TechBrief

Programs of the Federal Motor Carrier Safety Administration (FMCSA) encompass a range of issues and disciplines related to motor carrier safety and security. FMCSA's Office of Analysis, Research, and Technology defines a "research program" as any systematic study directed toward fuller scientific discovery, knowledge, or understanding that will improve safety, and reduce the number and severity of commercial motor vehicle crashes. Similarly, a "technology program" is a program that adopts, develops, tests, and/or deploys innovative driver and/or vehicle best safety practices and technologies that will improve safety and reduce the number and severity of commercial motor vehicle crashes. An "analysis program" is defined as economic and environmental analyses done for agency rulemakings, as well as program effectiveness studies, state-reported data quality initiatives, and special crash and other motor carrier safety performance-related analyses. A "large truck" is any truck with a Gross Vehicle Weight rating or Gross Combination Weight rating of more than 10,000 pounds.

Currently, the FMCSA Office of Analysis, Research, and Technology is conducting programs in order to produce safer drivers, improve safety of commercial motor vehicles, produce safer carriers, advance safety through information-based initiatives, and improve security through safety initiatives. The study described in this Tech Brief was designed and developed to support the strategic objective to produce safer drivers. The primary goals of this initiative are to ensure that commercial drivers are physically qualified, trained to perform safely, and mentally alert.

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Investigation into Motor Carrier Practices to Achieve Optimal Commercial Motor Vehicle Driver Performance: Phase I

Background

The current Federal Motor Carrier Safety Administration (FMCSA) hours of service (HOS) regulations for freight-carrying commercial motor vehicle (CMV) drivers prescribe that drivers:

- May drive 11 hours within a 14-hour window after coming on duty following 10 consecutive hours off duty.
- May not drive after 60/70 hours on duty in 7/8 consecutive days.
- May restart a 60/70-hour period after taking 34 or more consecutive hours off duty (the 34-hour restart provision).

The scientific evidence supporting the 34-hour restart rule is limited, and the rule may present problems in light of the current state of sleep science. Specifically, the rule does not take into account the well-described circadian rhythms in both performance and sleep propensity.

Depending on circadian placement of both the sleep opportunity and the period of on-duty time, the current restart provision may be (in the case of adverse placement of sleep and work relative to circadian phase) inadequate to restore performance and may be (in the case of optimal placement of sleep and work relative to circadian phase) adequate or even unnecessary to sustain performance. The FMCSA has commissioned scientific studies to evaluate the efficacy of the current 34-hour restart rule and to provide information in support of possible revisions to this rule.

Study Design

The objective of this project was to determine the effectiveness of the current 34-hour restart provision in the HOS regulations governing freight-carrying CMV drivers with regard to restoring performance. Specifically, the effectiveness of the 34-hour restart provision was evaluated using an in-laboratory experimental study design that tested cognitive task and driving simulator performance.

A sample of 27 healthy subjects was studied in a "worst-case"–"best-case" between-groups comparison of two 5-day (14-hour/day) work periods separated by a 34-hour restart period. Half the sample was randomized to the "best-case" condition, which entailed daytime wakefulness and work (and nighttime sleep) throughout the study, including the 34-hour restart period. The other half was randomized to the "worst-case" condition, which entailed nighttime wakefulness and work (and daytime sleep) during the two 5-day work periods, while transitioning back to a daytime schedule during the 34-hour restart period.

The main goal of the study was to evaluate whether the 34-hour restart period was effective at maintaining performance in both conditions. To this end, performance on a variety of cognitive tasks and on a high-fidelity driving simulator was measured throughout the study. The primary performance outcome measure was the number of lapses (reaction times greater than 500 ms) on a 10-minute psychomotor vigilance test (PVT), which is a validated tool for measuring the performance consequences of fatigue.

In the “best-case” condition, average PVT performance in the 5-day work period after the 34-hour restart was the same as that in the 5-day work period before the 34-hour restart, indicating that the restart period was effective at maintaining performance in this condition. In the “worst-case” condition, however, average PVT performance in the 5-day work period after the 34-hour restart was impaired relative to performance in the 5-day work period before the 34-hour restart, indicating that the restart period was not effective at maintaining performance in the “worst-case” condition (see Figure 1).

Similar effects were seen in other measures of performance, including driving performance on a high-fidelity driving simulator. Subjects in the “worst-case” condition also displayed a progressive increase in lane deviation over the hours of the night, which was accompanied by an increase of up to 1 percent in fuel use. However, the objective observations of performance impairment during the study were not reflected in subjective measures of sleepiness and mood, which inaccurately suggested that some adaptation to the “worst-case” condition would occur.

Despite equal durations of sleep opportunity in the two study conditions, subjects in the “worst-case” condition did not manage to get enough sleep, due to the adverse circadian placement of the sleep periods. All in all, the restart intervention, which involved transitioning back to a normal nighttime sleep schedule during the 34-hour restart period, was not effective at mitigating the sleep loss and consequent performance impairment in the “worst-case” condition.

The study findings highlight the importance of considering circadian effects on sleep and performance in HOS regulations. The full, final report describes the methodology and the results of the research study in detail.

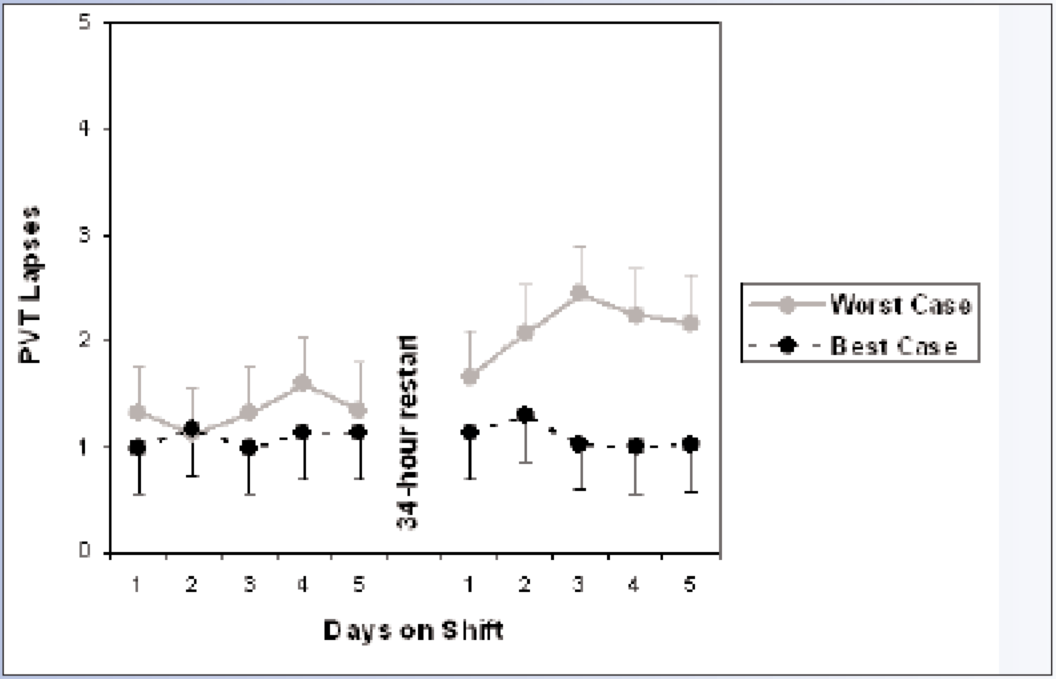

Figure 1. Lapses on the 10-minute PVT as a function of days in the 5-day work periods before and after the 34-hour restart period, for the “worst-case” (i.e., daytime sleep) and “best-case” (i.e., nighttime sleep) conditions (vertical error bars indicate standard error).

Findings and Conclusions

The most important finding was that the effectiveness of the 34-hour restart provision in the present HOS regulations depends on the circadian timing of sleep and wakefulness during the work periods. The authors' specific conclusions include:

- In the "best case" condition, average PVT performance in the 5-day work period after the 34-hour restart was the same as that in the 5-day work period before the 34-hour restart, indicating that the restart period was effective at maintaining performance in this condition.
- In the "worst case" condition, average PVT performance in the 5-day work period after the 34-hour restart was impaired relative to average PVT performance in the 5-day work period before the 34-hour restart, indicating that the restart period was not effective at maintaining performance in this condition.
- Consistent with biological principles of sleep/wake regulation, PVT performance deficits in the "worst case" condition were most prominent in the later hours of the night.
- Total sleep time was consistently reduced in the "worst case" condition relative to the "best case" condition during the two 5-day work periods.
- Perhaps due to the temporary transitioning back to a normal nighttime sleep schedule during the 34-hour restart period, the restart intervention did not effectively mitigate the sleep loss and consequent performance impairment in the "worst case" condition (and might even have contributed to the increased impairment after the restart).
- The level of PVT performance impairment reached in the "worst case" condition was modest when compared to the documented effects of one night of acute total sleep deprivation or a week of sustained sleep restriction to 6 hours per day.
- The research subjects were healthy young adults with no sleep disorders; results may be different in a sample of patients with sleep apnea (widely reported to be common among CMV drivers) or other medical conditions.
- Subjects in the "worst case" condition were subjectively sleepier than subjects in the "best case" condition, but did not show an increase in sleepiness after the 34-hour restart period. Thus, subjective sleepiness did not accurately track objective performance impairment, and can therefore not be relied upon to gauge level of impairment.
- Subjects in the "worst case" condition displayed an increase in lane deviation over the hours of the night. This was accompanied by an increase of up to 1 percent in fuel use across the night.
- Indices of driving impairment—speed variability, lane deviation, emergency braking reaction time, and fuel use—were significantly predicted by lapses on the PVT administered before driving.

Recommendations

The authors made a number of recommendations based on their conclusions from this study:

- Validation of fatigue and performance models for accurately predicting real-world driving performance would allow for the development of model-based fatigue risk management approaches, which could be mandated as a safe alternative for prescriptive HOS regulations.
- Driver fatigue could be reduced by establishing work schedules and adapting HOS regulations that allow greater flexibility (e.g., taking into account strategic napping and circadian timing).
- Individuals cannot be relied upon to self-evaluate fatigue-induced impairment. This puts a premium on development of individualized drowsy driver detection technologies and fatigue education programs.

Full report title:
Investigation Into Motor Carrier Practices To Achieve Optimal Commercial Motor Vehicle Driver Performance: Phase I (Report No. FMCSA-RRA-10-005)

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- Validation of the study findings in a sample of drivers in a real-world field study is important.
- Demonstration of the validity of fuel use on the driving simulators as an index of fuel use in real trucks on real roads would provide carriers with a bottom-line incentive to actively manage fatigue in CMV drivers.

The full final report may be found online:
www.fmcsa.dot.gov/facts-research/art-public-reports.aspx.