ELECTRONIC LOGGI
Early Outcomes of Use i

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TRUCK DRIVING SAFETY has been tied to government regulations since 1937, when the first hours of service (HOS) laws were established (FMCSA, 2015). The rules outlined limits for drivers to improve safety. The main aspects of driving addressed over the years were driving time, duty time, off-duty time and at what point the overall window resets (FMCSA, 2015). Significant modern changes to the HOS laws started in 2003. From 2003 to 2008, several changes were made, such as requiring drivers to be off duty for 10 hours instead of 8, requiring a 34-hour break before a driver could start driving again, and setting a 14-hour duty period that was not extendable, meaning that drivers had to complete all driving for a day within a strict 14-hour window (FMCSA, 2015). The next major shift from the Federal Motor Carrier Safety Administration (FMCSA) came in 2015, when electronic logging devices were required in phases. There were three phases, spanning from December 2015 to December 2019, which started with awareness and ended with full compliance (U.S. DOT, 2015).

The continuous growth in regulations was a result of complex factors that affected safety, including the increased use of the U.S. highway system, improved vehicle technology and industry growth. These factors can be measured directly. The increased usage of roads can be measured by vehicle frequency. The speed of trucks on highways can also be captured. The volume of trucks, number of companies and goods hauled can all be captured. These can then be correlated to trends in crashes and fatalities to understand whether a change in regulations may make the trucking industry safer.

KEY TAKEAWAYS

- **In 2015, the Federal Motor Carrier Safety Administration outlined new regulations for electronic logging devices (ELDs) used in the truck driving industry to improve highway safety.**
- **This article outlines the purpose and implementation of ELDs and what they were expected to provide truck drivers, their companies and regulators. Today, the ELD regulations are fully phased in, and, through interviews with truck drivers, the authors examine the problems these drivers experienced prior to, during and after ELD implementation.**
- **Finally, the authors examine the effectiveness of ELDs in improving trucking safety based on both the driver's perspective and trucking crash data.**

Other influences on trucking safety are harder to measure. For example, how can the fatigue of a driver be captured? Measuring fatigue is difficult; it is influenced by many factors (e.g., sleep quality, sleep debt, medications) and can affect people in different ways (Murray & Thimgan, 2016). Researchers can measure the lingering effects of tiredness indirectly by monitoring performance. The differences among people and how they recharge make it more challenging to determine what the proper rest time and process should be. This concern was a focus during the 2008 regulation review, and it was determined that there was no conclusive data on whether circadian disruption or recovery time was the better approach to reduce fatigue (U.S. DOT, 2008). This shows how difficult it can be to determine both a safety system and supporting regulations that provide effective results across diverse types of people and driving situations.

What Is an Electronic Logging Device?

Commercial motor vehicles are tracked via driving logs. This allows drivers, companies and regulators to monitor the hours and distance a driver has traveled. FMCSA formally refers to these logs as records of duty status (RODS). In the past, drivers would maintain their RODS in handwritten books. The recent shift to a digital record has progressed through a few systems, with electronic logging devices (ELDs) being the current federally mandated system for commercial motor vehicles.

An ELD is a digital system to track driving metrics. Specifically, it "synchronizes with a vehicle's engine to automatically record a driver's off-duty and on-duty time and securely transfer HOS data to a safety official" (FMCSA, n.d.-a). The ELD connects to the engine control module in the truck and is either a hardwired system in the truck or a wireless system connected

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to a smartphone. Regardless of how the system integrates to the truck, the system tracks six metrics; together, these metrics comprise RODS:

- engine power status
- vehicle motion status
- miles driven
- engine hours
- identification of driver/authorized user, vehicle and motor carrier
- duty status

Four main rules are associated with the ELD implementation. The ELD system was intended to help drivers and their companies comply with these rules to ensure that a driver has a regular opportunity to rest to avoid fatigue and increase alertness. The four rules are the 14-hour, 11-hour, 30-minute-break and 60/70-hour rules (FMCSA, 2020). The first three rules nest within one another. Once a person starts driving for the day, a 14-hour clock starts and the driver cannot exceed this until the individual has taken 10 consecutive hours off duty (i.e., the driver must have at least a 10-hour rest period before starting the next 14-hour clock). The 11-hour rule falls within the 14-hour rule and says that a driver can only drive 11 of the 14 hours. Within the first 8 hours of the 11-hour rule, a driver must take at least one 30-minute break. The 60/70-hour limit depends on whether the driver operates every day of the week, as a driver is limited to the total hours in a cycle. In a 7- or 8-day cycle, depending on the driver's work schedule, the driver may not drive after 60 or 70 hours, respectively. The weekly drive cycle resets once a driver takes 34 consecutive hours off.

The use of ELDs was phased in and focused on engines manufactured in 2000 or later, with some exceptions (FMCSA, 2018). The three phases helped align the trucking industry to a single ELD system (FMCSA, 2017). Each of the following phases lasted 2 years, providing time for the industry to adapt to the changes:

- Phase 1: Dec. 16, 2015, awareness and transition phase
- Phase 2: Dec. 18, 2017, phase in compliance
- Phase 3: Dec. 16, 2019, full compliance

Exemptions were provided, including four specific exemptions of pre-2000 vehicles, towaway drivers, drivers who do not need to maintain RODS and drivers who maintain logs for fewer than 8 days in a 30-day cycle. The exemptions helped provide a framework that supported truck drivers and companies moving goods over distances for commercial needs, while maintaining flexibility for other truck drivers. For example, farmers hauling grain from the field to storage were exempt because they have short times when they harvest. In contrast, hauling grain from an elevator to a processing plant may require driving several miles and is for commercial use.

Expected Outcomes of the ELD System

By implementing the ELD system, the expectation was to improve economy and driver safety. The logic was that by making data logging easier and more accurate, both trucking companies and authorities could have precise data on the HOS and RODS information during stops, such as during weigh station inspections. Digital records would remove a paperwork burden from drivers, as it would be automatically tracked and easy to read by authorities. The expectation was that this electronic system would also prevent both deliberate and inadvertent HOS violations (U.S. DOT, 2015).

It is unclear whether the ELD system resulted in improved driver safety. In 2014, the FMCSA funded a study to examine whether ELD systems improved safety. The study found an

improvement in decreasing HOS violations and an 11.7% crash rate reduction. However, the small sample size made it difficult to understand the results with respect to fatigue as a contributing factor in driving incidents (U.S. DOT, 2014). This difficulty tied into the challenges in measuring fatigue noted in the 2008 review and underscored the complexity of effective safety systems. The 2014 work showed that further study was needed to understand how the ELD system affects driving safety.

Measuring the outcomes of a safety system is difficult. The quantity of data was cited as a limitation, and it is possible that larger studies might help. The authors believe that considering the complexity of commercial motor vehicles, a study that considers safety in more depth would be useful. As such, the authors present research that takes a deeper dive through thorough qualitative data collections and analyses into how safety regulations, systems and specifically the ELD system affects drivers. To accomplish this goal, truck drivers themselves were involved. The research included 40 semi-structured interviews with truck drivers, with the majority conducted at truck stops. Quotes and common themes of the conversations were captured to help understand how the ELD system affected the drivers.

Research Methodology

To better understand the effects of the ELD system on drivers, the first author conducted a series of semistructured interviews with truck drivers. After obtaining institutional review board approval for the research, truck drivers were approached at a Love's truck stop in Missouri and offered a $10 gift card in exchange for completing a permission form, demographic survey and answering interview questions. Each interview took approximately 10 minutes, and answers were written down because the background noise of the truck stop caused audio recording issues.

In total, 40 truck drivers agreed to participate and were interviewed. Of the 40, 39 of the drivers were male and one was female. Participants spanned 32 different trucking companies, and the drivers were from 17 states. The majority of participants drove Class A trucks, one driver was licensed for Class E, and another was licensed for a CDL flatbed. Ages of drivers ranged from 23 to 68, and driver experience ranged from 3 days to 40 years.

The interviews started with the same set of questions. Following are several example interview questions:

- How has the ELD system changed your driving habits?
- Do you feel the ELD system has changed driving safety?
- What would motivate you to be safer?
- What would make you feel safer as a driver?

Each driver was asked every question and follow-up questions as needed to gain additional information about how the ELD system was changing their behaviors and what was motivating them as drivers. At 25 interviews, it appeared data saturation had been reached, where the same answers were being captured; however, an additional 15 were gathered (reaching a total of 40 interviews) to ensure that the data captured a variety of driving experiences. At this point, the research concluded.

Problems Prior to ELD Regulations

This research helped to uncover both common patterns that many of the drivers experienced, and a few extreme situations that showed the spectrum of pressures and decisions a driver may face because of structures embedded in the ELD system. For example, 11 drivers stated that the ELD system prevented them from engaging in illegal behavior, such as keeping multiple logbooks or driving longer due to company pressure, a practice referred to as "pushing" the driver. One driver with 10 years of Class A experience stated, "When I ran paper [logs], I ran three logs." He explained that paper logs required him to write, which slowed things down. Other drivers commented on using multiple logs so that HOS could be lengthened, allowing them to make more income by driving longer. A comment from a different driver with more than 19 years of Class A experience summarized many of the interviews. That driver said, "Before the ELD I drove how I wanted. I could stretch an hour. The ELD helps me get more rest." Several drivers commented on habits like the example of driving beyond the HOS laws. One expectation of the ELD mandate was to eliminate this tendency, and the interviews supported the FMCSA expectation.

Both of the preceding driver comments also touch on another expectation of the ELD system. Rest, alertness and fatigue all surfaced in the interviews. For example, a relatively new driver thought that the ELD system kept him safe by not allowing him to drive for more than 11 hours. Another with 15 years of experience made a similar comment: "It's stopped guys driving over hours." Yet another expanded on why: "ELD stops the dispatcher from driving you." This driver explained that dispatchers were motivated by moving product and were less concerned about the distance and time it took to drive. This research suggests that the motivation of a driver along with the driver's relationship with the company can create a culture of bypassing regulations.

A key part of understanding how a safety system affects a driver includes the relationship with the company the driver works for and the regulator rules. This is because the alignment between the driver, company and regulations is important. If a driver faces a conflict between driving longer to make more money, and this is supported by the company, which also benefits, the consequences that regulations enforce may not be sufficient to align behavior. For example, a veteran driver with more than 40 years of experience commented, "The company wants the drivers to be alert and ready to work when they start their day. Being alert and having good depth perception makes a good truck driver." However, this veteran driver also explained that before the ELD system, there was a big difference between what companies said and what was expected. When asked for an example prior to the implementation of the ELD system, the driver stated, "Decatur [IL] to LA in 2 days was a common expectation." A Google Maps query shows this is a 29- to 30-hour drive across 1,943 to 2,026 miles, depending on the route. The driver explained that ELD and GPS technology had helped align what companies say and their expectations.

In addition to company pressures prior to ELD implementation, drivers had other motives for extending their driving hours and pushing themselves. Specifically, most drivers stated during the interviews that they were motivated by money. In one extreme example, a driver provided insight into the amount of influence this had on his driving habits. The driver, who had 15 years of driving experience, explained that if a driver could get one more load in, it could mean another $300 or $400 in pay. He stated that prior to ELD implementation, he drove 3 or 4 days without sleep so he could get more loads in. The caffeine pills that enabled his driving binge caused an

enlarged heart and three hospital visits. These hospital visits were expensive, and they took the driver away from driving while he recovered. As a result, he lost his house. Although this is an extreme example, it illustrates how motivated drivers can be to earn extra money, especially without clear regulations in place to help discourage such behavior.

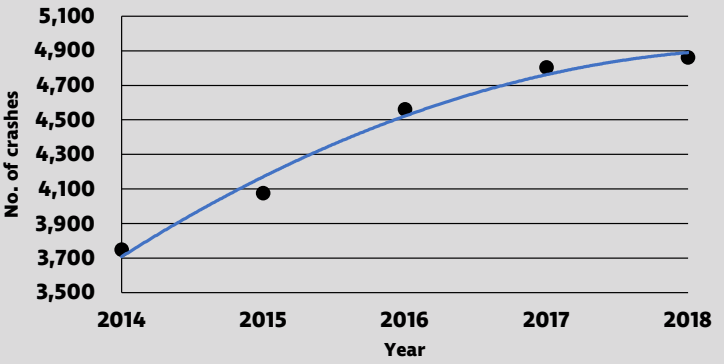
Did ELD Requirements Work?

The implementation of the ELD system was intended to improve both safety on the roads and the economy of the trucking industry. Part of this research was to dig deep and get beneath generalizations into the specifics of what was truly motivating drivers' behavior. Some drivers told a very different story about what happened as the ELD system phased in, not as positive as the comments shared thus far. Several drivers explained that their top speed is limited. So, to make up time lost from loading, bad weather or other complications, they would speed through construction zones and small towns. A driver with 20 years of experience who was hauling rolls of paper summarized by saying, "The old system a driver could stop the clock and sleep when needed, and then restart it. With the ELD, a driver has to drive." Drivers with 4 to 30 years of experience reported that they avoided eating and resting so they could keep up with the ELD clock. The pressure created by having a clock count down was influencing the drivers. As a result, they were driving while sick and distracted by hunger.

There were two indications as to why this shift in behavior occurred with the implementation of the ELD clock. The first factor was pay. With the ELD system, drivers could no longer extend their driving arbitrarily. Once they started driving, their ability to earn money was controlled by a clock, not themselves, and that time was precious. One driver explained that he was overloaded and needed to return to have some freight removed. His 14 hours had already started, so he would need to rush to complete that day's delivery to account for the lost time having to return part of his load. Other more seasoned drivers who drove before the ELD implementation explained that their income had been reduced after the ELD system, in large part because they could no longer "run outlaw," which means keeping multiple logs.

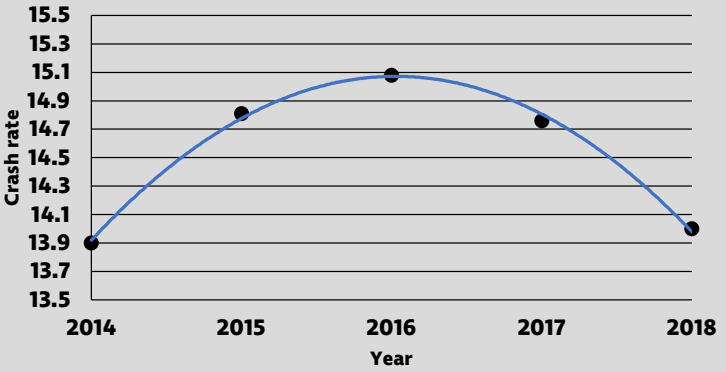
The second indication of the behavior shift was more complex. Drivers talked about watching the ELD clock run down and feeling that they were being treated like robots. They also talked about getting stuck in weather and traffic, which are hard to predict and plan for. For example, a driver with 15 years of experience hauling fuel reported that he drove faster because of the ELD system, and that he had to rush due to a 15-minute delay from traffic. He commented, "There is no leeway, no flexibility." The inflexibility of the clock impacted truck drivers in other ways. Drivers reported having difficulty finding open slots in truck stops or having to shut down in unsafe areas. The result was that drivers would

FIGURE 1
NUMBER OF LARGE TRUCK CRASHES



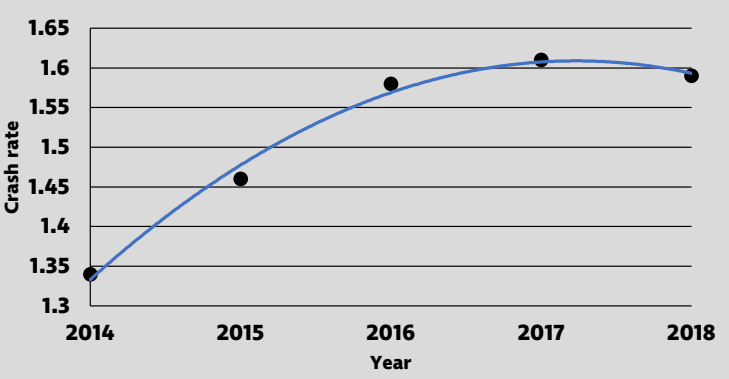
Note. Adapted from "FARS Encyclopedia: Trends," by National Highway Traffic Safety Administration (NHTSA), n.d.

FIGURE 2
CRASH RATE PER 100,000 REGISTERED TRUCKS



Note. Adapted from "FARS Encyclopedia: Trends," by National Highway Traffic Safety Administration (NHTSA), n.d.

FIGURE 3
CRASH RATE PER 100 MILLION MILES DRIVEN BY LARGE TRUCKS



Note. Adapted from "FARS Encyclopedia: Trends," by National Highway Traffic Safety Administration (NHTSA), n.d.

push to keep up with the clock, which was always counting down, to compensate for future events or delays. The drivers felt that they could no longer pull over or make professional judgments about the best way to address challenges.

Several drivers commented that they thought crashes had increased due to ELDs. A driver with 8 years experience driving a truck stated, "There were more crashes since [the ELD system] went into effect." It is important to understand the truck drivers' observations to determine whether there is a correlation between the implementation of the ELD system and changes in trucking crashes. Such correlations between qualitative and quantitative data can help to understand the relationship between changing regulations and the diverse people and driving situations who are affected by the changes.

To understand these comments and gain insight into the relationships, the authors extracted data from the National Highway Traffic Safety Administration's (NHTSA, 2014) Fatality Analysis Reporting System database to make a quantitative comparison with the truck drivers' observations. The authors compiled the data into several figures to show the total number of large truck crashes, the crash rate per 100,000 large trucks and the large truck crash rate per 100 million miles traveled. Because the ELD system was phased in beginning in 2015, the authors pulled data starting with 2014, the year before ELD phase-in.

The raw number of large truck crashes shows a steady increase each year (Figure 1, p. 29). This data show that crashes are increasing but do not account for any changes in the number of vehicles on the road or the number of miles driven. This raw trend needs normalization to provide context so it can be better understood.

The rate per 100,000 registered trucks (Figure 2, p. 29) normalizes the data to the number of trucks each year and shows an initial increase, then decrease (about 2 years after ELD phase-in started), resulting in a curvilinear relationship. This trend is more helpful, as it accounts for the changes in registered trucks. If the number of registered trucks increases or decreases, a reorganization of the crash data is needed to understand this relationship. However, it does not consider whether the trucks are being driven, only whether they are registered.

The rate per 100 million miles driven (Figure 3, p. 29) shows an increase, then leveling off, resulting in an asymptotic shape. The data presented in Figure 3 normalizes the data to truck activity on the road and provides the most helpful perspective. This normalization accounts for the trucks being driven and is closely related to the HOS concept previously described. The trend also aligns with the observations of the truck drivers who reported an increase in crashes.

Conclusion

The ELD system brought an overdue solution to pressure being placed on drivers to alter their records and drive longer than was safe to do so. It also eased the burden of paperwork and provides more accurate data on the trucking industry. However, the ELD system is rigid, and this is causing drivers to report concerns. Some drivers report that the ever-present clock counting down and knowledge that a storm or traffic jam might slow them down causes them to compensate in unsafe ways. The inability to cheat the system adds pressure to drivers to make what money they can in the time they are given. Looking beyond the comments of the drivers to crash data, crashes increased during the beginning of the ELD implementation and appear to be leveling off. Full ELD compliance was still a year away from when the crash data were available, meaning the correlation between ELD and crashes cannot be fully understood. Although early in the ELD implementation, these data indicate that a balance must be struck between rigid rules and flexibility of human judgment to maximize safety in the trucking industry. **PSJ**

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