the estimates of the change in the number of drivers, the primary determinant of HOS compliance costs.

Table 69: Changes in Drivers Needed for Full Compliance with HOS Limits

		Pre-2003	2003
Percentage Change	**LH**	**8.1%**	**4.2%**
	SH	**0.7%**	**1.4%**
Numbers	LH	121,500	63,000
	SH	10,800	21,300
	Total	**132,300**	**84,300**

The direct costs relative to the status quo are shown in table 70. This table shows the costs of the current rules with full compliance in the fourth column from the right. Because there would be costs for compliance with the pre-2003 rules, the costs of the current rules are higher relative to the status quo than relative to the pre-2003 rule with full compliance.

Table 70: Annual Direct Cost Changes for Full Compliance ($millions)

Cost Category	Pre-2003	2003

LH	Driver Labor Cost	1,185	550
	Other Costs	769	332
	Total Costs	**1,954**	**882**
SH	Driver Labor Cost	143	233
	Other Costs	90	168
	Total Costs	**232**	**400**
Total Costs, LH and SH		**2,187**	**1,282**

Table 71 shows the benefits and adjusted benefits of compliance with the current and 2003 rule relative to the status quo.

Table 71: Annual Value of Crashes Avoided under Full Compliance ($millions)

	Pre-2003	**2003**
Benefits of Avoided LH Crashes	429	653
Benefits of Avoided SH Crashes	22	32
Total Benefits of Operational Changes	451	685

Table 72: Annual Net Benefits for Full Compliance ($millions)

	Pre-2003	**2003**
Total Benefits	443	671
Total Costs	2,187	1,282
Net Benefits	-1,744	-611

Table 73 shows the effects of different fatigue-related crash percentage assumptions on net benefits relative to the status quo.

Table 73: Sensitivity of Net Benefits to Baseline Fatigue-Related Crash Percentage ($millions)

	Pre-2003 Rules	**2003 Rules**
Net Benefits, 5% Fatigue Crashes	-1,918	-876
Net Benefits, 8.15% Fatigue Crashes	-1,744	-611
Net Benefits, 15% Fatigue Crashes	-1,365	-35

H.5 Changes to Cost and Benefit Calculations from the 2005 HOS RIA

In the 2005, HOS rule, FMCSA changed the regulations to constrain the use of sleeper berths to ensure that each sleeper berth period is at least 8 hours, and is supplemented by a 2-hour break that may be outside the sleeper berth. At that time, the Agency also implemented an exemption from maintaining RODS for certain SH operations, which generates an ongoing paperwork savings. However, compliance costs and safety benefits to SH were unaffected.

H.5.1 Work Patterns

Patterns of working by drivers in the different sectors of the trucking industry for the basis for the 2005 HOS rule analysis. In particular, the analysis focused on intensity of effort; this may be thought of as the degree to which drivers work close to the limits imposed by the HOS rules. This can refer to hours worked (on-duty hours) in a week and in a day, hours driven in a day, days worked and days off in a week. These measures are important for analysis of both productivity and safety effects of rule changes.

H.5.1.1 Data Sources

The measures of work patterns and intensity were based on several data sources. There were four sets of data on current experience (under the 2003 HOS rule): data provided by Schneider National on some aspects of its operations; data from the Owner Operator Independent Drivers Association (OOIDA) based on a survey of its members; a survey of private carriers carried out by Professor Stephen Burks of the University of Minnesota; and data collected by FMCSA (the “field survey”). The Schneider, OOIDA, and Burks data were gathered with the express purpose of obtaining information on use of three aspects of the new rule: the 11th hour, restarts, and split sleeper periods. Each of these sources is focused on a different sector of the industry.

In addition to the above data, information was used from nine private interviews with carriers, eight small TL firms and one small LTL firm.

H.5.1.1.1 Schneider

Schneider's data are for a large TL firm and cover approximately 16,000 drivers. They were taken from company records for August and October of 2004.

H.5.1.1.2 OOIDA

OOIDA data are based on owner-operators and a few company drivers for TL firms. OOIDA posted a survey form on its website asking drivers for information on use of the 2003 rule provisions in June 2004. The data used here are based on responses from 1,223 drivers.

H.5.1.1.3 Burks

Professor Burks mailed a survey form to private carriers asking for information on their drivers' use of the new-rule features in June 2004. He received usable responses from 29 firms covering 3,311 drivers.

H.5.1.1.4 FMCSA Field Survey

The field-survey data largely represent company drivers with small TL companies. In terms of distribution of company size, this makes sense; the most TL companies are quite small. In the field survey, 86 percent of for-hire, TL/OTR companies have fewer than 25 tractors. Viewed in terms of truckload company size, the field survey is a representative sample, but these small companies account for a fairly small share of TL/OTR VMT, about 17 percent. LTL firms and private carriers are sparsely represented in the field survey.

These data, based on drivers' log books, were obtained from companies in the course of compliance reviews or safety audits. Data cover 542 drivers with 269 firms in the period July 2004 to January 2005. For each driver, data for one month of operation were collected.

H.5.1.2 Average Hours Per Day—On-Duty and Driving

Two basic measures of work are daily hours of driving and total work, the latter term including all on-duty time, both driving and other work. The field survey and the Schneider data provide information on driving time per tour; only the field survey provides data on on-duty hours per tour. The field survey provides some information on local drivers; the Schneider data do not distinguish between local and OTR operations.

A basic assumption in the calculation is that a day is equivalent to a tour of duty. While there are exceptions, most drivers work one shift in a day. A tour of duty comprises the time from the driver's start of work to end of work, including driving, other on-duty, and off-duty time. Results are in table 74. That the numbers for driving hours for Schneider and OTR drivers from the field survey are so close enhances confidence in these numbers, even though the Schneider data include local service along with OTR operation.

Table 74: Daily driving and on-duty hours—averages

	Field Survey	Schneider
Driving	7.7	7.6
On-duty	9.2	N/A

H.5.1.3 Average Hours and Days of Work Per Week

For OTR drivers, a typical measure of work is number of hours in eight days, which shows how close drivers work to the 70-hour limit for eight days. A more complete understanding of drivers' work patterns, though, is revealed by examining data on days worked per week. Both the field survey and the Schneider data give hours worked in eight days, 62 hours for Schneider drivers, 59 hours for field-survey drivers.[163] Some intermediate steps are required to convert these numbers to days per week. They are first divided them by 9.2, the field survey figure for on-duty hours per tour of duty, to obtain days worked per eight days and then make a further adjustment to obtain days worked per seven days. These results are presented in table 75.

[163] For both data sources, the analysis discarded all drivers with fewer than 50 hours of work in eight days on the grounds that they were not driving full-time in the period covered.

Table 75: Average Weekly Hours and Days Worked

	Field Survey	Schneider
On-duty hours/8 days	59	62
Days worked per week	5.6	5.9

H.5.1.4 Intensity of Effort

Examining only the average hours of driving and hours and days of work might lead one to conclude that all drivers work well within the limits imposed by the HOS rules. Many drivers work and drive longer hours than the averages, and this analysis relies on the percentages of drivers that work close to the limits for estimating productivity and safety effects. The following show the distributions of daily driving and on-duty hours and on-duty hours in 8-day periods.

Table 76: Driving Hours Per Tour of Duty

Driving Hours	Percentage of Tours		
	Schneider	**Field Survey**	**OOIDA**
11	10.7	16.2	28.0
10	15.5	16.1	N/A
9	16.4	11.2	N/A
<9	57.4	56.5	N/A

The OOIDA survey asked for frequency of use of the 11th hour but did not otherwise ask about driving hours. The figure presented here was calculated from the underlying survey data.

It is worth noting that the on-duty hours show a pattern relative to the 14-hour limit different from that of the driving hours relative to the 11-hour limit. Drivers are driving ten or more hours in more than 25.0 percent of their work days while reporting 13 or more on-duty hours for only 8.0 percent of days. The latter number suggests that drivers are generally taking two hours of break in a 14-hour tour or their normal work shifts are shorter than 14 hours. The Agency suspects that both are true. Inaccurate logging of on-duty hours could also be a factor.

Table 77: On-duty Hours Per Tour of Duty (Field Survey Only)

On-duty Hours	Percentage of Tours
14	2.7

On-duty Hours	Percentage of Tours
13	5.5
12	13.2
11	15.6
<11	63.0

Table 78: On-duty Hours in 8-day Periods

On-duty Hours	Percentage of 8-day Periods		
	Schneider		Field Survey
	Company	Leased	All TL
>64	41.0	41.3	26.3
60-64	23.5	25.7	16.6
50-59	35.6	33.1	57.1

Tables 77 and 78 show that, while daily on-duty hours tend to “bunch” away from the limit, multi-day on-duty hours bunch close to the limit, closer, indeed, than is the case for driving hours. Tables 76 and 78 give information on differences in behavior between company drivers and owner-operators. While driving hours show a marked difference, the difference in multi-day hours is slight. Some of this could be accounted for by the fact that OOIDA data include some owner-operators working on their own authority; those in the Schneider data are all leased.

Regarding differences in the average driving hours listed in table 79, it should be noted that there are few owner-operators in the field-survey data; the higher percentage of 11^{th}-hour use from the field survey, as compared with Schneider, suggests that smaller companies may push harder than larger ones, insofar as the driving limit is concerned. The OOIDA data on the 11^{th} hour could be seen as part of such a pattern, especially if one thinks the own-authority owner-operators are using the 11^{th} hour heavily. However, the multi-day hours show the reverse pattern. For 65.0 percent of reported instances, Schneider’s drivers have over 59 hours; from the field survey, the comparable number is 43.0 percent. This might suggest that a big company does not schedule as close to the driving limits as a smaller company might but enjoys greater success in marketing and, thus, is able to keep its drivers moving more consistently. There could, of course, be other explanations.

One must be wary of reaching too far in drawing inferences from these data. To the extent that data from different sources show consistent patterns, one can use this information in analysis with some confidence. One pattern that comes through consistently is that the preponderance of OTR drivers and trucking firms are not operating at, or close to, the HOS limits. Approximately 25 to 30 percent of drivers are driving more than nine hours regularly and 25 to 40 percent of drivers are regularly working more than 64 hours in eight days. The industry experts consulted for this analysis agreed that this is an accurate general view of industry operations.

H.5.2 Use of New Provisions of the 2003 HOS Rule

The analysis examined the use of three aspects of the 2003 rule: restarts, the 11th hour, and the split sleeper-berth provision. The data come from the sources already mentioned: Schneider, OOIDA, Burks, and the FMCSA field survey.

H.5.2.1 Restarts

All four of data sources reported on use of restarts. OOIDA reported that almost 90 percent of drivers used the restart at least some of the time.[164] Burks reported that private carrier drivers used the restart on 61.0 percent of their runs.[165] Neither OOIDA nor Burks, however, reported on length of restarts.

A driver using the restart provision may not be taking only the minimum 34 hours for the restart period. Schneider and the field survey both reported a high level of use of restarts and gave information on the length of restarts. In Schneider's data, only 2.0 percent of restarts were only 34 hours. Depending on the reporting period, one-quarter to one-third of the restarts were 44 hours or fewer. Forty-three percent were 58 hours or fewer. Schneider showed a bi-modal distribution with peaks at 39 and 62 hours. Presumably, the former reflects cases in which the

164 John H. Siebert, "A Survey of Owner-Operators and Company Drivers on their Use of Three New 'Hours of Service Features,'" OOIDA Foundation, September 15, 2004.
165 Stephen V. Burks, A Survey of Private Fleets on their Use of Three New 'Hours of Service Features,'" September 15, 2004

driver has taken one full day off, plus a few hours from the preceding and following days; the latter would reflect two full days off. The field survey shows that 33.0 percent of restarts were 44 hours or fewer. This comports well with the Schneider data. On this basis, one can say that at least one-third of restarts are short enough to bring a productivity gain. Using the alternative method of the moving eight-day period, drivers would usually have to stay off more than 44 hours before returning to work.

Anecdotal information on company attitudes towards restarts is that they like the provision and find some productivity gain even though drivers are staying off more than 34 hours. Managers seem hesitant to demand a return to work after 34 hours, except in unusual situations. It may, of course, be the case that taking only 34 hours off would not fit with the work schedule of many drivers, that is, there would not be anything for them to do at the 35th hour. For example, the 35th hour might come at 3:00 AM, and the company might have no use for the driver until 8:00 AM. When a TL driver comes off his restart, his first task is to pick up a new load; the hour at which the company needs his services will be set by the requirements of the shipper of that first load.

H.5.2.2 Split Sleeper Berths

Data clearly indicate that most drivers never split, and those that do do so only occasionally. Schneider data for October 2004 show 97 percent of drivers never splitting and only 0.4 percent splitting "regularly." Before the new rule, Schneider did not allow solo drivers to split at all and has only allowed them to split on an 8-and-2 basis under the new rule. The data from OOIDA and the field survey show many more drivers splitting occasionally but few splitting frequently.

Table 79: Incidence of Splitting

Splitting frequency	Field Survey	OOIDA
0 times per month	66%	55%
1-4 times per month	20%	20%
0-4 times per month (sum of above rows)	86%	75%
Average percent splitting per day	6%	13%

The Burks data show a higher percentage of frequent splitting, although they are not directly comparable with those from the field survey and OOIDA. They suggest that 52.0 percent of drivers split four or fewer times a month with the rest splitting more frequently. It is not clear why private drivers would split more frequently than others. There might be a higher percentage of teams in Burks's data; evidence suggests that teams split more frequently than solo drivers.[166]

The data in the following table come from an Insurance Institute for Highway Safety (IIHS) survey of drivers at weigh stations in Pennsylvania and Oregon and from FMCSA's Driver Fatigue, Alertness and Countermeasures Study (DFACS).

The IIHS and DFACS findings agree that teams split more than solo drivers. There is some anecdotal evidence that the incidence of splitting by teams is higher than that found by IIHS and DFACS. Several comments to the HOS rule docket suggested higher percentages than these and also indicated that team splitting is generally balanced; that is, sleeper periods and driving stints are about equal at four to six hours each.[167] The IIHS/DFACS findings for solo drivers sometimes splitting are lower than those from OOIDA and the field survey.

Table 80: Incidence of Splitting—Team and Solo

	IIHS	DFACS
Solo	**24%**	**22%**
Team	**47%**	**52%**

Data on splitting clearly show that splitting for most solo drivers occurs on an occasional and opportunistic basis. They do not build splitting into their operating routines. When they do take a split period in the sleeper, they go right back to the ten-hour rest at the next rest period. This does suggest that most drivers find the limited rest period unsatisfactory and use it only to avoid some other problem. An unexpected period of congestion would be one example. However, routine splitting is probably part of the daily operation of many teams.

[166] There is also some ambiguity in the Burks survey which asked for the percentage of "runs" using the splitting rule but did not define runs. It appears that some respondents interpreted "run" to be a multi-day period. The field survey data contained cases in which drivers reported splitting, though one of the "split" rest periods exceeded ten hours. These cases were discarded, but this shows the danger of inaccurate logging of split sleeper periods.

[167] Docket 19608; see comments by Yellow-Roadway, FedEx, CR England, Overnite, ATA, MCFA.

H.5.2.3 The 11th Hour

Table 81: Percentage of Work Days with 11th Hour Use

Schneider	**OOIDA**	**Field Survey**	**Burks**
10.4	**28.0**	**16.2**	**31.0**

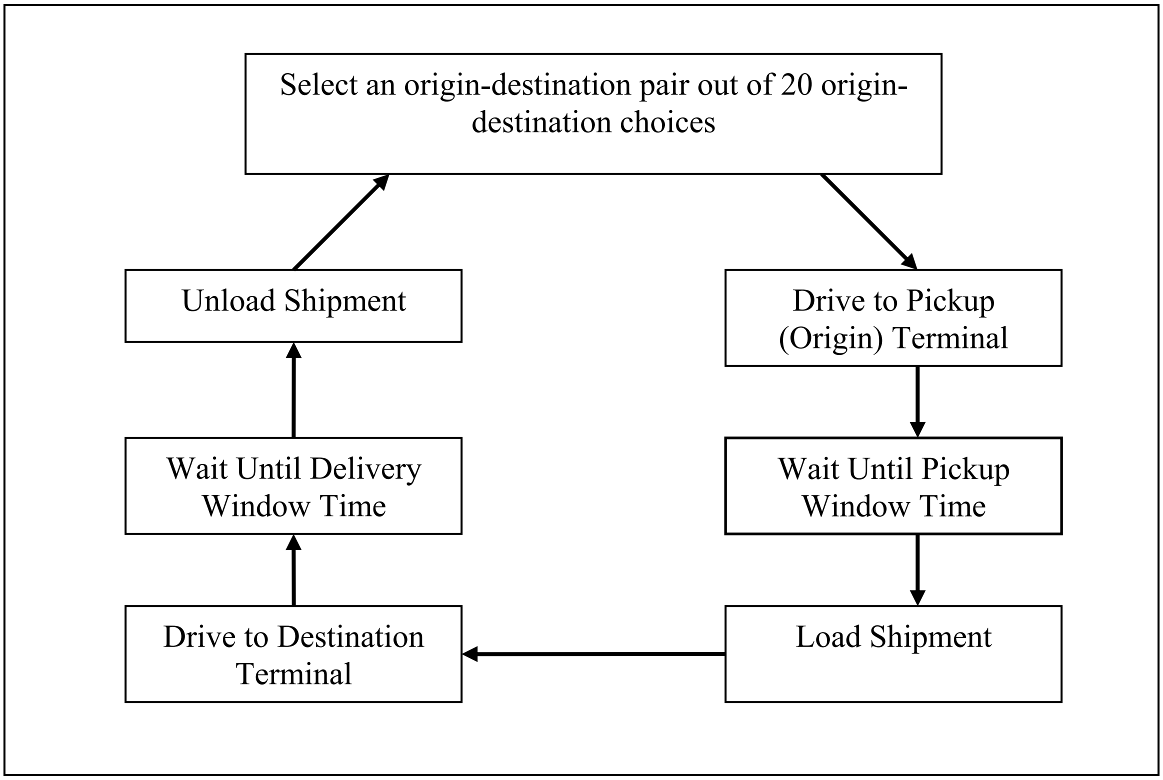
Field-survey numbers for compliant drivers only. Burks data might overstate 11^{th} hour use because drivers reported 11^{th} hour use for "runs," which may encompass an entire trip spanning multiple work days.

Data show that the 11th hour is definitely being used. Comparing Schneider data to OOIDA and the field survey implies that big companies use it less often than small companies or owner-operators. The analysis uses the assumption that usage is heavier for smaller firms and sets 25 tractors as the demarcation point between big and small TL companies. FMCSA estimates that 40 percent of TL VMT is from small companies and 60 percent is from large companies.

H.5.3 Carrier Operation Simulations

In the simulation model used to assess impacts on the more complex types of carrier operations, a truck's progress is tracked in a computer program as the driver moves between origin and destination points, choosing new loads at the end of each run from a set of choices randomly selected from a data base representative of inter-county shipment patterns. The driver's choices are made on the basis of which loads feasibly can be picked up and delivered within specified windows, given the limits imposed by the need to stop and rest. Within feasible choices, the driver is assumed to choose (or be assigned) the load that is most advantageous in terms of its contribution to its productivity. Because the HOS rules affect which loads can be delivered, and change the amount of time that can be devoted to driving, the model is able to estimate impacts on productivity, and the accompanying changes in typical schedules.

Operation Cycle of HOS Model



The model starts at the user defined home terminal. Out of 20 randomly generated origin-destination pairs, it chooses the pair that best fits its schedule as well as maximizes its productivity. Then it moves to the origin terminal, waits until the pick-up window time, and loads the shipment. It then drives to the destination terminal, waits until the delivery window time, and unloads the shipment. At this point, the model again analyzes another set of 20 origin-destination pairs and repeats the same procedure prescribed above for the time duration defined by the user. The movement of the truck in the model is constrained by HOS rules (i.e., all required rest periods) allowing the user to compare different facets of HOS rules with assumption of full compliance.

At the end of the simulation, the model yields an output that shows how the CMV operator behaved at each time of day. The truck's movement following the operation cycle is recorded in the schedule output table which reveals what the truck was doing at each time of the day each day during the whole simulation duration. The duration of simulation is defined by the user so the model can generate up to one year's worth of the schedule table. Table 82 is a snapshot of the schedule table showing only a small portion of it. The table actually has over 40 columns providing details such as time of the day, day of the week, driving status, load status, origin county, destination county, cumulative duty, driving, and rest hours.

Table 82: Schedule Output of HOS Model

Trip Day	Time of Day (24HR Format)	Day of the Week	Status	Load Status	Origin	Destn	Driving HRS Until Arrival	Load Time	Unload Time	Dummy Rest	Dummy On-duty	Dummy Driving	Cumulative On-Duty HRS	Cumulative Driving HRS
1	7.00	MON	REST	EMPTY	17,031	17,031	1.00	2.00	3.00	0	0	0	-	-
1	7.50	MON	DRIVE	EMPTY	17,031	17,031	0.50	2.00	3.00	0	1	1	0.50	0.50
1	8.00	MON	DRIVE	EMPTY	17,031	17,031	-	2.00	3.00	0	1	1	1.00	1.00
1	8.50	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	1.50	1.00
1	9.00	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	2.00	1.00
1	9.50	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	2.50	1.00
1	10.00	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	3.00	1.00
1	10.50	MON	DRIVE	FULL	17,031	5,045	10.50	2.00	3.00	0	1	1	3.50	1.50
1	11.00	MON	DRIVE	FULL	17,031	5,045	10.00	2.00	3.00	0	1	1	4.00	2.00
1	11.50	MON	DRIVE	FULL	17,031	5,045	9.50	2.00	3.00	0	1	1	4.50	2.50
1	12.00	MON	DRIVE	FULL	17,031	5,045	9.00	2.00	3.00	0	1	1	5.00	3.00
1	12.50	MON	DRIVE	FULL	17,031	5,045	8.50	2.00	3.00	0	1	1	5.50	3.50

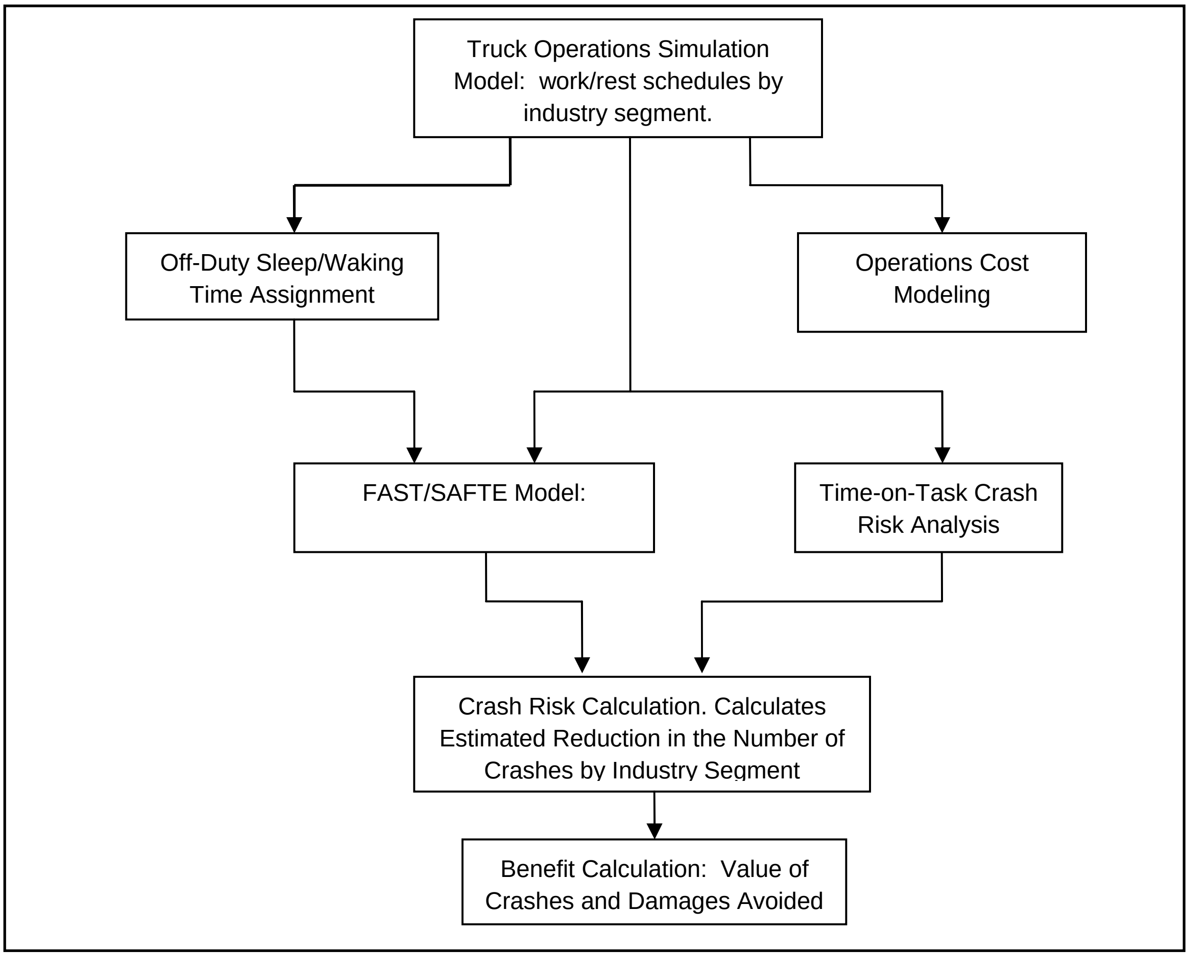
H.5.4 LH Safety Benefits

Safety impacts were measured by feeding the working and driving schedules from the carrier simulation model into a fatigue model to project driver effectiveness levels, and then estimating the resulting changes in crash risks for different cases. Changes in fatigue-related crash risks, calibrated to match realistic levels, were then multiplied by the value of all affected crashes to yield estimates of total benefits.

The approach to this analysis is illustrated in the flow diagram below. The crash and benefit analyses use the output of the truck operations simulations as the starting point for the analysis. The operations analyses provide a series of realistic truck driver schedules for each trucking industry segment. The schedules specify driver activity for each half hour (off duty, on-duty driving, and on-duty performing other activities such as loading, unloading, and waiting) over a multi-day period. The outputs of the simulations are also used as inputs into cost modeling.

The simulation model does not provide estimates on how the driver splits off-duty time between sleep and other personal activities. A separate analysis to address this question was carried out to add this information to the working schedules, based on sleep pattern surveys and similar research. These analyses led to a set of algorithms for sleep time based on the length of the break and the time of day at the start and end of the break.

Flow Diagram for Crash Risk Reduction and Benefit Calculations



The FAST/SAFTE human performance model, developed in part from research led by the Walter Reed Army Institute of Research, was used for the analysis. The model applies a large body of sleep and fatigue research, including circadian rhythms to provide an operator effectiveness percentage relative to a fully rested individual. The FAST/SAFTE model does not take into account TOT effects, so a separate analysis of these effects was performed to determine the relationship between TOT and crash risk. However, because the rule adopted in 2005 made no changes in the maximum number of driver hours per day, the results of the TOT analysis did not figure into the benefits calculations of the 2005 rule, but were used to evaluate alternatives that reduced maximum drive time to 10 hours.

H.5.4.1 Off-duty Sleep Time Assignment

In order to use the FAST/SAFTE model to process the outputs of the operational model, it was necessary to determine how much sleep the drivers were getting and when that sleep would occur during a given off-duty period. The productivity analysis outlined above focused on the lengths of drivers' on-duty, off-duty, and driving periods. While the safety model requires the length of the on-duty and off-duty periods, it also requires the amount of sleep taken by the driver, and the placement of that sleep within the off-duty period. These are the two functions of the sleep allocation model. After a driver's schedule has been separated into on-duty periods, off-duty periods and sleep periods, it is ready for input into the FAST/SAFTE model.

The first step in the sleep allocation process is to determine how much sleep a driver is expected to get based on past work history. This calculation is a decreasing function based on the cumulative amount of on-duty time in the previous 24 hour period. The basic function is identical to the one used in the 2003 RIA. For a driver who works 14 hours a day on a continuous basis, that amounts to 6.57 hours of sleep per 24 hour period. Once the amount of sleep is determined, the model checks to see how much sleep the driver has received over the previous 24 hour period. If the driver has had more sleep than he is expected to get, a sleep surplus is assumed to exist. If the driver requires more sleep than he has received over the last 24 hours, he has a sleep deficit and the model allocates sleep until the driver's deficit has been reduced to zero or until the driver begins his next on-duty period, whichever comes first.

The second step in this process is the actual placement of the sleep within the off-duty period. To begin, the model consolidates all of the driver's sleep within a period of time. For off-duty periods less than 24 hours, it is assumed that the driver will rest in a single session, and so the sleep is consolidated into a single sleep period. For rest periods equal to or longer than 34 hours, the driver is assumed to be taking a week-end break or restart of some length, and multiple sleep periods will be allocated based on the length of the rest period. Once the sleep has been consolidated, it needs to be placed within the off-duty period. After some test runs involving different rest period lengths and times of day, it was assumed that the driver's sleep period should be placed as late in his off-duty period as possible, while still allowing him to wake up 30 minutes prior to the beginning of his next on-duty period. This 30-minute buffer was included to allow the driver to overcome any sleep inertia present when he awoke. It was determined that by placing the driver's sleep towards the end of his off-duty period, it allowed the start of the on-duty period with the highest possible level of effectiveness. Whether drivers base their personal sleep allocation decisions on this same rationality is not clear at this time.

H.5.4.2 Importance of Regularity in Driver Schedules

Another observation from the results of the safety modeling was the importance of maintaining a 'regular' schedule, referring to the driver's ability to work and rest in the same general timeframe over consecutive work days. The importance of regularity stems from the effect that circadian rhythm has on driver effectiveness. Those drivers that had substantial shifts in their daily work/rest cycle performed considerably worse than those drivers that maintained a relatively constant schedule. It should also be noted that those drivers that shift to an entirely new schedule and maintain it over a period of weeks will eventually adapt to the new circadian rhythm. It is those drivers that shift to a different schedule on a daily or weekly basis that show substantial drops in effectiveness. Chart 7 compares effectiveness (y axis) for regular versus variable schedules across the work week (x axis) as modeled in FAST/SAFTE.

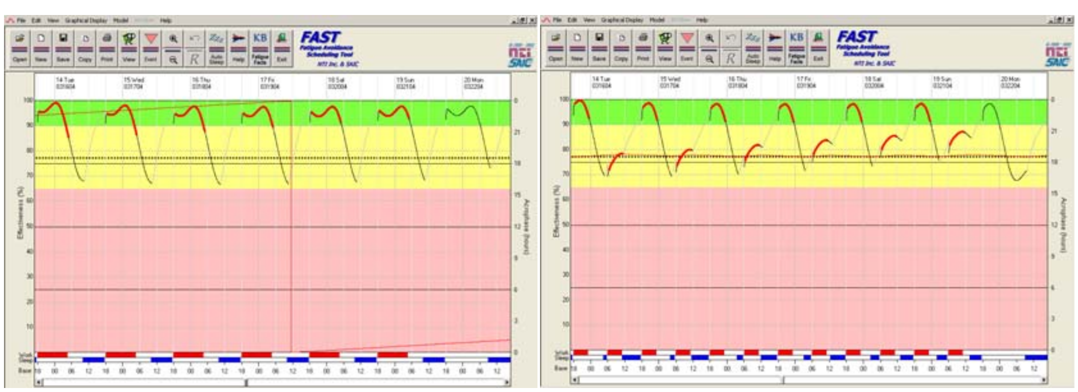
Chart 7: Regular (left) Versus Variable (right) Schedule

The 'regular' driver, in addition to showing a higher overall effectiveness, also shows much less variability in effectiveness. The large drops in effectiveness shown in the output of the variable-schedule driver are a characteristic of a constantly changing schedule. In the two examples above, the average driver effectiveness over a one-year period for the ‘regular’ schedule driver was 92.95%. This compares very favorably to an average effectiveness of 77.89% for the driver with the variable schedule.

H.5.4.3 Driver Effectiveness – Split v. Continuous Sleeper Berth Periods

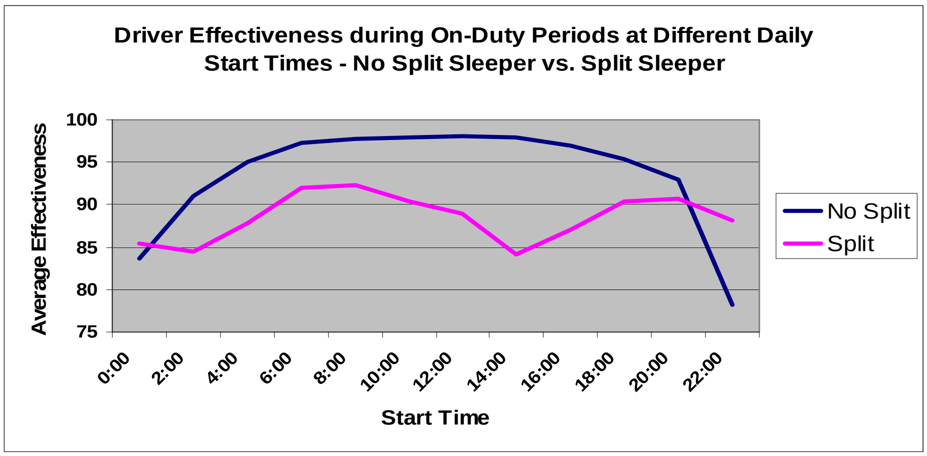
Another important observation from the FAST/SAFTE model was the difference in driver effectiveness values based on how drivers took their off-duty periods, and specifically their sleep periods. Of particular interest were drivers who split their sleep period as compared to those that chose not to split. To model these two different drivers, the Agency used the FAST/SAFTE model to calculate the effectiveness of drivers with 10 hours of on-duty time and 14 hours of off-duty time each day. One driver was given the 14 hour off-duty period in one single block and the other driver was given two 7 hour off-duty blocks. Twelve simulations were run for each driver, each offset by 2 hours, to determine the combined effect of splitting and circadian rhythms. Four weeks of driver data were modeled for this particular analysis. In general, drivers who split their sleep period into two, 7-hour blocks had lower levels of effectiveness than those drivers that took one continuous 14-hour break. Chart 8 shows two screen shots from the FAST/SAFTE model comparing driver effectiveness for a continuous and a split off-duty period.

Chart 8: Continuous (left) Versus Split (right) Off Duty Periods



At different start times over the course of a 24-hour period, the driver that chooses not to split generally has a higher average effectiveness than the driver that splits. However, modeling shows that drivers beginning their shift between the hours of 22:00 and 0:00 show higher levels of effectiveness if they choose to split their rest period. Chart 9 illustrates these findings.

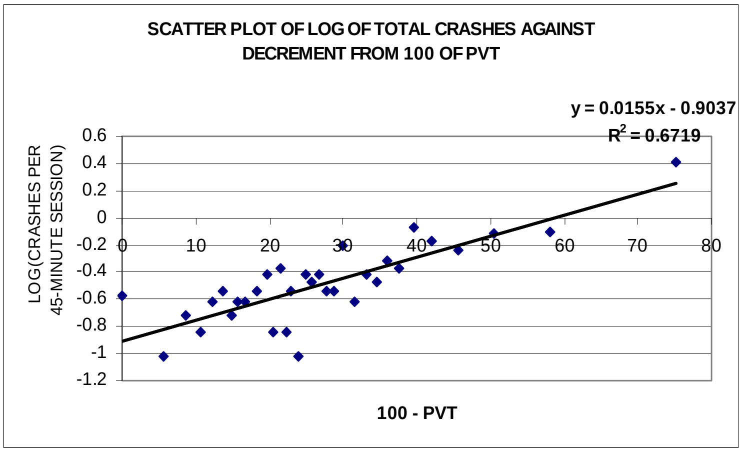
Chart 9: Driver Effectiveness at Different Start Times – With and Without Splitting



H.5.4.4 Estimate of Raw Crash Increment

The primary source of data to form a link between crash risk and PVT scores produced by the FAST/SAFTE tool was a laboratory study carried out by Walter Reed Army Institute of Research, in which driving performance on a truck simulator was compared with PVT measurements for different levels of sleep deprivation. A robust straight line relationship between the log of crashes during a 45 minute driving session and fatigue level as measured by 100-PVT score was obtained. Chart 10 shows the scatter plot and the linear relationship. PVT scores were scaled so that a score of 100 indicates a fully rested individual.

Chart 10: Relationship of PVT to Relative Crash Risks



H.5.4.5 Estimate Actual Fatigue-Related Crash Risk.

The final stem in the analysis is to convert the raw crash risk increments to an estimate of crash risk. This is achieved by calibrating the crash risk increments for a base case to real-world fatigue related crash data. The procedure is identical to that described used in the 2003 HOS RIA. The raw crash risk increments are the percentage increase in crash risk over the crash risk for a fully rested driver. Thus the proportional change in fatigue-related crashes is represented by the ratio:

[100+crash increment for 2003 HOS Rules]/[100+crash increment for 2005 HOS Rules]

The base case for this analysis is the fatigue-related crash risk for LH truck operations under the 2003 HOS regulations, estimated at 7% of all truck involved crashes. The fatigue-related crash risk percentage for each of the HOS scenarios analyzed in this analysis is then as shown below:

7.0 x [100+crash increment for 2005 Rule]

[100+crash risk increment for 2003 HOS Rule]

H.5.4.6 Crash Risk Results

The results of the crash risk modeling were found to be decrease in crash risk of 0.3 percent for LH operations. When these results are weighted by VMT such that experiences the real drivers can be extrapolated from the simulated drivers, the crash risk reduction was found to be 0.1 percent. This percentage was valued by multiplying it by an estimate of the total annual damage associated with LH truck crashes. For consistency with the 2003 HOS analysis, the Agency used the value from the previous analysis of $32.2 billion in year 2000 dollars, or about $34.9 billion in year 2004 dollars. The 2003 RIA also presented an estimate of the percentage of total damages that were caused by the LH segment. Applying the same percentage – just over 58 percent – to $34.9 billion yields just over $20 billion. The reduction in risk attributable to the 2005 HOS rule, given this total value for all LH truck crash damages, is 0.1% * $20 billion or about $20 million per year.

H.5.5 LH Compliance Costs

The analysis of costs recognizes that the different provisions of the options will affect carrier operations in complex and interacting ways. It also recognizes that these effects will depend strongly on the carriers' baseline operating patterns, which vary widely across this diverse industry. To produce a realistic measurement of the options' impacts, then, FMCSA divided the industry into broad segments, collected information on operations within these segments, and then created a model of carrier operations as they are affected by HOS rules. The variety of operational patterns made it necessary to limit the analysis to the most important cases.

The model was first loaded with data representative of shipping patterns and carrier cost structures, and tested to ensure that it could realistically simulate typical lengths of haul, empty mile ratios, and productivity. It was then set up to cover most important cases, under constraints representing the options, and used to simulate carrier operations under different conditions. The Agency then analyzed the data representing the simulated operations, using changes in miles driven as a measure of productivity impacts. Output measures from individual runs were weighted to give a realistic representation of the affected industry, including the drivers' use of the most important provisions. The weighted changes in productivity from this procedure were then used to estimate the cost increases imposed on the industry by the options, using an analysis of the changes in wages and other costs likely to result from changes in productivity. These productivity-related costs were combined with transition costs associated with shifting to new rules to produce estimates of total social costs.

For representative carriers in each of several carrier size categories, the financial impact of the HOS rule was estimated in terms of the change in net income (in 2004$) to the carrier, as well as a change in profits as a fraction of operating revenues. The approach used to estimate these impacts involved the development of a pro forma financial model of firms of different sizes confronted by changes in productivity, wages, and prices. Financial impacts were estimated under two assumptions about prices of trucking services: unchanged prices (representing the short run), and prices after industry-wide cost changes have been passed through to consumers.

The 2005 rule resulted in small adverse financial impacts (reduced profits) on most carriers, directly related to the magnitude of the drop in labor productivity. The results in terms of profit impacts relative to revenues seem to suggest very small impacts for firms across the wide range of size categories examined, including both large and small entities. The threshold for impacts considered to be of moderate size is generally taken to be one percent of revenues, and the average impacts of the rule fall well below that magnitude.

H.5.5.1 Core Cost Components

A significant portion of the total cost is driver labor costs. Changes in the number of hours drivers can work or drive were translated to changes in driver's labor productivities using the simulation model explained above. These changes were then used to calculate the additional number of drivers needed to achieve full compliance. Changes in the number of drivers were then translated into labor cost changes using the estimated wage-hours worked functional relationship for truck drivers used in the 2003 HOS RIA, described in section H.2.1.1.1 and table 49 above. The changes made in the 2005 HOS rules were also evaluated with respect to the same non-wage costs considered in the 2003 HOS RIA, discussed in section H.2.2 above.

The results of the simulation model described in section H.5.3 above showed a 3.9 percent decrease in productivity for LH drivers (a 7.0 percent decrease for regional less a 3.1 percent productivity increase for LH OTR) using split sleeper berths as a result of the elimination of the sleep sleeper berth provision in the 2005 HOS rule. These percentages are calculated for the simulated drivers; to extrapolate to the real driver population, these figures were weighted according to the fraction of total VMT attributable to these drivers, resulting in a productivity loss of 0.042 percent (a 0.08 percent decrease for regional less a 0.038 percent productivity increase for LH OTR).

The 2003 HOS rule analysis found that a 3.9 percent increase in LH labor productivity from the 2003 rules could be valued at about $1 billion, or about $275 million per percentage point (referred to as the "unit cost") in year 2000 dollars. The 2005 rule analysis updated this figure to $298 million per percentage point of productivity year 2004 dollars using the GDP deflator. Converting the total cost changes to a unit cost number, as is done here, is possible because the 2003 HOS analysis showed that there was a linear relationship between changes in driver labor productivity and the associated costs. Table 83 presents the breakdown of LH unit costs.

Table 83: LH Unit Costs for HOS Rule Changes

Unit: Change in Labor Demand	1%
Change in Number of Drivers	15,000
Driver Labor Cost	**$176**
Avoided Labor Wages	-$429
Avoided Labor Benefits	-$26
New Labor Wages	$482
New Labor Benefits	$149
Other Costs	**$121**
Non-driver Labor	$7
Trucks	$50
Parking	$15
Insurance	$11
Maintenance	$19
Recruitment	$20
Total	**$298**

H.5.5.2 Training Costs for New HOS Rules

Several commenters provided data on costs of re-training drivers and other personnel on changes to the HOS rules. Costs per driver varied between $75 and $150, and the Agency assumed $100 in its analysis of the 2005 HOS rule. Using a 7-percent interest rate, 10 years as the amortization period, and 1.5 million total LH truck drivers (the same basis as for the 2003 RIA), it was calculated that the annualized re-training costs for the LH segment to be $21 million.

H.5.5.3 Total Costs of the 2005 HOS Rule Changes

Table 84: Total Costs of the 2005 HOS Rule

Change in LH Productivity	0.042%
Change in Annual Costs due to Productivity Impact=0.042*298	$13
Incremental Annualized Retraining Cost	$21
Total Annual Incremental Cost	$34