COMMERCIAL MOTOR VEHICLE DRIVER RESTART STUDY
REPORT TO CONGRESS

Pursuant to Section 133 of the
Consolidated and Further Continuing Appropriations Act, 2015 (Pub. L. 113-235)
March 2017

Section 133 of the Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. 113-235, division K, (The Act) requires the Secretary of the U.S. Department of Transportation (DOT) to conduct a naturalistic study of the operational, safety, health, and fatigue impacts of the restart provisions in sections 395.3(c) and 395.3(d) of title 49, Code of Federal Regulations, on commercial motor vehicle (CMV) drivers.

BACKGROUND

The hours-of-service (HOS) regulations in effect until June 30, 2013, prescribed the following:

- Drivers may drive 11 hours within a 14-hour non-extendable window after coming on duty following 10 consecutive hours off duty.
- Drivers may not drive after 60/70 hours on duty in the most recent 7/8 days.
- Drivers may restart a weekly duty cycle after taking a restart break of 34 or more consecutive hours off duty (commonly referred to as the 34-hour restart rule).

Under the new restart rule that went into effect on July 1, 2013, if CMV drivers choose to use a provision allowing "restart" of the 60- or 70-hour duty-cycle limit, they are required to include at least two nighttime periods—defined as periods from 1 a.m. until 5 a.m. (based on the time zone for their home terminal)—in their restart breaks. Use of the 34-hour restart was limited to once every 168 hours.

Pursuant to section 133 of The Act, to investigate the operational, safety, health, and fatigue impacts of these two versions of the restart provisions on CMV drivers, the Federal Motor Carrier Safety Administration (FMCSA) sponsored a naturalistic field study where participating drivers worked their normal schedules and performed their normal duties. As required by statute, and over a period lasting as long as 5 months, this study compared operational (work- and sleep-related), safety, fatigue, and health outcomes among CMV drivers operating under a restart period that included 1, 2, or more than 2 nights. The study also analyzed the safety and fatigue effects on those drivers who had less than 168 hours between their restart periods and those drivers who had at least 168 hours between their restart periods. The Act temporarily suspended the enforcement of the rules until the Secretary submits the final report to Congress.

The study assessed work-related and sleep-related operational factors, drivers' safety-critical events (or SCEs, which include crashes, near-crashes, and other safety events), fatigue, driver stress estimates, and driver health outcomes. Table 1 describes the study's statutory requirements and the actions taken to meet them.

Table 1. Study compliance with statutory requirements.

Statutory Requirement/Section	Actions Taken to Successfully Meet Requirement
1. Initiate a naturalistic study of the operational, safety, health, and fatigue impacts of the two restart provisions. **[Sec. 133(c)]**	FMCSA initiated and completed a naturalistic study of drivers who used one or both of the two restart provisions. Data were collected on the time of day and day of week when drivers operated their vehicles, fatigue levels, safety performance, and amounts of sleep and stress.
2. Compare the work schedules and assess operator fatigue between the two groups of drivers (i.e., drivers who take a 2-night [or more] rest period and drivers who take a 1-night rest period). **[Sec. 133(c)(1); Sec. 133 (c)(4)]**	Electronic logging devices (ELD) generated detailed data on driver schedules, including on-duty and drive time. Data were also collected on driver fatigue levels. The levels of operator fatigue were compared between the different duty cycles.
3. Compare 5-month work schedules and assess SCEs, which include crashes, near-crashes, and crash-relevant conflicts, and operator fatigue between the two groups of drivers. **[Sec. 133(c)(2)]**	Each driver was provided a 5-month period to contribute data. Onboard monitoring systems (OBMS) were used to capture and record SCEs. Primary statistical testing involved within-subject and between-subject comparisons.
4. A statistically significant sample should be comprised of drivers from fleets of all sizes, including long-haul, regional, and short-haul operations in various sectors of the industry, including flat-bed, refrigerated, tank, and dry-van, to the extent practicable. **[Sec. 133(c)(2)]**	The Office of Inspector General (OIG) concluded that "the study plan included a sufficient number of participating drivers to produce statistically significant results." Drivers were recruited from a wide variety of fleet sizes and operation types, making the sample representative of the industry to the extent practicable.
5. Assess drivers' SCEs, driver fatigue and levels of alertness, and driver health outcomes by using both electronic and captured record of duty status, including PVT, e-logging data, actigraphy watches and cameras that record SCEs and driver alertness. **[Sec. 133(c)(3)]**	The study utilized state-of-the-art tools including OBMSs, ELDs, Brief Psychomotor Vigilance Tests (PVT-Bs), actigraphy watches, and smartphone-based daily activity logs and self-reports to collect data on SCEs, driver fatigue, and health outcomes.
6. Utilize data from ELDs. **[Sec. 133(c)(4)]**	Each vehicle in the study was equipped with an ELD.
7. Initial study plan and final report subject to an independent peer review by a panel of individuals with relevant medical and scientific expertise. **[Sec. 133(c)(5)]**	An independent panel reviewed the initial study plan and the final report, both of which reflect the panel's comments.
8. Study to contain a sufficient number of participating drivers to produce statistically significant results. **[Sec. 133(d)(1)(A)]**	The study met the statistical significance requirement with 235 drivers who contributed 3,287 restarts for analysis.
9. Use reliable technologies to assess operational, safety, and fatigue components of the study. **[Sec. 133(d)(1)(B)]**	OIG concluded that "the study plan identified reliable technologies to produce consistent and valid results when assessing operational, safety, fatigue, and health impacts."
10. Use appropriate performance measures to properly evaluate the study outcomes. **[Sec. 133(d)(1)(C)]**	Data were collected on driver demographics and health-related factors, hours of driving and time of day, SCEs, sleep duration, behavioral alertness (PVT-B), and stress measures to assess differences in driver duty cycles. OIG concluded that "the study plan outlined appropriate performance measures to evaluate study outcomes."
11. An appropriate selection of the independent peer review panel. **[Sec. 133(d)]**	OIG concluded that "FMCSA selected individuals with relevant medical and scientific expertise to form an independent peer review panel."
12. Submit work plan to OIG by February 14, 2015. **[Sec. 133(d)]**	Study work plan was submitted to OIG on February 12, 2015, and later posted on the USDOT/FMCSA Web site. OIG briefed Committee staff on March 16, 2015.
13. Submit final report and Department recommendations to OIG. **[Sec. 133(e)]**	The final report and Department recommendations were submitted to the OIG on January 5, 2017.

STUDY OVERVIEW

Researchers conducted the naturalistic field study from March to September 2015. As required by statute, this study compared operational (work- and sleep-related), safety, fatigue, and health outcomes among CMV drivers operating under a restart period with 1, 2, or more than 2 nights. The study also analyzed the safety and fatigue effects on those drivers who had less than 168 hours (these drivers had varying amounts of time less than 168 hours) between their restart periods and those drivers who had at least 168 hours between their restart periods. The sample included drivers from fleets of various sizes (small, medium, and large) and operations (long-haul, regional, and short-haul) in various sectors of the industry (flat-bed, refrigerated, tank, and dry-van) to the extent practicable. Table 2 summarizes the industry segmentation of drivers who provided data for analysis in the study.

Table 2. Driver empanelment by industry segmentation.

Industry Segmentation	Drivers Contributing Data to the Study	Number of Carriers
Small	43	45
Medium	73	34
Large	119	16
Total	***235***	***95***
Long-haul	187	90
Regional	31	8
Short-haul	17	3
Total	***235***	***101****
Dry-van	130	55
Flat-bed	35	14
Refrigerated	59	26
Tank	11	11
Total	***235***	***106****

*A total of 95 different carriers participated in the study. Some carriers provided drivers from more than one industry segment.

As required, the study utilized a range of technologies to measure driver hours of operation, fatigue, and safety performance. These technologies are described in Table 3.

During the study, drivers were monitored for up to 5 months, permitting up to 32 duty cycles (observational periods), each of which constituted a unique sampling unit for analysis. Each sampling unit was defined to include the restart period and the duty or non-restart period. The study team recruited CMV drivers who indicated they routinely drove duty cycles that involved one of the two restart provisions.

In total, 235 individual CMV drivers provided more than 3,000 restarts for analysis. Male drivers comprised 95 percent of the sample (mean age: 45 years; range: 22–67 years). Female drivers comprised 5 percent of the sample (mean age: 42 years: range: 26–56 years). All participating drivers were asked a series of questions about their health to identify whether there were any medication or health issues that could have an impact on their levels of fatigue or alertness. Participating drivers provided a total of 26,964 days of data (17,628 duty days and

9,336 restart days) and drove a total of 140,671 hours during this field study. Each driver received compensation for participating in the study.

Table 3. Summary of assessment technologies used in the study.

Technology Name	Short Description	What it Measured
Onboard monitoring system	An electronic monitoring system with video recorder was installed on the dashboard of each instrumented vehicle. An OBMS event is triggered by certain criteria (e.g., hard braking or swerving). Each event is subsequently reviewed.	• Safety-critical events.
Electronic logging device	Device that electronically tracks a driver's on-duty and off-duty driving time for hours-of-service (HOS) monitoring purposes.	• HOS. • Driver duty status.
Wrist actigraph	Device similar to a wristwatch that collects movement information while worn and is used to measure sleep/wake patterns.	• Sleep timing. • Sleep quantity.
Smartphone application (app)	Interactive data collection program installed on a touchscreen mobile phone. The app allows study participants to record sleep/wake times and caffeine use and collects subjective ratings pertaining to fatigue, stress, and difficulty of drive.	• Sleep timing and quantity. • Caffeine consumption. • Perceived fatigue and stress (using fatigue and stress scales). • Perceived difficulty of drive and degree of drive hazards.
Brief Psychomotor Vigilance Test (PVT-B)	Interactive data collection app installed on a smartphone. Each PVT-B lasts 3 minutes and requires drivers to react to triggers that appear on the screen.	• Behavioral alertness.

STUDY DESIGN AND PROCEDURES

Prior to data collection, participants were given a detailed explanation of the study procedures and the informed consent process. The study team provided each participant a smartphone, a wrist actigraphy device, and training on how to operate the devices. Throughout the study, members of the study team communicated with drivers on an as-needed basis and during weekly scheduled debriefs. The purpose of this contact was to clarify any misaligned data with drivers, to allow drivers to ask questions and to provide feedback about missing data, study equipment problems, or study procedures that were not followed correctly.

Participants used a custom smartphone data collection app to complete various tasks, including 3-minute reaction time tests (Brief Psychomotor Vigilance Tests, or PVT-Bs), subjective ratings related to perceived stress and fatigue, subjective sleepiness ratings [using the Karolinska Sleepiness Scale (KSS)], and sleep/wake/duty diaries. Participants used the smartphone app every day throughout the 5 months of data collection at the following points in time: at the beginning of a duty period before driving; during a break from driving, about halfway through a duty period; and at the end of a duty period after driving.

Participants also used the app during restart days to provide the same measures at a time within 2 hours of waking, about midway through the wakeful period, and within 2 hours prior to sleeping. The app detected motion and did not allow participants to complete the smartphone-based PVT-B while the vehicle was in motion. For team drivers, the study team provided instructions to the off-duty driver in the sleeper berth to complete assessments at the same time as his or her driving partner before the drive, after the drive, and when taking a break.

The ELD data were collected using a variety of approaches based on which ELD solution was deployed by the carrier. In cases where a carrier did not have an ELD solution in use, a smartphone-based ELD solution was provided during the study. Drivers' safety-critical events were captured using camera-based onboard monitoring systems (OBMS). Each OBMS unit was installed in a location that did not impede the driver's view of the forward roadway and was mounted so that it would provide a good view of the forward roadway and the driver (from the driver's lap to the top of the driver's head), thereby allowing data analysts to code fatigue and/or engagement in any non-driving tasks (e.g., texting or eating).

KEY OUTCOMES

Table 4 highlights the key study findings. Following Table 4 are some of the key results for each of the four outcome domains. The full report, detailing all analyses, can be accessed at: https://www.fmcsa.dot.gov/safety/research-and-analysis/commercial-motor-vehicle-driver-restart-study.

Table 4. Key findings for the examined research domains.

Domain	Research Questions	Study Findings
Operational	Do drivers using the 1-night restart provision have longer work hours per day than drivers using a 2-night restart?	No statistically significant difference.
	Do drivers with <168 hours between restarts have longer work hours per day than drivers with ≥168 hours between restarts?	No difference, based on the variations among drivers in the shorter periods between the restarts.
Safety	Do drivers using the 1-night restart provision experience a higher safety-critical event (SCE) rate per 100 instrumented hours than drivers who use a 2-night restart?	Not higher.
	Do drivers with <168 hours between restarts experience a higher SCE rate than drivers with ≥168 hours between restarts?	Not higher, based on the variations among drivers in the shorter periods between the restarts.
Fatigue	Do drivers using the 1-night restart provision have slower psychomotor vigilance responses (lower reciprocal reaction times) on the PVT-B than drivers using a 2-night restart?	Not slower.
	Do drivers with <168 hours between restarts have slower psychomotor vigilance responses (lower reciprocal reaction times) on the PVT-B than drivers with ≥168 hours between restarts?	Not slower, based on the variations among drivers in the shorter periods between the restarts.
Health	Do drivers using the 1-night restart provision experience increased perceived stress compared to drivers using a 2-night restart?	No significant increase.
	Do drivers with <168 hours between restarts experience increased perceived stress compared to drivers with ≥168 hours between restarts?	No significant increase, based on the variations among drivers in the shorter periods between the restarts.
	Across all provisions, do drivers sleep more during their restart periods as compared to during their duty cycles?	Yes, ≥2 hours more sleep per 24 hours during restart.
	Across all provisions, do drivers experience more stress during their duty cycles as compared to their restart periods?	Yes, more stress during duty cycle.

Operational Outcomes

The measurement of operational impacts consisted of acquiring electronic information on the effects of the restart schedule on two major sources of driver fatigue: work and sleep. The first domain, operational outcomes (work-related), involved collecting electronic information on the impact of the restart schedule on the demands of driving. As displayed in Table 5, the study found several effects on average daily driving and working hours per 24 hours of duty time relative to the use of the 1- or more-than-2-night restart, but not the 168-hour provision.

Table 5. Overview of operational outcomes.

Study Component and Measurement	1-night Restart	2-night Restart	>2-night Restart	34-hour Restart <168 Hours	34-hour Restart in ≥168 Hours
Mean driving hours per 24 hours in duty periods	8.22[a]	8.08	8.00[a]	8.06	8.06
Mean work hours per 24 hours in duty periods	10.20[a]	10.11[b]	9.98[a,b]	10.11	10.03

Note: Same superscripts indicate statistically significant difference at .05 level.

Safety Outcomes

The primary safety outcomes were the rates of SCEs and fatigue-related SCEs captured via OBMS. These included electronically-recorded hard braking, hard acceleration, swerves, contact with other objects, and driving in excess of posted speed limits. The study did not find evidence that either provision had an effect on the rate of SCEs (Table 6).

Table 6. Overview of safety outcomes.

Study Component and Measurement	1-night Restart	2-night Restart	>2-night Restart	34-hour Restart <168 Hours	34-hour Restart in ≥168 Hours
Safety-critical events per 100 hours instrumented driving time in duty periods	0.34	0.37	0.35	0.36	0.37

Note: Same superscripts indicate statistically significant difference at .05 level.

Fatigue Outcomes

Driver fatigue was objectively assessed by measuring driver performance on daily iterations of an electronic PVT-B, which is sensitive to fatigue from inadequate sleep. Driver sleepiness was subjectively assessed via driver ratings on the KSS. Drivers also completed a visual-analog fatigue scale on a smartphone app to capture any combined effects of work and sleep on drivers' self-perceptions. Table 7 shows that findings based on the primary fatigue measure (PVT-B) did indicate the measure was affected during some restart and duty periods by how the provisions were used.

Table 7. Overview of fatigue outcomes.

Study Component and Measurement	1-night Restart	2-night Restart	>2-night Restart	34-hour Restart <168 Hours	34-hour Restart in ≥168 Hours
Mean Brief Psychomotor Vigilance Test (PVT-B) response speed* in duty periods	3.79	3.79[a]	3.77[a]	3.78	3.77
Mean PVT-B response speed* in restart periods	3.78[a]	3.77[b]	3.73[a,b]	3.76[c]	3.73[c]
Mean PVT-B number of lapses** in duty periods	2.97	2.90[a]	3.08[a]	2.94[b]	3.09[b]
Mean PVT-B number of lapses** in restart periods	3.16[a]	3.20[b]	3.59[a,b]	3.27[c]	3.48[c]
Mean driver-rated fatigue scores† in duty periods	1.94	1.94	1.93	1.94	1.93
Mean driver-rated fatigue scores† in restart periods	2.01[a,b]	1.95[a]	1.95[b]	1.96	1.95
Mean Karolinska Sleepiness Scale (KSS) scores‡ in duty periods	3.46	3.47	3.47	3.47	3.46
Mean KSS scores‡ in restart periods	3.67	3.58	3.61	3.60	3.60

Note: Same superscripts indicate statistically significant difference at .05 level.
*PVT-B response speed ≥3.8 = good performance.
**PVT-B lapse number of 0 = good performance.
†Fatigue scale ranges from 1 "alert" to 5 "tired."
‡KSS ranges from 1 "extremely alert" to 9 "extremely sleepy."

Health Outcomes

The effects of restart schedules on daily sleep duration and driver-rated stress, which can pose increased risks to health, were assessed daily during the study. In addition, drivers' pre-existing health conditions (i.e., obesity, sleep apnea, hypertension, insomnia, diabetes, and pain) were assessed via a background survey at study entry.

Sleep-related outcomes were measured using data collected via actigraphy devices and the sleep diary smartphone app. These tools acquired data on the impact of the restart schedule on (recovery) sleep relative to three outcomes: 1) total sleep time per 24 hours on duty and non-duty days; 2) subjective sleep quality ratings on duty and non-duty days; and 3) subjective stress ratings on duty days and non-duty days. Sleep duration and sleep quality ratings were affected during restarts, depending on how the provisions were used (Table 8). Drivers' ratings of their stress levels during their duty periods were unrelated to the restart provision used. However, their stress ratings were significantly higher during duty periods than during restart periods.

STUDY LIMITATIONS

The typical limitations associated with observational or naturalistic driving studies include not being able to randomize driver assignments or intervene in daily operations. This can impact the generalizability of the findings to the overall trucking industry and the determination of cause and effect.

Table 8. Overview of health outcomes.

Study Component and Measurement	1-night Restart	2-night Restart	>2-night Restart	34-hour Restart <168 Hours	34-hour Restart in ≥168 Hours
Mean sleep duration (in hours) per 24 hours in duty periods	6.48	6.59	6.59	6.55	6.58
Mean sleep duration (in hours) per 24 hours in restart periods	8.86[a]	8.83[b]	8.32[a,b]	8.57[c]	8.71[c]
Mean driver-rated sleep quality ratings* in duty periods	3.75	3.79	3.80	3.79	3.80
Mean driver-rated sleep quality ratings* in restart periods	3.79[a,b]	3.86[a]	3.87[b]	3.86	3.86
Mean driver-rated stress scores† in duty periods	1.54	1.56	1.58	1.57	1.57
Mean driver-rated stress scores† in restart periods	1.40	1.42	1.44	1.44	1.42

Note: Same superscripts indicate statistically significant difference at .05 level.
*Sleep quality scale ranges from 1 “poor sleep quality” to 5 “high sleep quality.”
†Stress scale ranges from 1 “not stressed” to 5 “very stressed.”

CONCLUSION

The study was not able to demonstrate conclusively that the restart rule that went into operational effect on July 1, 2013, provided “a greater net benefit for the operational, safety, health and fatigue impacts” [section 133(e) of The Act] compared to the restart rule in operational effect on June 30, 2013. Because the study did not demonstrate that the revised restart rule satisfied even the initial outcome requirements in section 133 of The Act, FMCSA has elected not to re-open the study to assess the additional outcome requirements of the Further Continuing and Security Assistance Appropriations Act, 2017.