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Operational Impact of ELD adoption by Canadian Motor Freight Companies

By

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CERTIFICATE OF ETHICS APPROVAL

This is to confirm that the research project described below has been evaluated in accordance with ethical conduct for research involving human subjects, and that it meets the requirements of our policy on that subject.

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ABSTRACT

Electronic Logging Devices commonly known as elogs or ELDs are used in commercial vehicle operations to record and track a driver's hours of service (HOS), with the overall goal of improving safety and operational performance. Granted motor freight carriers experience economic benefits from improved operational performance; it is important for carriers to understand how ELDs directly affect operational performance for them to accept it.

ELDs are an evolving technology that promises many opportunities for Canadian motor freight carriers. Within the Canadian Council of Motor Transport Administrators (CCMTA) and among Canadian motor freight carriers, there has been an intense curiosity in the potential benefits of adopting electronic logbooks, and to the potential challenges of adopting elogs (Codère, 2018).

This M.Sc. thesis has been written in order to answer the following research question: What are the operational benefits and challenges of ELD adoption by Canadian motor freight companies?

The answer to this question will be presented based on observations of actual Canadian motor freight companies who have already adopted ELDs. The data for this study was obtained using interviews of stakeholders and results from a nationwide survey of drivers. The participation of over 100 industry stakeholders to this study highlighted some of the challenges of adopting ELDs, the opportunities of adopting ELDs and the factors that contributed to the successful implementation of ELDs.

This research project can also serve to act as a foundation on which other researchers can build on to examine the trucking revolution currently taking place.

Keywords: ELD, electronic logbook, elog, Hours of service (HOS), emerging technology, supply chain, Onboard Monitoring Systems, Electronic Onboard Recorder

SOMMAIRE

Les appareils de log électronique souvent appelés elogs ou ELD sont utilisés dans les véhicules commerciaux pour suivre et enregistrer les heures de service (HOS) d'un conducteur, dans le but général d'améliorer la sécurité routière et la performance opérationnelle. Étant donné que les transporteurs de fret voient des avantages économiques grâce à l'amélioration de leur performance opérationnelle, il est important que les transporteurs comprennent comment les ELD affectent directement leur performance opérationnelle pour qu'ils l'acceptent.

Les ELD sont une technologie en évolution qui promet de nombreuses possibilités pour les transporteurs de marchandises canadiens. Au sein du Conseil canadien des administrateurs en transport motorisé (CCATM) et parmi les transporteurs de fret au Canada, l'adoption d'elogs a suscité une curiosité intense des avantages potentiels de l'adoption de log électroniques et des défis potentiels liés à ça (Codère, 2018).

Cette thèse de M.Sc. a été rédigée afin de répondre à la question de recherche suivante: Quels sont les avantages et les défis opérationnels de l'adoption des elog par les entreprises de transport routier canadiennes?

La réponse à cette question sera présentée à partir des observations des compagnies de transport canadiennes qui ont déjà adopté les elogs. Les données de cette étude ont été obtenues à partir d'entretiens avec des parties prenantes et des résultats d’un sondage national auprès des conducteurs. La participation de plus de 100 intervenants d'industrie à cette étude a souligné certains défis liés à l'adoption d’elogs, les opportunités liées à l'adoption des elogs et les facteurs qui ont contribué à la bonne implémentation des elog.

Ce projet de recherche peut également servir de base sur laquelle d'autres chercheurs peuvent s'appuyer pour examiner la révolution du camionnage actuellement en cours.

Mots-clés: ELD, log électronique, elog, heures de service (HOS), technologie émergente, chaîne d'approvisionnement, systèmes de surveillance à bord, enregistreur électronique

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LIST OF ABBREVIATIONS

3PL: Third party logistic

AOBRD: Automatic onboard recording device

BCA: Bnefit-cost analysis

BOL: Bill of Lading

BYOD: Bring your own device

DOT: Department of Transportation

EDI: Electronic Data Interchange

ELD: Electronic logging devices

EMS: Engine management system

EOBR: Electronic onboard recorder

EU: European Union

FMCSA: Federal Motor Carrier Safety Administration

FMS: Fleet management system

HOS: Hours of service

IT: Information technology

MVOHWR: Motor Vehicle Operators Hours of Work Regulations

NPV: Net present value

OBMS: On-board monitoring system

OIPT: Organizational information processing theory

POD: Proof of delivery

REB: Research Ethics Board

RFID: Radio Frequency Identification

RODS: Record of duty status

TCPS: Tri-Council Policy Statement

TMS: Transactive memory system

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CHAPTER 1 INTRODUCTION

Concerns about driver fatigue and public safety were the underlying reasons behind regulating truck drivers' working hours. Truckers have been federally regulated in Canada since 1940 and, in the late 1980s, the federal government introduced the National Safety Code which is the code governing current regulations (Transportation in Canada, 2014). The Motor Vehicle Operators Hours of Work Regulations and The Commercial Vehicle Drivers Hours of Service Regulations both set the rules governing maximum daily and weekly (or bi-weekly) on-duty and off-duty hours for commercial drivers. In the mid-1990, the regulations were reviewed and, by January 2007, multiple amendments had been enacted into the regulation (Transportation in Canada, 2014).

A break down in motor carrier safety has a direct impact on the supply chain of an organization. A motor carrier that is involved in a crash or is put out of service due to a Department of Transportation (DOT) violation can potentially disrupt the supply chain of an organization. A trucker hauling raw materials to a factory can negatively affect the production schedule of that factory if the trucker is placed out of service for a DOT violation. Transportation is an essential part of the supply chain since it deals with the movement of goods or raw materials from one location to another within the supply chain. Therefore, as goods are delivered from suppliers to their customers, some form of transportation is involved. Furthermore, motor freight transportation happens to be the largest form of transportation employed within most supply chains. In 2015, motor freight carriers transported 72% of goods domestically within Canada (Transportation in Canada, 2015) and in 2016 motor freight carriers transported 60% of (Transportation in Canada, 2016) international freight between the US and Canada. As a result, truck accidents, delays or disruption, can bring about significant costs to an organization.

Most accidents involving motor freight carriers have driver fatigue as the primary factor of those accidents (Crum and Morrow, 2002; Wylie et al., 1996). Drivers within the trucking industry are prone to working long hours and irregular work schedules, all of which contribute to driver fatigue and subsequently to highway accidents (Saltzman and Belzer, 2002). After 9.5 hours of driving, the likelihood of being involved in a driver fatigue-related accident significantly increases the more the driver keeps driving (Saccomanno et al., 1995).

Environmental factors and economic factors are the two elements that contribute to the increase in driver fatigue (Crum and Morrow, 2002). Economic factors such as financial demands of the driver and carrier economic pressure push drivers to work beyond their limits. Most drivers within the trucking industry are paid on a per mile basis and hence are motivated to drive as long as possible to maximize their earnings on a given day, and that is usually at the cost of insufficient respite (Labaton, 2006). Carriers are sometimes levied penalties for late deliveries, and hence these carriers push drivers to perform unsafe practices in an effort to deliver on time. Environmental factors such as trip control and quality of rest affect driver fatigue (Iyznicki, 1998). Trip control measures how closely a driver's trip matches what was planned, situations such as adverse weather conditions require drivers to be more attentive and reactive, this subsequently means they will use more energy than usual while driving. The quality of rest takes into account the amount of uninterrupted sleep a driver receives during off-duty hours. A driver sleeping in the sleeping berth of his truck by the side of the road will not receive the same quality of sleep as if he had been sleeping in the comfort of his bed at home (Hege et al., 2015).

Driver fatigue can be remedied in several ways most of which involve the carrier support. Factors such as operational practices of the carrier and concern and commitment to reducing driver fatigue and improving safety influence drive fatigue. Operational practices of the carrier have a direct impact on how drivers avoid fatigue. Practices such as carrier assistance in loading and unloading or keeping to a minimum the amount of night driving that a driver does help reduce driver fatigue (Crum and Morrow, 2002). Carriers that show concern for safe driving and show commitment to that concern by investing resources such as driver training and dispatcher training contribute directly to minimizing fatigue involved in accidents. Carriers that also had their customers (i.e., shippers and receivers) participate in establishing safety conscious scheduling practices, such as not wasting time loading or unloading trailers also contributed to less driver fatigue.

Another way to reduce driver fatigue-related accidents is to specify the appropriate amount of hours that a driver can safely operate a commercial vehicle.

In an attempt to promote safety and minimize any negative impact on the motor freight industry, the Federal Motor Carrier Safety Administration (FMCSA) established rules and regulations specifying the number of hours of service (HOS) that a truck driver can drive in a given day. The regulations differentiated drive time, on-duty time, off-duty time and sleeper berth time within a seven to eight day period. The regulations have been revised multiple times in an attempt to balance driver fatigue accidents and potential economic impact to the motor freight industry. In order to enforce these regulations, drivers were required to maintain detailed and accurate logs of their work hours. The compilations of drivers daily logs constitute a drivers record of duty status (RODS). Figure 1 shows a sample HOS log and how the various statuses are recorded. The graph on the log gives enforcement officers a quick visual representation of how the hours were partitioned throughout the workday.

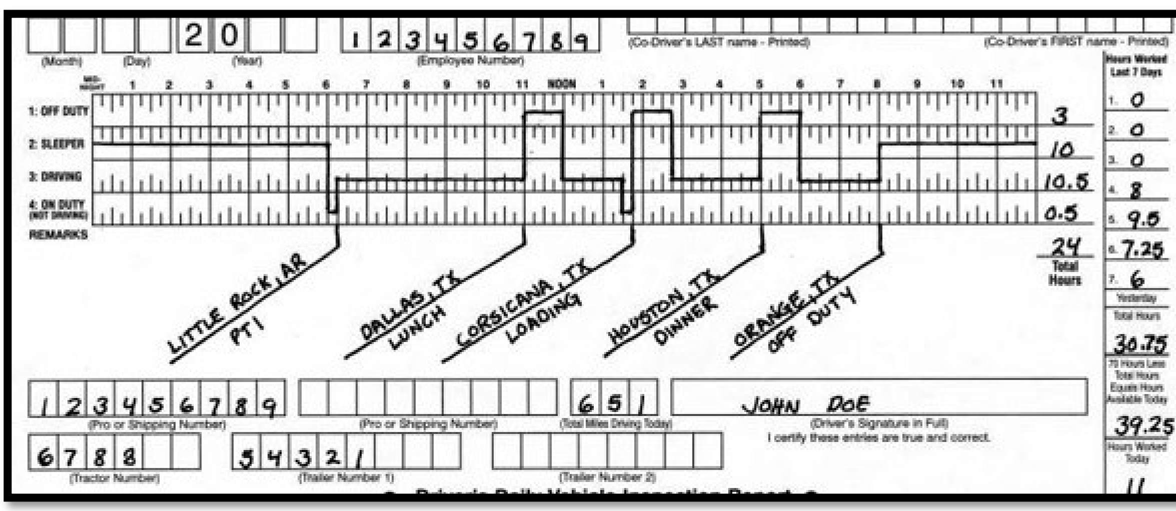


Figure.1.0 Hours of service log.

Note. Retrieved December 1, 2017, from http://www.trucking.org/History.aspx

In comparison to the European Union (EU), the US lags behind in adopting technology for capturing record of status information. In 1980 the U.S. Department of Transportation authorized motor carriers who voluntarily wanted to adopt electronic on-board recording devices (EOBR) (sometimes referred as automatic on-board recording devices - AOBRD) that would capture their driver's daily logs and maintain their record of duty status. In 2000, regulations were amended in order to require long-haul drivers and regional drivers to use EOBRs to track their hours automatically, however, these regulations were not enforced. The amendments were an attempt by the government to prevent rampant falsification of HOS logs or RODS. Paper logs allowed the drivers to write down anything they wanted and hence it was tempting to misrepresent the actual hours worked (Saltzman, 2002).

The EU, on the other hand, has been a forerunner in requiring motor carriers to use automatic recording devices to capture work hours. The EU also has stricter HOS standards requiring more extended rest period for drivers as can be seen in Table 1.

	EU	USA	Canada
Maximum Daily Driving time	9 hours (can be extended to 10 hours no more than twice a week)	11 hours (only after 10 hours of rest)	13 hours of driving in a work day or work shift
Mandatory Rest Breaks	45mins	30mins	None mandatory
Weekly Rests	45 hours after six days of work (rest hours can be reduced to 24 hours after every second week)	34 hours after 60/70 hours of on-duty	36 hours after a 70-hour on-duty cycle or 72 hours after a 129-hour on-duty cycle
Required Daily Rest	11 hours (can go down to 9 hours no more than 3 times a week)	10 hours	8 hours

Table 1. Comparison of hours of service in EU, USA, and Canada

Table 1 shows some of the differences between EU HOS, US HOS, and Canadian HOS. The EU requires drivers to work less and be more rested than US drivers. In 1985, the EU amended its regulations and was first to require motor carriers to adopt technology that automatically recorded the hours worked by drivers (Saltzman, 2002). The on board devices would record on paper sheets the different periods of time such as drive time, work time, periods of availability and, break time. In 1998, the EU further amended its regulations to require second-generation automatic on-board recording devices (Saltzman, 2002). The amendment was an effort by the EU to prevent motor carriers from circumventing hours of service rules. The second-generation devices were required to capture more information than their previous counterpart did; the devices required each driver to have their own personal driver card that was to be inserted into the device at the start of the workday.

The effectiveness of HOS regulation in reducing driver fatigue is debatable (Min, 2009). Abrams et al. (1997) determined that many drivers were already tired when they started their driving duties, signifying that restricting the number of hours a driver operates does not necessarily reduce driver fatigue. EOBRs as a recording device is ineffective in accounting for a driver's time spent not driving. The devices still depend on the honesty of the driver to honestly and accurately account for time spent on non-driving activities. However, giving that non-driving activity account for several hours of a driver's on-duty status drivers are not motivated to be honest. This, therefore, offers drivers the opportunity to claim they were in the sleeper berth while in fact, they were overseeing loading or unloading.

In addition to obeying Canadian regulations, Canadian truckers hauling loads into the United States have to observe American regulations governing hours-of-service. The implementation of electronic logging devices (ELD) by some Canadian motor freight carriers has played a significant role in maintaining compliance to The Federal Motor Carrier Safety Administration (FMCSA) 395.15 by Canadian motor carriers serving US markets. Nonetheless, such a technology has the potential of enhancing a company's competitiveness through improved operational processes.

1.1 RELEVANCE OF THE RESEARCH TOPIC

As part of their design, ELDs capture a significant amount of real-time data generated by the driver and the truck. Top performing carriers have been able to leverage that data to identify which of their vehicles were underutilized and, measure the efficiency of their drivers and the idle time of their trucks during deliveries. The data provided a means to improve performance, and certain companies have supposedly seen improvements in vehicle utilization, a reduction in vehicle downtime and a decrease in operating costs (Haffenden and Yeomans, 2007). This, therefore, means that installation of ELDs can be a management tool used for controlling cost and hence providing a competitive advantage to the motor freight carrier. The information provided by ELDs can be harnessed as part of a motor freight carrier's decision-making effort.

This study will attempt to understand the business implication of ELDs on motor carriers from the perspective of Canadian motor carriers operating in US markets. The principal objective is to identify the various benefits and limitations associated with implementing the newer electronic recording of hours of service. The data collected during this study and the fact that the study is quantitative instead of qualitative will be valuable to the motor freight industry. The relevance of the study will assist decision makers within the motor freight industry to be able to justify investment in the technology or to assist in building implementation roadmaps based on facts rather than intuition.

1.2 Research Question

The understanding of this subject will be developed through observation of the industry, specifically by interviews with managers and surveys of drivers. The interviews and the surveys should provide sufficient data to recommend how Canadian motor freight carriers can successfully implement ELD technology in their motor freight operations. Understanding this subject will allow this study to answer the following sub-questions:

1. What are the perceived opportunities for implementing ELDs in Canada?
2. What are the perceived challenges for implementing ELDs in Canada?
3. What are the most influential factors that contribute to the successful implementation of ELDs in motor carrier operations?

1.3 Thesis structure

This study is organized as follows: Chapter 2 explains what ELDs are and the evolution of how hours-of-services were recorded. Chapter 3 provides a comprehensive overview of the literature into previous studies and research on implementation of technology within the motor freight industry, hours of service and driver fatigue. Chapter 4 proposes and describes the methodology used for the study, which is based on a series of semi-formal interviews and a province-wide survey. Chapter 5 summarizes the data collected during the study followed by an empirical analysis of the data and a discussion of the results. Chapter 6 proposes some of the implications of ELD adoptions to the Canadian motor freight industry. Chapter 7 provides a conclusion to this study with a discussion of the limitations of the study and some potential future research opportunities derived from the study.

CHAPTER 2 ELECTRONIC LOGGING DEVICE

2.1 WHAT IS ELD?

An electronic logging device is a class of automatic onboard recording device (AOBRD) sometimes also referred to as an electronic onboard recorder (EOBR). These are all electronic hardware that attaches to the engine of a bus or commercial truck to record the driving time of that vehicle and automatically record the hours of service (HOS) for the driver. They electronically track and manage a driver's record of duty status (RODS). ELDs are the current industry version of AOBRD that record more information than their predecessor AOBRD and are all compliant with FMCSA 395.15 (Obrien, 2017). Most ELDs on the market must meet Federal Motor Carrier Safety Administration (FMCSA) requirements, and fleet owners are recommended to choose a manufacturer that has been approved by the Federal Motor Carrier Safety Administration (FMCSA). Devices on the market usually include additional bells and whistles for driver efficacy and conveniences, such as GPS navigation and web browsing (Obrien, 2017). Higher end ELDs may be part of a larger fleet management system and include additional features such as routing, planning and driver workflow. The leading manufacturer of ELDs is Omnitracs better known under its Qualcomm brand. Omnitracs currently has the largest market share for ELD devices. As of writing this thesis there are two types of ELDs: [1] standalone systems [2] bring your own device (BYOD) systems (Fisher, 2018). The standalone system involves a dedicated device that is tethered and installed into a commercial truck.

Standalone system

BYOD system

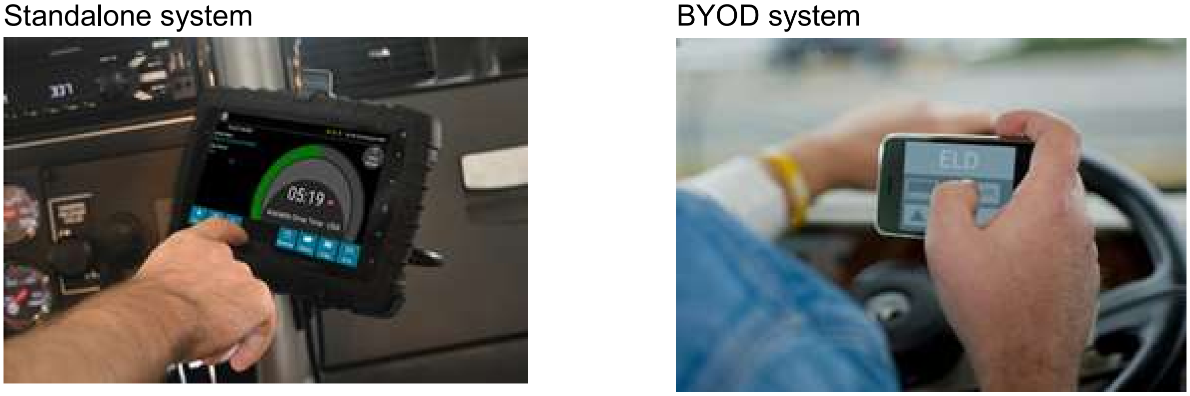


Figure 2.1 Standalone system vs. BYOD system *(Note. Adapted from Gpsinsight, 2018)*

On the other hand, a BYOD system uses a cell phone or tablet that connects via Bluetooth to an ELD device installed on a commercial vehicle's engine management system (EMS). Whichever device a motor freight carrier decides to use must be certified and registered with the FMCSA.

Logistics companies and motor carriers use the following metrics to classify the advantages and limitations of various ELDs: upfront cost, monthly cost, convenience, and compliance.

The upfront and monthly costs involve the investment cost that most carriers must make to adopt an ELD. Upfront costs usually entail the cost of the device and the cost of installation. BYOD systems usually have zero cost of the device. However, they do have installation costs for installing the "ELD's black box" to a truck's EMS. The monthly costs are the costs involved in getting the satellite connections, the online data storage and for various services and features offered by the ELD manufacturer. A motor freight carrier has to take into account the overall upfront and monthly costs when calculating the total cost of the device. A low upfront cost with high monthly cost can quickly add up to a higher overall cost than a device that has a higher upfront cost and lower monthly cost.

The convenience and compliance of a device also weigh on the selection of a device or not. For roadside inspectors to consider the data produced by a device, the device must comply with FMCSA regulations and be among the approved FMCSA devices. Carriers also weight the features offered by the devices, for example, some manufacturers offer Bluetooth connectivity, messaging, and navigation. The number of features offered and the type of features offered in most cases directly affect the monthly costs.
Once all these metrics have been wholly weighted and all the advantages/disadvantages and strengths/limitations taken into consideration, only then can a carrier select a device that meets their needs.

2.2 Difference between ELD and past AOBRD

The Federal Motor Carrier Safety Administration (FMCSA) proposed AOBRD on 31st of January 2011 (FMCSA, 2011). AOBRD are similar to the digital tachographs installed in trucks within the European Union. AOBRD track multiple data points from a vehicle, such as date and time, engine hours, vehicle miles, location, and duty status of the driver. The records provided by AOBRDs could be entered manually or edited, and the AOBRD tracked edit history of the records. The newer ELD provides better and more detailed information, similar to the AOBRD. ELD also tracks date and time, engine hours, and vehicle miles. However, ELD provides better information about location and duty status. For duty status, ELD captures better identifying information on the driver, motor carrier, and vehicle. ELDs can have drivers login or logout, allowing for multiple drivers per vehicle. As for tracking location, ELDs provide an accuracy of within one mile when tracking on-duty hours and an accuracy of within ten miles when tracking personal use/conveyance. The RODS data captured by the ELDs must be in a format that allows the data to be automatically transferred to FMCSA.

Table 2.1 AOBRD Vs. ELD

	AOBRD	ELD
Recorded Data	▪ Date and time ▪ Engine hours ▪ Vehicle miles ▪ Drive times ▪ Locations ▪ Duty status of the driver	▪ Date and time ▪ Engine hours ▪ Vehicle miles ▪ Drive times ▪ Locations ▪ Identifying information on the driver, motor carrier, and vehicle ▪ Engine malfunctions
Location	▪ Recorded during each change of duty status ▪ Can be entered manually	Recorded automatically when: ▪ Change in duty Status ▪ 60 min driving intervals ▪ Engine cycled on and off ▪ At the start and end of yard moves or/and personal conveyance
Editing Record	▪ Records who made edits and when ▪ Driving time can only be edited when attributed to the wrong driver ▪ Does not readily display edit history	▪ Records who made edits and when ▪ All edits require an annotation ▪ Driving time cannot be edited ▪ Automatically recorded events can only be annotated ▪ Edit history is readily displayed to DOT inspectors

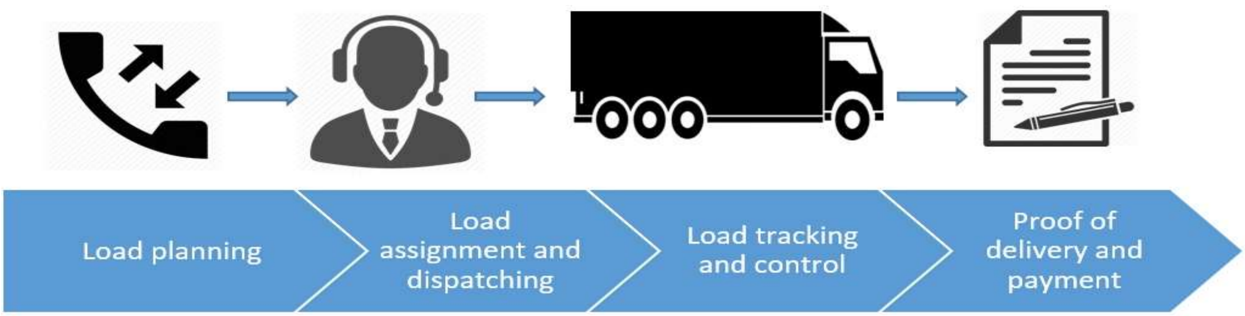
Note. Adapted from Aobrds vs. Elds similarities and differences by Kotowski

The above table (Table 2.1) provides a summary of the significant differences between the previous AOBRD technology and the newer ELD technology.

2.3 MOTOR FREIGHT CARRIER BUSINESS PROCESS

In order to understand how ELD adoption can affect a motor freight carrier's business operation, one must understand the operational complexity of the freight management process. A simplistic view of the process can be divided into four stages: [1] load planning [2] load assignment and dispatching [3] load tracking and control [4] proof of delivery and payment. Figure 2.1 illustrates the freight business process

Figure 2.2 Motor freight Business process



Note. Adapted from *Development of a Transportation Real-Time Technology Readiness Framework* by David Cantor

Load planning entails the carrier either searching on load boards for customer orders or receiving loads directly from customers and consolidating those orders. The process of receiving load orders is called tendering, and at this stage, the carrier receives all pertinent information about the load such as load type, weight, destination, consignee contact, handling instructions, etc. From this, the carrier can determine if they can accept the load. Most carriers receive load orders electronically through their fleet management system (FMS) directly from customers by EDI (Electronic Data Interchange). Once the carrier has accepted the load, they enter it into their FMS for scheduling.

Load assignment and dispatching entails dispatching the order to a specific motor carrier, i.e., matching loads to specific drivers. At this stage, the HOS of the planned driver is verified to ascertain if the driver can safely make the delivery. A dispatcher will ensure that the driver has all the necessary documentation (e.g., bill of lading, certificate of origin, etc.) and, that the driver has all the pertinent information needed to make the delivery (e.g., delivery address, delivery time, etc.). The dispatcher stays in contact with the driver during the loading process, at which point possession and liability of the load transfers to the carrier once trailer doors are shut (and in some cases sealed), and the shipper has signed the Bill of Lading (BOL).

Load tracking and control involves the transit of the load. The carrier stays in contact with the driver throughout the transit with the help of GPS technology and satellite communications. Constant tracking helps ensure that everything is on track and that delivery is made on time. Dispatchers will often provide the driver with optimal driving directions, best refuel solutions and any traffic or weather delays. At this stage, the HOS of the driver has the potential to affect the timely delivery of the load.

In the “Proof of delivery and payment” stage, the driver has made the delivery and has documented their arrival time and, in cases where consignee delays unloading, detention time is accrued. The consignee accepts possession of the load by documenting any shortages, damages and signing the (BOL); this then becomes the Proof of delivery (POD) which is used with any other necessary paperwork to invoice the customer.

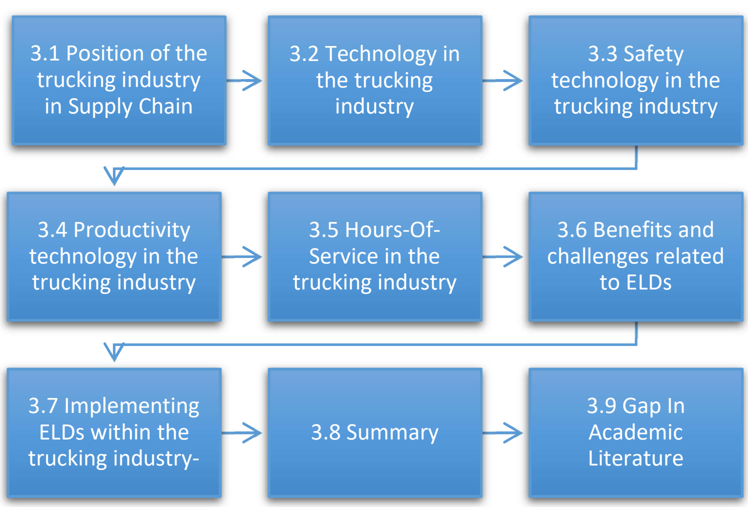
Chapter 3 Literature Review

The following section surveys information revealed in over 18 articles within a 17-year period. The articles comprise various management journals and scholarly dissertation from both the US and Canada, this allowed for a broader perspective of the subject. The adoption of technology within an industry affects that industry, and our literature review will establish how technology adoption by a motor carrier and industry performance are interrelated, progressively narrowing in scope towards ELD adoption.

The first part of this section will define the role of trucking within the supply chain (Section 3.1). Section 3.2 will then dive a little deeper into the application of technology within the trucking industry. Section 3.3 will follow that with a review of the literature on the adoption of safety technology within the trucking industry. We will then review in section 3.4 the available literature for the adoption of technology for productivity within the trucking industry. Section 3.5 will review the available research into hours-of-service within the trucking industry. Given the central focus of this thesis, we will review the literature on the benefits and challenges of ELDs and, the implementation of ELDs within the trucking industry in Sections 3.6 and 3.7 respectively.

Finally, we will summarize the literature review in Section 3.8 and, identifying how the current research plugs any gaps in the available academic literature in Section 3.9. The sequence of topics for the literature review section is visually mapped out in Figure 3.1.

Figure 3.1 Literature Review Map



3.1 Position of the trucking industry in Supply Chain

The highly competitive nature of today's business environment has made it essential for companies to obtain and maintain a competitive advantage, and companies have turned to streamline their supply chain to eliminate waste and reduce cost. Transportation has been a prime candidate for cost reduction within the supply chain (Manrodt et al., 2003; Xu et al., 2017). Lummus et al. (2001) best describe a supply chain as ***"All activities involved in delivering a product from raw material to the customer, including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information system necessary to monitor all of these activities."*** From that definition, we can observe that distribution and delivery highlight the importance of transportation within the supply chain. Transportation usually falls within the logistics branch of a supply chain management and where economically feasible is outsourced to a third-party logistic (3PL) company. In the past, traditional supply chains were slow and generated high inventory cost and high transportation cost (Manrodt et al., 2003). However, modern supply chains are more reactive and more cost-effective thanks in part to the improvements in technology, communication, and transportation.

Many studies have highlighted the important role that transportation plays within a supply chain. McKinnon (2006) assessed how dependent the UK economy was to the motor freight transportation system. He proposed that the UK industrial, commercial and welfare systems would collapse if the motor freight transportation system was disrupted for a week. McKinnon recognized the low probability of such a catastrophic event, but also noted that such an event could have a very high impact on the whole country, potentially bringing the country to a standstill. The distribution of finished products within the supply chain is usually monopolized by road transportation, and any disruption within road transportation would significantly affect the consumer. Other parts of the supply chain would also be negatively affected, many manufacturers have adopted just-in-time production schedules and depend on reliable and rapid delivery of their stocks. An interruption in the motor freight carrier system would sever the links between the various points in the supply chain; this means that inventory would be held upstream in plants, warehouses or cross-docks thereby affecting manufacturing and production. The author collected data from previous motor freight crises and extrapolated the effects of the proposed disruption onto various key sectors of the economy. The study was further strengthened by conducting interviews with various logistics and supply chain managers. Several assumptions were made in order to develop the catastrophic scenario: [1] no advance warning would be given of the event, [2] the rate of consumption of products would remain constant, and hence no panic buying would occur, [3] only large commercial trucks would be affected (McKinnon, 2006).

The study focused on sectors that had the following characteristics: [1] sectors that predominantly distributed their products by road, [2] their deliveries are highly time sensitive, [3] they held limited inventory within their supply chain, [4] they wield substantial influence on the economy and/or quality of life. Sectors such as grocery retailing, healthcare, postal services, agriculture, manufacturing, and construction are some of the industries that were examined and met the characteristics. The results of the study showed that following a total disruption of motor freight activities, there would be a sharp drop in the level of economic activity, and this would plunge the country into a profound economic and social crisis. Many businesses would not make it through a week of suspending their operations, and even after resuming operations, it would take several weeks to recover production and distribution operations. The author calculated that once motor freight operations would resume, carriers would use vehicle capacity intensively to try to clear the backlog. The study concluded that trucking plays a crucial role in maintaining a supply chain, this is especially true with businesses that operate on a JIT basis (McKinnon, 2006).

Atwater et al. (2014) attempted to build a risk assessment model for motor freight carriers to measure a carrier's ability to withstand major disruptive events. Within their study, they recognized that transportation played a vital role in the resilience of a supply chain, and hence should be a part of a supply chain risk management plan. Hossein et al. (2017) in their publication about managing transportation risks within a humanitarian supply chain, not only recognized the critical role that transportation played in a supply chain, they believed that managing transportation risks within a supply chain would foster effectiveness, efficiency and in turn better responsiveness from that supply chain. Agrell et al. (2017) conducted a study examining the governance structures of the trucking industry in Sweden and how it impacts the coordination between forwarders and carriers. The authors affirmed the vital role that transportation plays in the supply chain of organizations, and how transportation cost make up a bulk of logistics cost. The study focused on transportation in the grocery retail supply chain in Sweden. The study concluded that a governance structure that promotes carrier-cooperation among the various carriers would lead to carriers earning more despite the supply chain profits being lower.

3.2 TECHNOLOGY IN THE TRUCKING INDUSTRY

Rishel et al. (2003) published a qualitative exploratory case study in which they attempted to gain a better understanding of the impact of satellite communication systems on motor freight carriers and their customers. The research was conducted by doing a case study of four shippers that used motor freight carriers that had adopted satellite communication within their operations. The cross-case case-study compared the firm's perception of satellite communication system, the benefits of satellite communications and the type of data transmitted to provide insight into why firms might want to select motor freight carriers with satellite communication capability. The interviewee from each firm was generally the transportation director, transportation manager, or customer service coordinator. The firms selected were in various stages and positions within their supply chain (Rishel et al., 2003).

All four firms replied consistently that customer service was the motivation behind selecting and using motor freight carriers that had adopted satellite communication systems. They all perceived that using motor freight carriers with satellite capabilities provided them with customer service benefits. All four firms indicated that the type of information received from the motor freight carrier included: ETA (estimated time of arrival), truck locations and notices of breakdown (Rishel et al., 2003). They also all reported that the information provided by the satellite communication provided all the firms with the ability to measure, monitor and audit a motor freight carrier's performance. Three of the four firms pointed out that they used satellite communication in order to track mileage and use that information to audit their private fleet of trucks and assess the accuracy of invoices provided by commercial carriers. One of the four firms reported having customers that required JIT (just in time) deliveries and the data provided from the satellite communication allow the firm to meet customer demand by reordering stops and/or changing the final destination of the shipment (Rishel et al., 2003).

Rishel et al. (2003) assumed that most firms would see comparable benefits and that these benefits would, in the end, lead to an enhancement of collaboration among partners within the supply chain. This would be because visibility of in-transit inventory would help reduce uncertainty within the supply chain. According to Rishel et al. (2003), the continuous monitoring of in-transit inventory and sharing of that information allowed decision makers to make critical manufacturing and inventory management decisions.

Rishel et al. (2003) concluded that satellite communication allowed firms within the supply chain with the ability to collaborate with customers and improve customer service. The technology provided firms with the connectivity needed to make timely decisions and the visibility to be responsive to customer demands. Rishel et al. (2003) indicated that satellite communications allowed firms to efficiently and effectively manage inventory, production schedule and human resources in a JIT environment. In addition, supply chain partners could meet their goals while reducing cost by merely developing a delivery strategy. Finally, the paper determined that carriers use satellite communications to locate quickly their available assets in order to efficiently plan and optimize their routes leading to increased capacity and flexibility (Rishel et al., 2003).

Manrodt et al. (2003) discussed the benefit of motor freight carriers adopting mobile communication technology within their business operation. The authors believed that carriers would become more efficient if they adopted technology that increased the visibility of the supply chain. This is especially true for the dispatchers managing drivers and for the decision to move assets and the pickup and deliveries of loads. The gain in efficiency meant that dispatchers could manage more drivers per dispatcher. Manrodt et al. (2003) suggested that the ability to know where a shipment was without any input from the driver meant that drivers would no longer have to waste precious time to update dispatching leading to fewer stops per day. The article further suggested that the adoption of mobile communication technology would lead to an increase in load ratio, an increase in revenue per mile, a reduction on total operating costs, and a decrease in deadhead (non-revenue generating trip) miles.

The study surveyed 565 motor freight carriers from a list of 2736 motor freight carriers nationwide for a 21% response rate. The respondents of the survey were presidents and CEOs of for-hire fleets, and fleet managers and transportation directors of private fleets. The survey was developed in coordination with Qualcomm Incorporated, a leader in mobile communication technology and a major communication provider in the motor freight industry. The survey was designed to measure thirteen key success factors for motor freight carriers before and after mobile communication implementation. Before being deployed, the survey was pre-tested by a small sample of motor freight carriers and Qualcomm for readability. Manrodt et al. (2003) found that, as predicted, the number of trucks managed per dispatcher increased by 22 percent, the overall number of minutes spent at each stop decreased, the load ratio increased, deadhead miles decreased, and there was an increase in revenue per mile. However, contrary to what was predicted, costs per mile did not decrease. The authors hypothesized that this increase in cost could have been related to the cost of installing and implementing the necessary hardware and software or inconsistency of what constituted "cost per mile" from each respondent. Although the authors could not clearly explain the discrepancy in the result, they recommended further analysis of operating cost versus savings from operational efficiency.

Manrodt et al. (2003) concluded that motor freight carriers could achieve several key benefits by implementing mobile communications technology within their operations. The implementation of such a technology would increase visibility within the supply chain implying that shippers would also reap the benefits of using motor freight carriers that had implemented mobile communications.

3.3 Safety Technology in the Trucking Industry

Safety within the motor freight industry is not only an organizational issue, but it is also a public safety issue. Accidents involving large commercial trucks have significant costs to human life but also have an impact on the supply chain of an organization. When a motor carrier is involved in a crash, the load transported by that carrier can be damaged or destroyed, this would, therefore, disrupt the supply chain of the organization. Cantor et al. (2009) published a correlational study examining how technology could be used to contribute to the safety of drivers of large commercial trucks. The authors assessed the use of electronic logbooks (EOBR) in preventing the occurrence of catastrophic events. They credited driver fatigue as a significant factor to motor carrier accidents and proposed that EOBR could alert the driver and/or dispatcher when the driver was about to exceed their maximum allowable driving hours (Cantor et al., 2009). Cantor et al. suggested that adoption of EOBR would reduce HOS violations and they believed that HOS violations mediated the relationship between EOBR adoption and motor freight accident. The authors also suggested that motor freight carriers with below than average safety records would see the most significant reduction in HOS violations after adopting EOBR, with that regard they would also see the most reduction in accidents compared to their counterparts with above than average safety records (Cantor et al., 2009).

The researchers conducted a multivariate statistical analysis of motor freight firms' safety performance. The study synthesized crash records with hours of service violations from the FMCSA's Safety Management Measurement System database. Poisson regression models were used to examine the correlation between the use of EOBRs, HOS violations, and a motor freight's accident record. The authors tested the significance of each hypothesis by developing Poisson Models for each hypothesis. The results of the Poisson regression strongly supported the authors' belief that that adoption of EOBR reduced HOS violations and reduced motor freight accidents. The regression models also supported the authors' claim that motor freight carriers with below than average safety records would see a significant reduction in HOS violations and motor freight accidents. Cantor et al. (2009) concluded that the use of EOBR would contribute to a reduction of HOS violations and that there was enough statistical evidence to show that HOS violations mediated the relationship between EOBR adoption and motor freight accidents.

Cantor (2010) in another study, conducted an exploratory qualitative study to develop a voluntary compliance model that could be applied to the FMCSA's regulatory proposal to adopt EOBR in the motor carrier industry. Motor freight carrier drivers historically entered the motor freight industry because of the autonomy and independence that long-haul trucking provided. The authors, therefore, speculated that the EOBR proposal would have widespread opposition from drivers and other stakeholders. However, the government as an institution is tasked with implementing public policy that governs safety practices and/or improves safety performance. Cantor et al. (2010) suggested that voluntary compliance with such government initiatives would be more effective in promoting obedience to these regulations, rather than a command-and-control attitude by the government. A literature review on the subject uncovered three basic premises that affect the voluntary compliance model and, they were as follows: [a] procedural justice, [b] technology readiness, [c] attribution issues (Cantor et al., 2010).

The study evaluated the reactions of motor freight drivers to the EOBR safety proposal. 581 driver comments published on the US government website in response to FMCSA's request for comments were selected and sent a follow-up questionnaire. 293 of the selected drivers responded to the follow-up questionnaire for a response rate of 50.4%. Respondents were selected nationwide to avoid any geographic bias. Content analysis of the data collected revealed that drivers' concerns could be categorized into four themes: [1] government control over workplace behavior, [2] financial impact, [3] technology readiness, and [4] attribution issues (attribution issues in this context are how drivers perceived the causality of safety problems. In this study, drivers viewed shippers and receivers as the cause of safety problems). The analysis also revealed that more than 70% of the comments expressed some form of opposition to EOBR adoption (Cantor et al., 2010). Drivers expressed concerns about the government intruding and controlling workplace behavior, hence invading and violating their privacy. Financially drivers expressed concerns about the cost-effectiveness of EOBR adoption; they believed that it would inevitably lead to an increase in transportation prices. Older drivers expressed concerns about their ability to embrace and use the new technology. Finally, drivers asserted that accidents were erroneously attributed to them, they commented that only few motor freight accidents were actually the commercial drivers' fault and therefore the EOBR mandate was unfairly penalizing all commercial drivers for the poor judgment of a few individuals.

In conclusion, Cantor et al. (2010) developed a voluntary compliance model that could be used by policymakers in addressing driver opinions and concerns when developing a final EOBR rule. The model developed by the authors could also help motor freight carriers ameliorate driver apprehension of these advanced technologies and new safety practices.

3.4 PRODUCTIVITY TECHNOLOGY IN THE TRUCKING INDUSTRY

Cantor et al. (2011) attempted to examine the reaction of commercial drivers from a procedural justice point of view and their intention to quit their job once government regulations concerning the adoption of EOBR within the motor freight industry were enacted. The authors believed that driver turnover within the motor freight industry was a serious issue that had the potential to disrupt the supply chain. A motor freight carrier facing high turnover will be negatively impacted financially and will experience a drop in capacity. Driver turnover can approximately cost a firm anywhere between $2000 and $21000 per driver (Cantor et al., 2011). Costs such as training costs, drug screening, and road testing can quickly drive the finances associated with driver turnover high. Furthermore, high turnover can represent a real constraint to a motor freight carrier, in turn affecting the capacity of the supply chain of an organization. Motor freight carriers may be forced to decline loads due to the lack of drivers. The study proposed that drivers who participated in the EOBR rule-making process would perceive procedural fairness more than drivers who did not. In that same regard, they proposed that drivers with lower perception of procedural fairness were more likely to quit.

The authors conducted a national survey of commercial vehicle drivers prior to the amendment of the FMCSA regulation proposing to incorporate EOBR. A total of 1,919 surveys were sent, and 604 participants responded for a response rate of 31.47%. The driver's intention to quit was used as the dependent variable and, it was indicated on a scale of one to seven with one being extremely unlikely to quit and seven being extremely likely to quit. To assess the validity and adequacy of the factor structure of the model, the authors conducted a confirmatory factor analysis that suggested a high association between the proposed hypothesis and the observed variables.
The structural equational modeling showed that increased perception of fairness by drivers participating in the EOBR rule-making process was not supported. Furthermore,

a driver's likeliness to quit due to a driver's lower perception of procedural fairness was strongly supported by the data (Cantor et al., 2011).

The study concluded that motor freight carriers should consider procedural justice when establishing motor freight carrier safety. The study showed that broad public safety policy might have unintended outcomes also affecting labor. A driver's intention to remain employed can be impacted by how a company manages the perception of procedural justice of its drivers. Overall driver retention can be affected by their perception of the fairness of the decision-making process of a policy and their perception of the fairness of the impact of the policy.

Ellinger et al. (2003) conducted a study to try to understand and develop a comprehensive synopsis of website content for motor freight carrier's websites and in order to assess how motor freight carrier firms are progressing in their advancement into e-commerce. This study is relevant to our research for the reason that Ellinger et al. (2003) evaluated the impact of technological improvement on the improvement of motor freight carrier performance. The study looked at the quantitative improvements of motor freight carrier websites within the motor freight industry. The authors believed that the internet as a medium for communication could be used to improve a motor freight carrier's performance. The authors after a comprehensive literature review developed a list of potential measures that they used to perform content analysis on a sample of motor freight carrier's websites. The sample of carriers consisted of 98 motor freight carriers from the "Top 100 Motor Carriers" from September 1999 edition of inbound logistics and, 57 motor freight carriers of 100 "Other motor carriers" randomly selected from the www.logisticsmgmt.com website for a total of 155 sites. The study assessed the content of each website and determined the presence or absence of elements representing the categories of: [1] site design, [2] informational content and, [3] interactive content. They obtained item frequencies for each category and compared the feature availability from "Top 100" websites to that of the "Other" websites.

Ellinger et al. (2003) found that there was a significant difference between the "Top 100" websites to that of the "Other". The "Top 100" offered to site visitors significantly more features ($p<.05$) in each category to that of the "Other". In conclusion, the study found that motor freight carriers still had substantial improvements to make on their websites regarding the informational and interactive content of their sites. The authors noted that smaller motor freight carriers' websites provided less content in terms of their informational and interactive content. Furthermore, the study determined that the motor freight industry as a whole was underutilizing the opportunities provided by the internet and the presence of a fully developed website. Adoption of such technology offers web-based opportunities to improve business performance and customer relationships.

Starr et al. (2010), published an empirical analysis of the motor freight carrier industry examining the extent to which technology impacted a motor carrier's productivity. This study is relevant to our study since Star et al. (2010) demonstrated that changes in regulations could have an impact on performance within the industry. The authors believed that deregulation of the motor freight industry allowed carriers to expand their technological possibility leading to an alteration of the production structure of motor freight carriers. Starr et al. (2010) proposed the hypothesis that deregulation of the motor carrier industry allowed firms to operate more efficiently by adopting technology that allowed motor carrier firms to operate more cost-effectively. The researchers conducted the study by comparing the production structure of a deregulated trucking environment to that of a regulated trucking environment. Starr et al. (2010) applied the duality theory to compare the estimated cost function of motor carrier firms operating in 1977 to that of motor carrier firms operating in 1983. In order to eliminate problems with comparing costs from heterogeneous firms, the authors sought to compare homogeneous firms by examining a subgroup of motor carriers; carriers viewed as transporting specialized commodity using specialized equipment. The empirical results showed a reduction in real unit cost in firms evaluated post the deregulation period suggesting that there was indeed a change in the production structure of motor carrier firms post-deregulation. This implied that deregulation of the motor carrier industry allowed motor carrier firms the freedom to adjust their distribution more efficiently by increasing returns of scale and, the implementation of efficient technologies assisted them with this. The study concluded that motor carrier firms had become more efficient after deregulation, but the results of the study could not attribute the efficiency to technology. However, the authors viewed the efficiency of motor carriers after deregulation as an outcome of the development of least cost network by the carriers. Although the study could not directly attribute efficiency of the industry to the adoption of technology by motor carrier firms, other studies were able to observe a relationship between efficiency and technology adoption.

Pitera et al. (2012), attempted to understand the value and sustainability of technology advancements that monitored and supported the safety of commercial truck drivers. Their study aimed to develop a framework for a benefit-cost analysis (BCA) that could be used to determine the net economic benefit of on-board monitoring system (OBMS) implementation. This included systems such as: [1] drowsy driver detection, [2] EOBRs, and [3] lane departure warning system. The authors believed that the slim margins of carriers made it imperative for carriers to compare the initial and recurring costs of system implementation to the safety benefits and efficiencies generated from deploying such systems. Various safety related and non-safety related benefits were considered in order to get a comprehensive understanding of the economic benefits of system implementation. Safety-related benefits such as reductions in motor freight accidents and HOS violations and non-safety related benefits such as reduction in fuel consumption and improved truck routing all provide an economic benefit to the motor carrier (Pitera et al., 2012).

The study evaluated the operational costs associated with hours of service recording and crashes from one terminal of a mid-size regional carrier. The data provided from the carrier would be a base case for calculating the net present value (NPV) needed for generating the BCA. The terminal site examined in the study consisted of 62 vehicles with approximately 7,900,000 total miles per year traveled among the vehicles. The data and analysis showed that OBMS implementation has the potential to provide economic benefits to motor freight carriers due to a reduction in commercial vehicle crashes with an NPV of $54,000. The NPV of both crash reduction benefits and HOS benefits was $281,625 showing that OBMS implementation can be economically feasible (Pitera et al., 2012). Pitera et al. (2012) identified certain circumstances where OBMS adoption was not economically viable. The authors noted that viability of the system was directly related to the number of crashes and HOS violations committed by the carrier prior to OBMS use. Therefore, a reliably high safety rated carrier with few HOS violations would not see immediate benefits. Viability was also dependent on the business duration of the carrier, carriers that did not remain in business longer than the life of the system made OBMS adoption impractical. Furthermore, the authors mentioned that beyond the economic feasibility of OBMS adoption, issues such as driver acceptance factored into the successful adoption of OBMS.

Pitera et al. (2012) concluded that in many operational circumstances, the economic benefit of OBMS adoption outweighed the costs associated with the systems. Benefits of OBMS adoption can further increase if the carriers can improve operational efficiency by capitalizing on other system components of OBMS.

3.5 HOURS-OF-SERVICE IN THE TRUCKING INDUSTRY

Multiple studies have been done on the impact of HOS on safety, and company performance. However, most of the available literature on these studies were mainly done in the United States. This current study preferred to focus on the literature of studies conducted in Canada.

Coiquaud (2016) attempted to examine and map out the existence of a “third time” for drivers that would complement the working time and rest time and examined how laws and regulations respond to it. The researcher used a priori conceptual framework to define this third time. The author defined the third time as the time when an employee is not considered to be at work, but the employee is required to be subordinate to the potential demand for work from the employer (Coiquaud, 2016). Within this time, the employee does not have the freedom to go about their own business as they choose. This gray area of time is considered neither rest time nor working time. The author used a mixed research methodology to grasp the context of how HOS legal provisions were effectively being applied in society, especially in the province of Quebec. The author examined fifty-three collective agreements in order to identify the clauses regulating the remuneration of different work times and performed forty-two semi-structured interviews to better understand the obligation to be available.

In Canada, two regulatory blocs govern HOS rules, the first block stems from the Motor Vehicle Operators Hours of Work Regulations (MVOHWR), and it aims to protect the driver. The second block is derived from the Motor Vehicle Transport Act, and it aims to ensure public safety from unsafe commercial vehicles and unsafe driving practices (Coiquaud, 2016). However, the author could not deduce from analysis of the legal provisions the existence of a third time. The laws and regulations clearly determined working time and rest time and left no space for interpreting a third time. Nevertheless, analysis of collective agreements showed that motor carriers had negotiated various times unrelated to driving, where drivers were not remunerated for their time. It was noted that most collective agreements had the driver bear the responsibility of unpredictable events (such as traffic congestions or detours) or the poor logistical planning by the organization (such as waiting for consignee) leading to a decrease in the driver's wages.

Coiquaud (2016) determined that the latitude that drivers had in interpreting or using the regulations governing their hours of service, endowed a substantial informal normative system at the margins of the formal labor laws that lead to the existence of a third time. The study concluded that three elements contributed to the emergence of the third time: [1] the conceptual fluidity of the laws and regulations, [2] the introduction of an informal normative system which was derived by the manipulation of regulatory times, [3] regulations from the Ministry of Labor and Ministry of transportation that are far removed from the realities of drivers' working conditions (Coiquaud, 2016). The study showed the urgency to align regulations with the reality of the twenty-first century and the demands of the job.

Drouin (2008) in his study attempted to evaluate the impact of the 2007 changes to the Motor freight law of 1987 proposed by Transport Canada. The proposed changes to the law was an attempt by the government to tighten legislation concerning the HOS of the Canadian trucking industry. The objectives of the study was to evaluate the impact to motor freight carriers if Canadian and American HOS laws were standardized. The author believed that HOS regulations had an impact on the productivity of motor freight companies and that standardizing these HOS laws throughout North America could have an impact on motor freight companies (Drouin, 2008). The Researcher analyzed the data collected by two long-haul Quebec motor freight companies that serviced both Canada and the US. These companies collected for 33 weeks, logs and reports from fifty roundtrips. Drouin used the data to analyze four scenarios that allowed the study to determine any potential improvement or decline in productivity among the four scenarios. Scenarios 1 used the proposed 2007 regulations in Canada and the US as the baseline to compare the three other scenarios. Scenarios 2 used the previous 1987 regulations in order to analyze the potential impact of the 2007 proposed regulations to the industry. Scenarios 3 standardized Canadian HOS laws throughout North America and, scenario 4 standardized US HOS laws throughout North America.

Drouin (2008) found out that the previous 1987 HOS laws had little impact on the Canadian motor freight industry. Analysis of the data showed that had Canadian HOS laws been standardized throughout North America, there would be a gain in productivity within the North American motor freight industry. The study also found that there would be a decline in productivity had US HOS laws been standardized throughout North America. The study concluded that the proposed 2007 regulations favored long-haul carriers and that the further the roundtrip distance the more a change in HOS regulation would be susceptible to affect the productivity of motor freight carrier. Drouin (2008) determined that once a regulation affects workings hours, then the number of pickups and deliveries would predetermine the productivity of the carrier, which makes it even more important to minimize the wait-time and delays at customer locations.

3.6 Benefits and challenges related to ELDs

Understanding the benefits and challenges of ELDs will provide a comprehensive interpretation of the results and evaluation that are done in the forthcoming chapters of this study. The identified advantages and limitations of ELDs helped design the questionnaire used in the survey and the semi-structured interviews, all of which were used to collect data for this study.

3.6.1 Benefits of ELD Technology

The study was able to identify, through review of available literature and our initial interview with industry experts, several benefits associated with the implementation and use of ELDs. The benefits included the following: 1) reduction in cost, 2) improved load planning, and 3) improvement in driver safety and performance.

Reduction in cost

From a business operations standpoint, motor freight carriers discussed the cost savings from implementing ELDs. The first savings experienced by motor freight carriers are the reduction of administrative cost. Elog implementation eliminates the manual paperwork involved in purchasing and stocking logbooks, processing and archiving the paper logs (Pitera et al., 2012). In addition to administrative cost, some carriers experienced lower insurance premiums. The GPS tracking feature of ELDs lower the risk of a truck being stolen or hijacked, and therefore insurance companies offer better rates to companies with ELDs. If implementing ELDs would theoretically lead to a reduction in HOS violations (Pitera et al., 2012), then it would theoretically lead to a reduction in penalties applied to a motor carrier.

Improved load planning

ELD adoption has allowed load planners to instantly review a driver's up-to-date HOS and to quickly determine if a driver can safely deliver a load on time. The GPS function on ELDs also allows planners the ability to view where drivers are located, and the available hours each driver has, this allows the planner to quickly determine the closest driver with the most hours necessary to pick up and deliver the load (Pitera et al., 2012). Planners and dispatchers have also used elogs to quickly forestall any delay in delivery. Planners and dispatchers with up-to-date HOS can evaluate if a driver will not have enough hours to make delivery on time and contact the consignee to make alternative arrangements.

Improvement in driver safety and performance

ELDs as a monitoring device allows a carrier to monitor and analyze a driver's performance. Additionally, companies can track the amount of time a driver spends performing specific tasks such as loading, refueling, and border crossing. This constant monitoring serves two functions: [1] it serves as a deterrent for unsafe drivers, [2] it provides data that the company can use to improve their performance (Pitera et al., 2012). Industrywide ELD adoption will prevent truck drivers from driving fatigued, meaning most truck drivers on the road "should" be alert and well rested which in turn "should" lead to safer roads.

3.6.2 Challenges of ELD Technology

The study also identified through review of available literature and our initial interview with industry experts, several challenges associated with the implementation and use of ELDs. The challenges included the following: 1) less flexibility, 2) equipment limitation, 3) wasted time and 4) negative perception.

Less flexibility

Electronic logbook strictly enforces HOS regulations with no room for nuances. This means a drivers judgment of the situation is removed from the equation (Saltzman, 2002). A driver who starts his day may be forced to drive even though he is tired since his workday clock cannot be paused even if he stops to rest. On the other hand, a driver who has been delayed all day at a shipper's location may not have enough hours to drive even though he spent the whole day resting and is fully awake and alert.

Equipment limitation

ELDs come in various shapes and sizes, and different manufacturers offer various bells and whistle with their respective devices. Our initial interview with industry experts revealed some elog devices served as a bottleneck to a driver's productivity. One expert pointed out that some devices had a tendency of system failure, in which case a driver could lose any HOS of service not saved to the server. The various types of devices such as the standalone devices also limit the driver to operating the device in the truck cabin. The range of operability of standalone devices is limited to the length of the cable that tethers the device to the truck. Certain manufacturers offer cables long enough for the driver to operate the device from within the sleeper berth. Although, bring your own devices such as tablets have the flexibility of being operated anywhere, some drivers have reported that cold weather conditions affect the operability of some devices such as tablets when left in the truck overnight (Hausladen, 2017).

Wasted time

Although ELDs might save carriers time from processing paper logs, some industry experts in our initial interview claimed that they wasted the drivers time, one expert pointed out that although fleet management systems offered an elog function, the systems were not integrated, and drivers would waste time entering the same information multiple times. Indeed, a driver that accepts a load through the FMS has to enter information provided by the FMS (such as trailer number and BOL number) into the elog. Another example would be when crossing the border a driver must confirm it with the FMS and with the elog.

Negative perception

Most commercial drivers are attracted to the independence that long-distance driving offers them, and they view ELDs as an intrusive device meant to micromanage them. This negative perception affects how they interact with the device and how successfully they adopt the technology. Industry expert interview revealed that older drivers viewed the technology negatively and some drivers even resigned in protest of the company adopting the technology.

3.7 Implementing ELDs within the trucking industry

Cantor (2016) in his article developed a theoretical framework for how to implement real-time workplace monitoring and how it might influence team coordination activities. He explored the factors that affected the extent to which an organizations management and employees could benefit from workplace monitoring. The author believed that the amount of data collected on work productivity could represent an opportunity for improvement within a supply chain. According to him, organizations could analyze and leverage the performance data collected in order to design workplace productivity and hence supply chain improvements. The study supplemented the organizational information processing theory (OIPT) with the transactive memory system (TMS) in order to assist managers and supervisors promote improved workplace coordination with the information collected about an employee’s behavior. The author took into consideration all types of data collection tools used to track work performance, such as RFID (Radio Frequency Identification), GPS electronic logbooks, etc. The author pointed out the following recommendation for successful implementation of workplace tracking technology: [1] Managers should take into account the timing and process of rolling out the technology and its continued support. [2] Senior management should be involved in the procurement process. [3] The technology should be deployed on a rolling basis if possible. [4] Management should understand what features of the system workers and users are willing to tolerate.

The article concludes that whenever a workplace monitoring system is implemented, both managers and workers should avoid erroneous conclusions based on inadequate analysis of the data. The author determined that user training and continued employer support are critical components of a successful monitoring technology implementation.

The transition of paper log to electronic log not only involves a technological change but it also involves a change of company culture (Birkland, 2016). Dealing with the resistance to change involves establishing a clear vision for the ELD adoption and being transparent about the whole process (Birkland, 2016). Birkland (2016) in her article advised motor freight companies first to understand how the ELD technology could affect their overall business. Once a company knew how the technology affected their operations, they could explore the opportunity for more efficiency within their operations by automating the compliance process. Only then, could a motor freight company decide which device would fit their need; taking into account not to outgrow the device or having the device become obsolete (Birkland, 2016).

3.8 SUMMARY

In **Table 3.1** we summarize the relevant research and highlight the main point that they explored. The research developed by Cantor et al. (2009) will inspire the purpose of our study. The variables and constraints used by Pitera et al. (2012), will influence the methodology. In the following section, we will introduce and describe the research methodology used in our study.

Table 3.1 Relevant Research Summary

Sections	Authors	Main Point
Trucking position	McKinnon (2006)	Evaluates impact to economy of a complete disruption of the motor freight industry
	Xu et al. (2017)	Discusses the cost of Transportation within the supply chain
	Hossein et al. (2017)	Evaluates the importance of trucking within a supply chain
	Atwater et al. (2014)	Evaluates the importance of trucking within an economy

	Agrell et al. (2017)	Examined the governance structures of the trucking industry in Sweden and how it impacts the coordination between forwarders and carriers
	Manrodt et al. (2003)	Discusses the cost of Transportation within the supply chain
	Lummus et al. (2001)	Provides a detailed definition of a supply chain
HOS	Coiquaud (2016)	Determines the existence of a third time not tracked by HOS but affecting driver safety
	Drouin (2008)	Evaluated the impact of the 2007 changes to the motor freight law of 1987, proposed by Transport Canada.
Trucking tech	Rishel et al. (2003)	Presents findings on the benefits from carriers that adopt the use of satellite communication technologies.
	Manrodt et al. (2003)	Discusses the benefits stemming from both the shippers and the carriers on the adoption of mobile communications technology by motor freight carriers.
Safety tech	Cantor et al. (2009)	Theoretical and empirical evidence that electronic logbook adoption affects firm-level safety performance and identified factors that affected safety technology adoption
	Cantor et al. (2010)	Developed a voluntary compliance model for motor carrier safety by adopting electronic on-board recorder
Productivity tech	Cantor et al. (2011)	Investigated how procedural justice surrounding the proposed electronic logbook mandate may affect driver-level behavior
	Ellinger et al. (2003)	Analyzed motor carrier websites to illustrate the changing internet practices of the trucking industry's information technology (IT) capabilities
	Pitera et al. (2012)	Discusses the economic implication of on-board monitoring system through a benefit-cost analysis
	Starr McMullen (2010)	Examined to what extent IT impacts firm productivity

Implementing HOS recording devices	Cantor et al. (2010)	Developed a theoretical framework for how to implement real-time workplace monitoring
	Birkland (2016)	Discusses implementation strategies for ELD adoption by trucking companies.

3.8 Gap In Academic Literature

To help understand the impact of EOBR within motor freight carrier operations, we have provided a broad overview of adopting technology within the motor freight industry. We then narrowed it down to the specific topic that we will be focusing on; the economic implication of EOBR adoption. Within each section, we introduced the different literature on technology adoption by the motor freight industry, the methodologies that each author used and the conclusion of each study. The literature review confirmed that technology plays a vital role in a motor freight carrier's efficiency, performance, and safety.

Based on the review of the available literature, and to the best of our knowledge, we are unaware of any peer-reviewed study that has examined how EOBR adoption affects motor freight carrier business operations, specifically in Canada. Canadian motor freight companies facing a mandatory deadline of full EOBR adoption are struggling to understand how EOBR adoption will affect their business, and this presents a significant gap in knowledge regarding understanding the issues that several Canadian industry stakeholders will face when EOBR adoption becomes mandatory in the spring of 2019 (Smith, 2017). The research gap could be explained by the newness/novelty of this technology within North America, and we firmly believe that our research will contribute to exploring the benefits and challenges associated with mandating the Canadian motor freight carrier industry with EOBR adoption.

CHAPTER 4 METHODOLOGY

Yin (2003) proposes that researchers can increase the validity of their study by triangulation of the data collection method when investigating the research question of interest. This section will describe the research procedures employed in the study. These included: (1) Literature review (2) semi-structured interviews, and (3) survey data.

The literature review provided a clear picture about the role of technology within the motor freight industry, and how the adoption of technology within that industry can and has affected the industry. This chapter presents the methodology used to answer our research question.

4.1 QUALITATIVE AND QUANTITATIVE METHODOLOGY

Three research methods were considered to conduct this study; these included qualitative, quantitative and mixed-method methodology. A quantitative research methodology seeks to understand the relationship between two or more variables; this is done using data and statistical analysis (Vance et al., 2013). A qualitative research methodology seeks to explore what individual believe about a business problem; this is done by heavily relying on business leader's beliefs and how they make sense of that problem (Lee, 2014). A mixed-method research methodology seeks to obtain multiple opinions and beliefs, and collect verifiable data; this is done by incorporating both qualitative and quantitative research methodologies (Caruth, 2013). One of the roles of researchers is to determine the best study methodology to explore information about a study's question (Yin, 2014). Thus, the mixed-method research methodology seemed appropriate for this study. A quantitative correlational study in the form of a Canada wide survey was used to enable us to extract data that would address my research question and, qualitative research methodology in the form of interviews with industry experts will be used in order to validate the data and the conclusion drawn from that data. A logistic regression of the collected data will be used for analyzing the impacts and predictability of the various factors and help derive a conclusion from that data.

Quantitative correlational studies provide a researcher with a non-experimental approach to evaluate and understand the relationship between independent and dependent variables. (Marcelino-Sádaba et al., 2014; Welford et al., 2012). Welford et al. also stated that the statistical analysis of correlational studies allowed for predictions based on these relationships. Cantrell (2011) further defined non-experimental as a study that lacks manipulation of the independent variable and to which no participants are randomly assigned groups. Cantrell (2011) stated that a quantitative correlational study design does not require a control group or comparison group, for that purpose, the researcher for this study did not include a control group or a comparison group. Furthermore, Cantrell (2011) stated that quantitative correlational studies were especially useful for describing the current experience of participants and exploring that relationship among variables not easily manipulated by the researcher.

4.2 Ethical Considerations

All research must conform to TCPS 2 (Tri-Council Policy Statement) requirements, and HEC Research Ethics Board (REB). Prior to commencing data collection, research study approval was obtained from the REB, description of the research, questionnaires and all consent forms were submitted to the REB for approval. In addition to ethical consideration, we took additional actions to protect participant's confidentiality by [1] encrypting and locking all data in a locked drawer, [2] limiting access to the data to only the authorized researchers involved in the study, [3] assigning a unique identifier to each participant so that no name was used during the interview. As per REB requirements, all data will be kept for two years, after which all data will be destroyed.

4.3 Participants

Given the relevance of the research topic, industry stakeholders easily showed interest in participating in the study. The study participants included 146 industry experts in the Canadian motor freight industry, including drivers from multiple motor freight carriers throughout Canada. The study also included important industry stakeholders such as

Planners, Dispatchers, Driver Trainer, Safety Officer and Senior Management from a prominent Canadian motor freight company. All of our sample operators used elogs (electronic logbooks) and operated on either a regional basis or a national basis. Getting the point of view of multiple stakeholders, provided the study with a wealth of information and varying perspectives. The study sample size enabled an understanding and validation of the data collected and was therefore deemed appropriate (Suresh et al., 2012).

4.4 DATA COLLECTION - INTERVIEWS

Although there are multiple tools that can be used to collect qualitative data, we decided on semi-structured Interviews. Given the direct contact that participants granted the study, we were allowed to conduct face-to-face interviews in order to establish a comfortable relationship with the participants and allow any new idea to be brought up and explored ("Semi-structured interview", n.d.). A semi-structured interview is one where the interviewer provides a direction for the interview but is allowed to ask questions depending on the answers to the previous question (Gravel, 1986). All interviews were scheduled to allow enough time to explore any new ideas brought up during the interview. Semi-structured interviews can be inherently biased since they involve a conversation between two individual (Yin, 2003). Participants can be induced into answering questions in various ways depending on how the interviewer asks the question.

Prior to starting the interviews, an interview guide was built (see Appendix 1), and on the day of the interview, interviewees were explained the objectives and purpose of our study. Moreover, the interviewer encouraged and answered any questions that the participant might have. The interviewer also confirmed that all participants had signed their consent agreement forms and were fully aware of their privacy rights. Depending on the participant's native language or language of comfort, interviews were conducted in either English or French. No questions were asked about the participant's personal life or unrelated professional activities.

The interviews served two purposes: [1] Interviewing industry experts on the same topics and issues that are being assessed by the survey allows the researcher the possibility to use the expert's insight to explain observations and/or trends from the survey results. [2] Fine tuning the survey questionnaire. Although most of the information collected during the literature review helped in building the survey questionnaire, interviews with industry experts provided complementary information not collected during the literature review. Interviews conducted prior to the survey deployment allowed the researchers to fine-tune specific questions. Interviews conducted after survey deployment were insightful in illuminating and explaining trends. Table 4.1 below shows the number of interviewees and their role within the motor freight industry.

Group	**# of interviewees**
Drivers	10
Dispatchers	4
Planners	4
Driver Trainer	2
Safety Officer	1
Senior Management	1
Total	22

Table 4.1 industry role off Interviewees

All of the semi-structured interviews were conducted within a single company and most of the semi-structured interview participants had: [1] multiple years of experience within the motor freight industry, [2] worked with both paper log and electronic log, [3] worked in multiple motor freight companies throughout their work experience.

4.5 Data Collection - National Survey

In addition to the semi-structured interviews, a questionnaire was deployed throughout the Canadian motor freight industry in order to gather quantitative data about the subject. The Questionnaire contained 22 questions covering the following themes:

- Nature of the participants
- Characteristics of employer
- Perceived opportunities for ELD utilization

- Perceived challenges for ELD utilization

The questionnaire was primarily an electronic multiple-choice questionnaire with a paper version available for those who requested one. Information obtained during initial semi-structured interviews further fine-tuned the questionnaire, and that version of the questionnaire was translated into Canadian French. Both the English and French versions were pretested with five well-known industry stakeholders and academia, and the proposed amendments were adopted for a final version of the questionnaire which can be found in the appendix section of this thesis (see appendix 2 and 3).

The population of the survey was composed of commercial vehicle drivers, driver managers, and load planners within the Canadian motor freight industry. The survey was deployed to all the drivers of one large motor freight company by email within their weekly newsletter from which the link (**www.eldsurvey.ca**) to the electronic version was shared. The newsletter reached 536 drivers, 116 responded to the survey for a response rate of 21.6%. Moreover, the researcher attempted to increase the sample size by canvassing various truck stops and trucker gathering locations to solicit study participation and was able to gather an additional 26 responses totaling 142 survey responses[1]. As previously stated, 34 surveys had to be eliminated due to incomplete responses making for 108 usable survey responses.

4.6 VALIDITY OF THE COLLECTED DATA

The suitability and feasibility of a survey depends on how the researcher minimizes the following four types of errors: [1] measurement error, [2] sampling error, [3] statistical conclusion error and [4] internal validity error (Karlsson, 2009). This research minimized sampling error by only sending the survey to stakeholders within the industry. Participants of the survey had to be either commercial truck drivers, load planners or driver managers within a motor freight carrier firm. However, the sample was mostly composed of drivers from one company, which makes it difficult to extrapolate the results

1 Study had 146 study participants = 142 survey responses + 4 interviewees who did not take survey

to the whole Canadian industry. Measurement error was minimized by offering participants multiple choice questions from which they could choose their favorite choice. The internal validity of the study was confirmed since the conclusion of the survey reflected the opinion of the survey participants. Moreover, the external validity of the survey was confirmed since the conclusion of the study only applies to the Canadian motor freight carrier industry, and the results cannot be applied to any other Canadian industry, nor to the motor freight industry of any other country. There are two types of statistical conclusion errors, type 1 error and type 2 error. Given the type of study, the researchers focused on minimizing type 2 errors by obtaining a high sample size and obtaining a high p-value in the ANOVA test.

4.7 SUMMARY OF METHODOLOGY AND TRANSITION

Chapter 4 describes the several methodologies considered by the researcher, the research method, and the data collection method for the research project. In the study, we used a mix-method methodology to investigate how ELD implementation by motor carriers would affect a carrier's business operation. The chosen methodology provided the study the advantage of data (quantitative data) which was used to identify statistically significant trends from the results of the survey. The reasoning behind the trends is explained by the qualitative data gathered through the face-to-face semi-structured interviews with industry experts.

The next section will present a synopsis of the results obtained through the survey. The distribution of the data collected, regression models and a summary of significant trends identified from the data collected. At the end of the section, the survey will be analyzed and explained using information obtained during the face-to-face interview.

CHAPTER 5 RESULTS ANALYSIS AND DISCUSSION

This chapter of the thesis presents the analysis of the results of the ELDs survey and some of the findings discovered through interviews. The survey served as a significant source of data for the study analysis. It was possible to distinguish the perceived challenges, opportunities and favored proposals from industry stakeholders. Each set of results will be discussed in detail in order to identify the trends and provide an explanation of information provided by the specialists interviewed after the survey. The areas of concerns discussed in this section are as follows:

- Appreciation of ELDs by industry stakeholders
- Main opportunities with ELD adoption
- Main Challenges with ELD adoption
- Factors for successful implementation of ELDs

5.1 COMPOSITION OF SURVEY PARTICIPANTS

In order to get a clearer picture of the survey results, we have provided their demographic profiles. Table 5.1 below shows the number of individuals who participated in the survey and they are grouped according to their role in the motor freight industry.

Group	**# of participants**
Drivers	100
Dispatchers	4
Planners	4
Total	108

Table 5.1 Participation per industry role

The variety of the groups ensured that the survey would be able to capture the trends of the industry through the views of different experts. The survey sample is deemed well-distributed given that all the significant roles in the motor freight industry are represented, and the main stakeholders are represented by a larger number of participants.

The provincial presence of the participants is depicted in Table 5.2. As can be seen from Table 5.2, most of the participants came from Quebec and Ontario. This was to be expected given they are the two most populated provinces in Canada ("List of Canadian provinces and territories by population growth rate", 2016) and the company they work for is actively present in those two provinces, hence leading to the highest number of truckers (“Driver Shortage”, 2013). The survey was available online at the privately obtained domain name **www.eldsurvey.ca** and answered nationwide. Paper versions were mostly answered in Quebec truck stops by a sample of drivers from companies mostly based in Quebec.

Province	# of Participants
Quebec	57
Ontario	31
Nova Scotia	1
New Brunswick	4
B.C	5
Other Province	10
Total	108

Table 5.2 Provincial breakdown of participants

5.2 Results of Survey

5.2.1 Appreciation of ELDs by industry stakeholders

The appreciation of ELDs by industry stakeholders represents one of the main topics examined by our study. Consistent with the findings from our initial interviews, ELD stakeholders and operators indicated that using electronic logs was preferable than using paper logs. However, the experts pointed out that the drawbacks of the ELDs clouded the full appreciation of the technology. The study showed that a considerable amount of participants preferred using electronic logs. The interest of the stakeholders in adopting electronic log could come from the ease of use of ELDs. According to some drivers interviewed during the study, the fact that ELDs automatically calculated and displayed the available drive time saved them the time of having to calculate their available hours manually. In-office stakeholders such as planners and dispatcher/driver managers also preferred the use of electronic logs. Interviews with planners provided some insight into why office staff readily embraced the technology. First, we need to consider that RODS accuracy and HOS accuracy profoundly affects how loads and drivers are planned. Drivers with too few hours will not be planned for a load that needs to be delivered immediately.

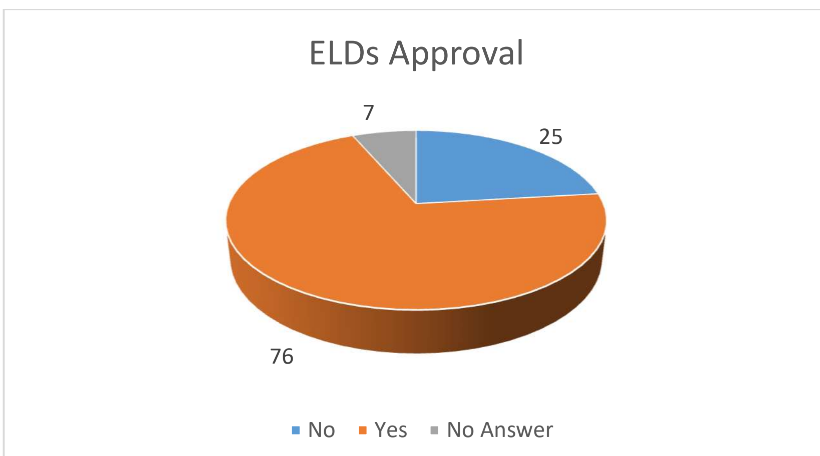


Figure 5.1 Graph of those who like ELDs vs. those that do not

	Yes	No	Blank
Driver	72	22	6
Dispatcher	1	3	0
Planner	3	0	1
Total	76	25	7

Table 5.10 Breakdown of ELDs Approval

Our initial interview with drivers prior to the survey questionnaire portrayed an industry were drivers disliked ELDs; it was, therefore, reasonable to hypothesize that drivers would prefer paper logs compared to electronic logs. However, the data failed to support that hypothesis. The high approval rate shows that most drivers within the motor freight industry support ELD adoption. Figure 5.1 shows a pie chart of participants who like ELDs versus those that did not. It is apparent from the pie chart that a majority of participants liked elogs over paper logbooks. Table 5.8 presents a breakdown of the various participants and whether they preferred elogs or paper logs. One unanticipated finding was that 3 dispatchers responded no to liking ELDs. Further investigation into this revealed respondent bias, these 3 dispatchers had incorrectly assumed the hypothesis being tested and answered the survey accordingly.

5.2.2 ELD main opportunities

During our initial interview, we were able to identify several opportunities perceived by the industry expert. After the literature review, we narrowed our list of opportunities to six main opportunities: [1] savings in time, [2] faster planning, [3] less driver fatigue, [4] less HOS violations, [5] more accurate RODS. The graphs below present the point of view of the drivers towards the opportunities that ELD adoption presents.

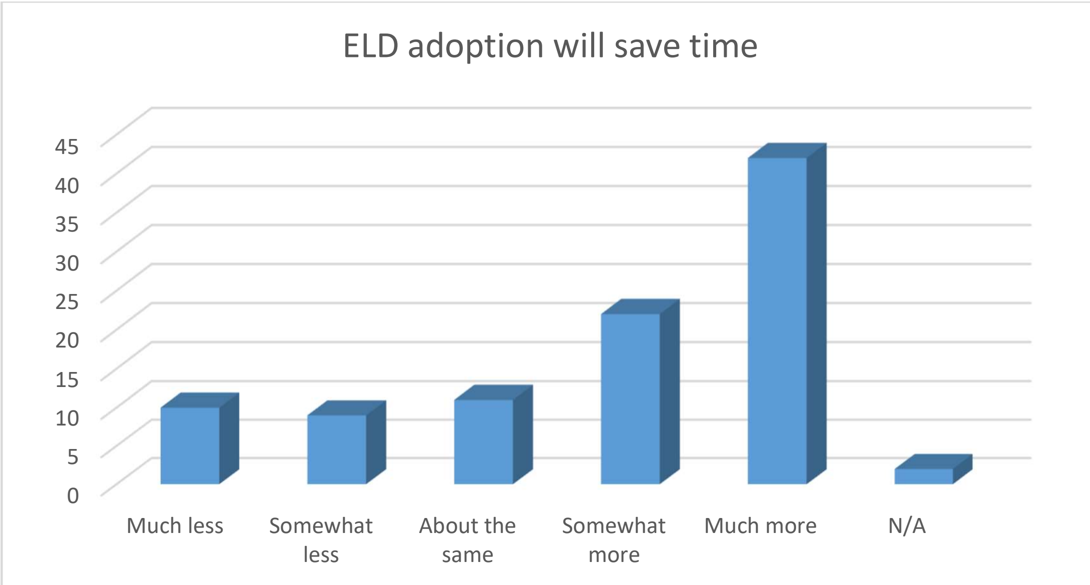


Figure 5.2 ELD perceived to save time

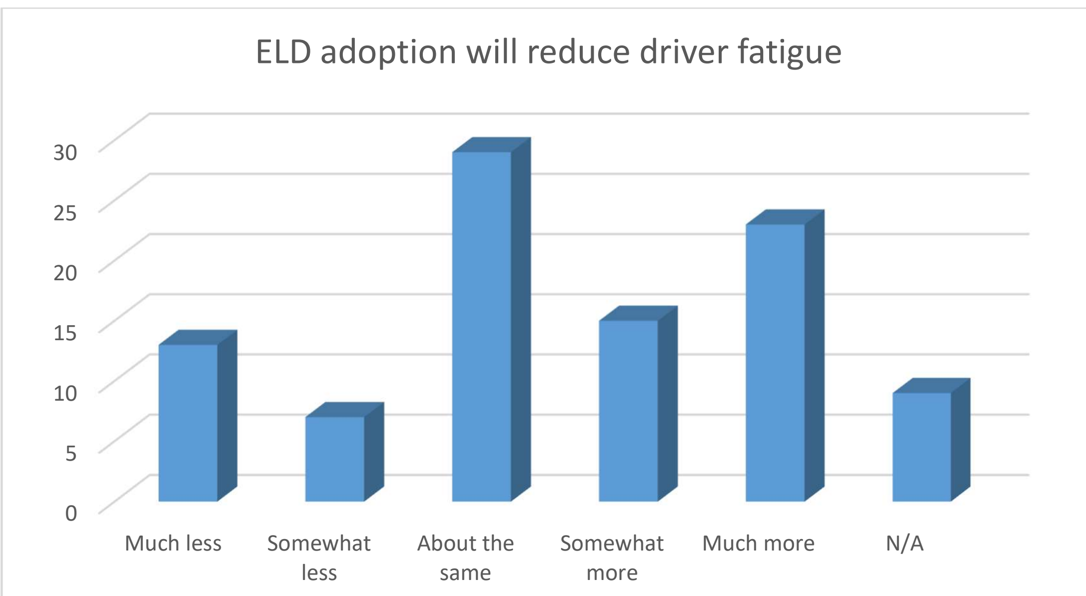


Figure 5.3 ELD perceived to reduce driver fatigue

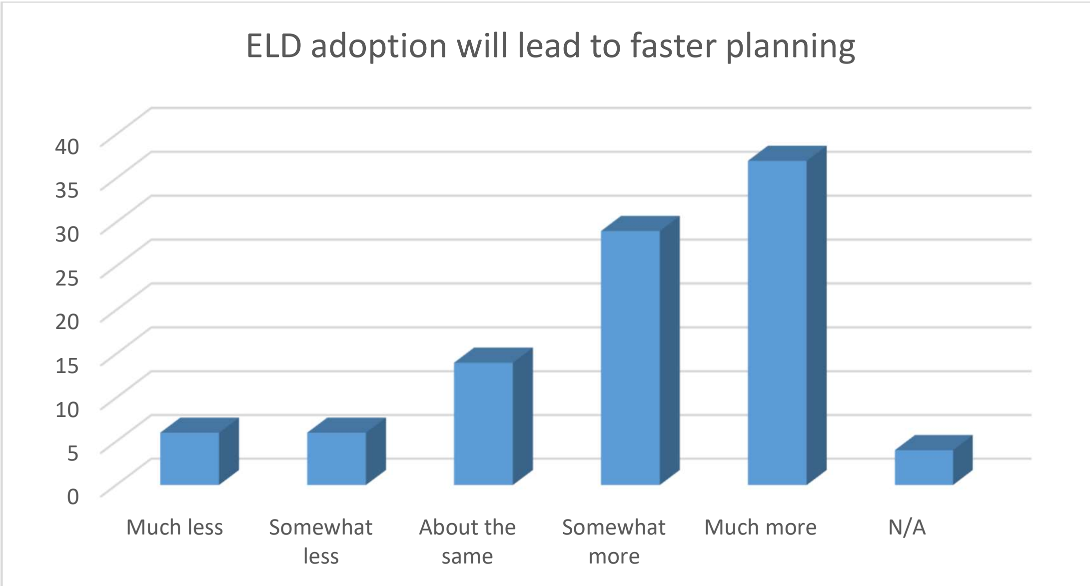


Figure 5.4 ELD perceived to speed up planning

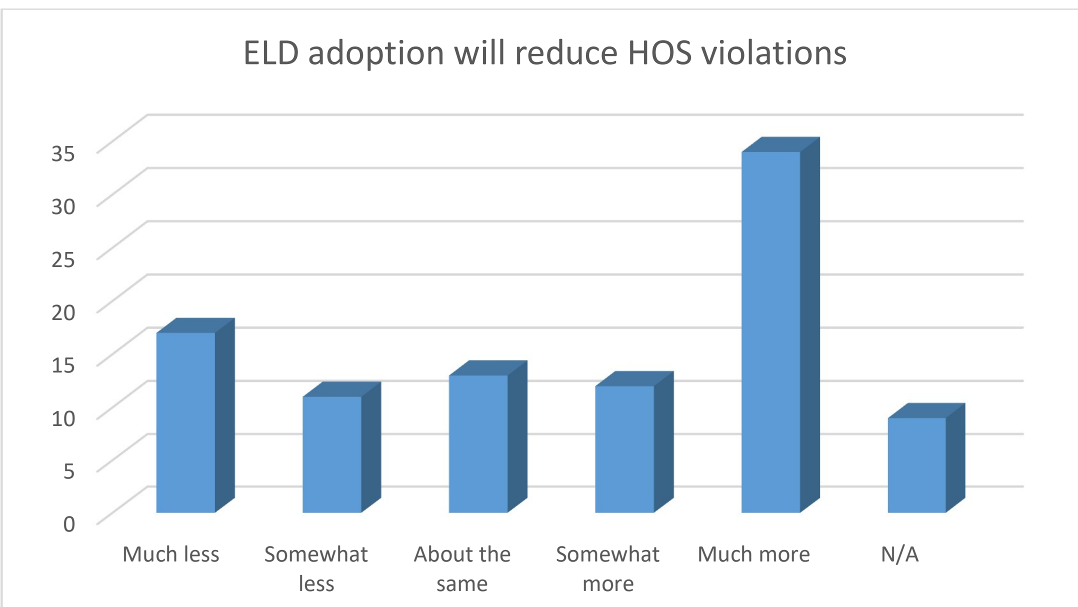


Figure 5.5 ELD perceived to reduce HOS violations

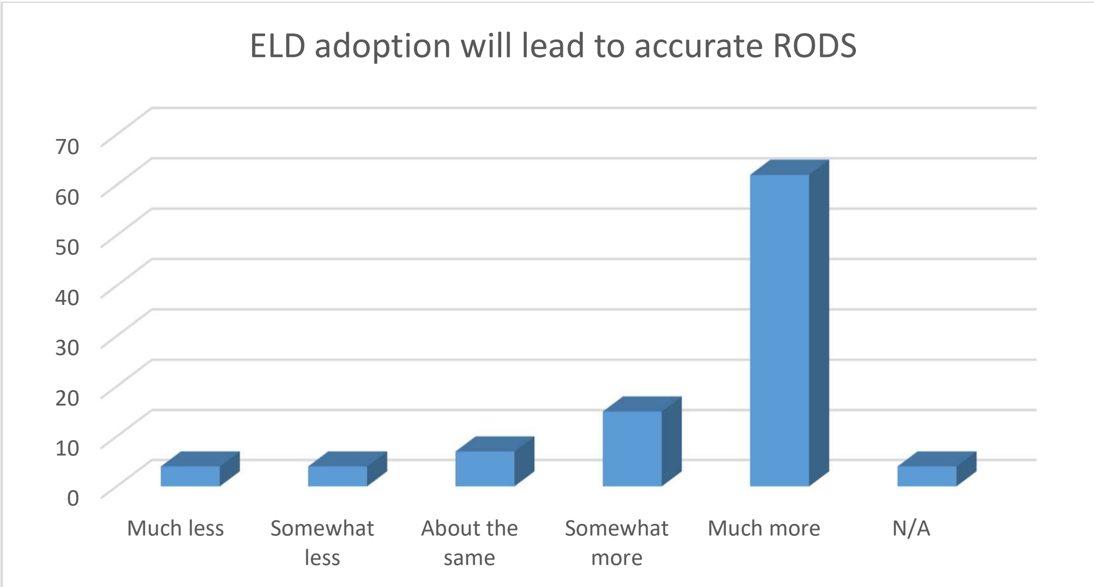


Figure 5.6 ELD perceived to lead to accurate RODS

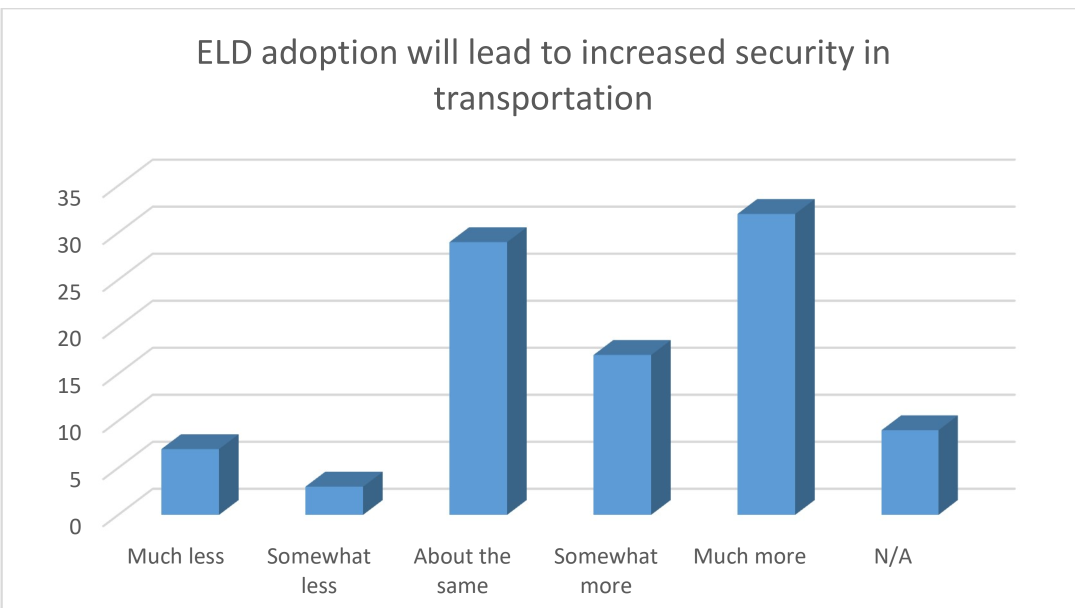


Figure 5.7 ELD perceived to lead to safer roads

As it can be observed in Figure 5.2 through Figure 5.7 drivers overwhelmingly agreed that ELDs provided savings in time, allowed for faster planning, helped reduce HOS violations, helped provide accurate RODS.

In surveying for time saved by using ELDs as one of the opportunities of ELD adoption, the results show a resounding agreement by most drivers that using ELD saves time. Figure 5.2 shows that a majority of drivers perceived much more time saved by using ELDs. During our initial interview with drivers, most drivers agreed that they had noticed palpable savings in time since switching from paper logs to electronic logs.

Figure 5.4 shows that most drivers viewed that ELD adoption would lead to faster planning decisions. A large number of drivers agreed that a motor freight carrier that had adopted ELDs could quickly plan drivers by quickly seeing their available HOS, and rapidly determining if the driver could safely deliver a load. Our initial interview included an interview with a Planner who indicated that he used the real-time data provided by the ELDs to quickly see who was available for a load, how close they were to the pickup location, and could they safely deliver the load.

As concerns drivers perceiving a reduction in HOS violations due to ELD adoptions, most drivers seemed to agree that ELD adoption would lead to much more reduction in HOS violations. Figure 5.5 shows strong agreement by participants that a carrier that adopts ELDs will notice a reduction in violations. This result matches with our findings during our initial interview with industry stakeholders. However, it should be noted that a manager interviewed during our initial interview recalled noticing a slight increase in HOS violation during the first few weeks of ELD implementation. After which, HOS violations dropped back to normal level before dropping below the normal level. The manager said the company had attributed that increase to drivers getting “use” to the devices. This manager also brought up the possibility that the initial increase was the exposing of drivers who in the past “fixed” their paper logs.

In surveying for RODS accuracy as a result of ELD adoption, Figure 5.6 shows overwhelmingly that participants perceived adopting ELD would lead to much more accuracy with the RODS. Post survey interviews with industry experts revealed that the ability to make corrections within the electronic logs ensured that the RODS were accurate. Drivers interviewed commented that as long as they took the time to review their HOS before approving it, their RODS, for the most part, was always accurate.

One of the goals for the ELD mandate is to improve road safety by strict monitoring of HOS and even stricter enforcement of HOS. Which is why the study surveyed participants to see if they perceived roads to be any safer as a result of ELD adoption. Figure 5.7 shows that the majority of participants viewed that ELD adoption would lead to safer roads. However, the participants seemed to disagree with the degree of safety. Post survey interviews with industry experts show that the disagreement in the degree of safety was a result of the varying perception into ELD effectiveness. One driver mentioned the fact that they had to share the road with noncommercial drivers who were allowed to drive as long as they wanted. Another driver remarked that ELDs reduced the "cowboy"[2] mentality that drivers in the past had, but he highly doubted it would make much of a difference in making the roads safer.

The survey, not surprisingly failed to show that drivers saw ELD adoption as a way to reduce driver fatigue. Figure 5.3 shows that a plurality of participants viewed that ELD adoption would lead to about the same amount of driver fatigue. Post survey interviews with industry experts provided some insight into why reducing driver fatigue was not viewed as an opportunity for ELD adoption. First, we need to consider the fact that drivers still experience fatigue despite strict regulation and strict enforcement by ELDs. HOS regulation provides a one size fits all approach to dealing with driver fatigue, and it fails to recognize that individuals have different circadian systems (Kerkhof, 1985) (Ingvild, 2011) and experience fatigue differently. One driver talked about how all he needed was 6 hours of sleep; a 10-hour reset would fatigue him making him start his workday tired. Drivers expressed their frustration when they spent a whole day sleeping at a shipper's location and when they were finally loaded and ready to go, they would not have enough hours despite being well rested. These factors may explain why participants did not perceive that ELDs would help reduce driver fatigue.

5.2.3 ELD main challenges

The second aim of our initial interviews was to identify the main challenges to ELD adoption, and the industry experts provided a wide range of challenges of ELD adoption. We were able to narrow the list of challenges down to six main challenges: [1] system

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[2] *One having qualities (such as recklessness, aggressiveness, or independence) ("Definition of COWBOY", 2018)*

breakdown [2] more observable HOS violation [3] more training [4] system not flexible [5] more errors in RODS [6] time wasted operating ELDs. As previously mentioned, some of the challenges identified were just the opposite of some of the identified opportunities. This was due in part to the disagreement among industry experts and among some of the available literature.

The graphs below present the point of view of the respondents towards the challenges that ELD adoption presents.

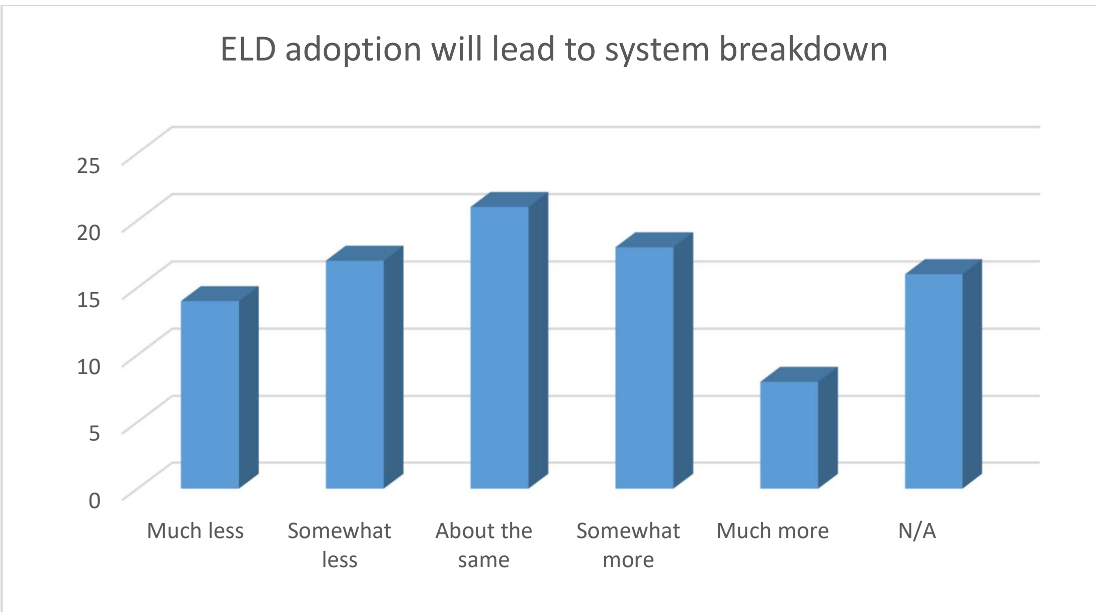

Figure 5.8 ELD perceived to lead to system breakdown

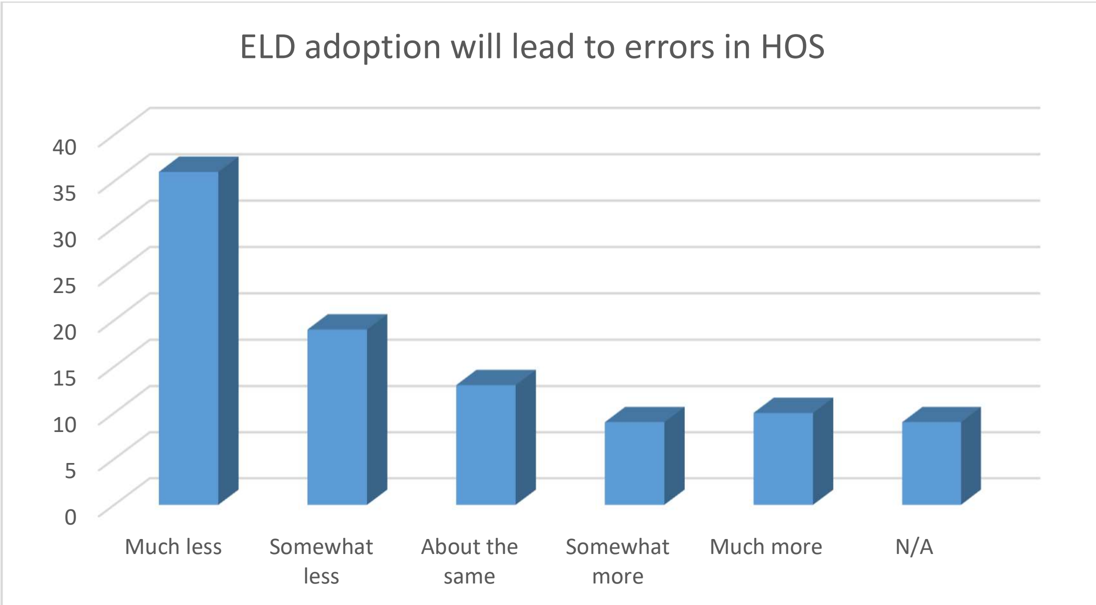

Figure 5.9 ELD perceived to lead to errors in HOS

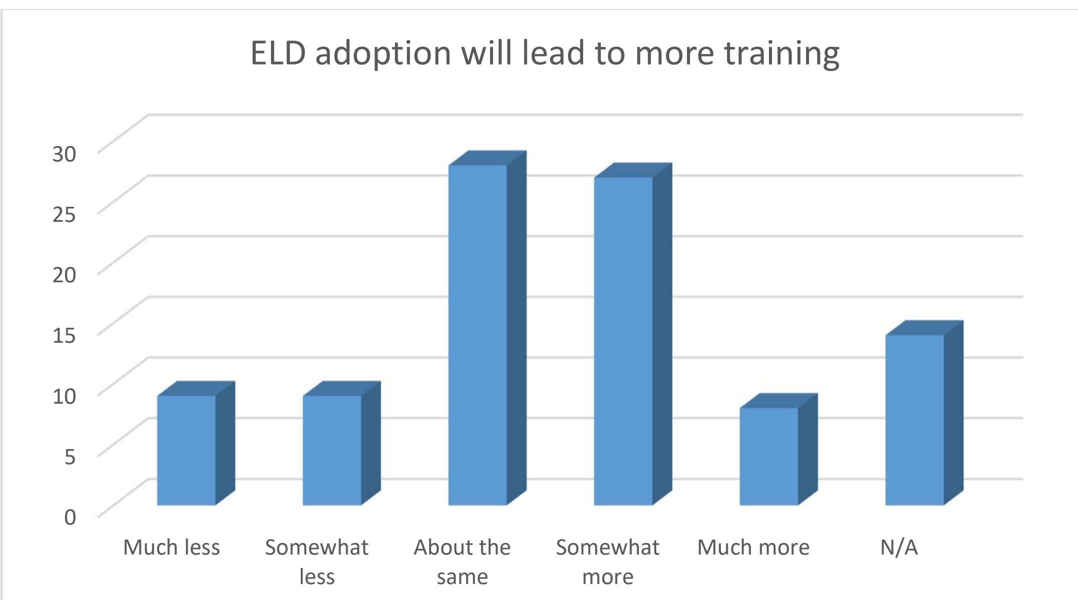

Figure 5.10 ELD perceived to lead to more training

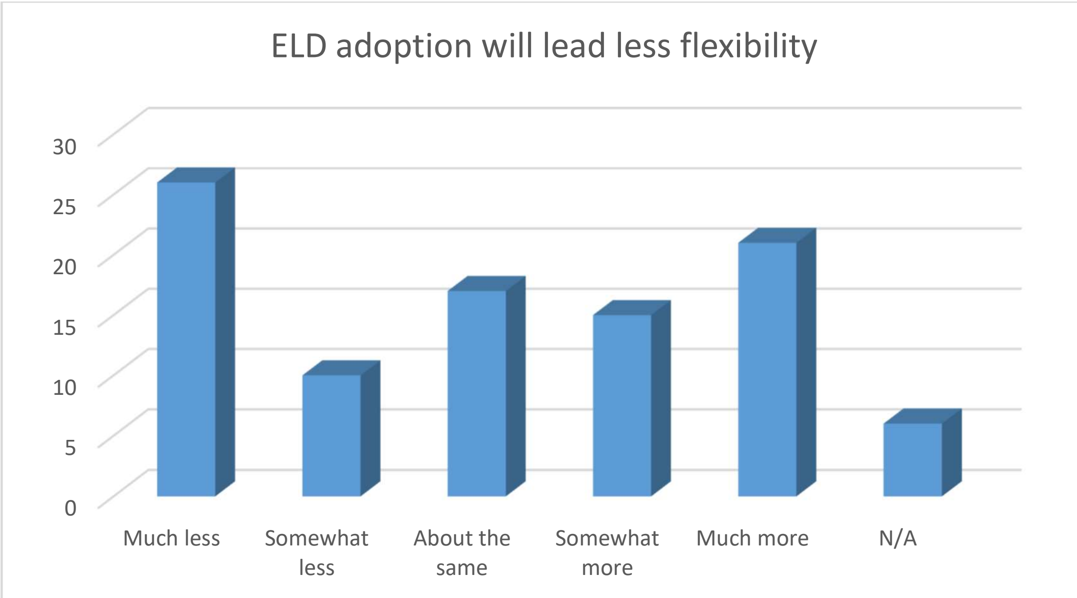

Figure 5.11 ELD perceived to lead to less flexibility

Figure 5.12 ELD perceived to lead to wasted time

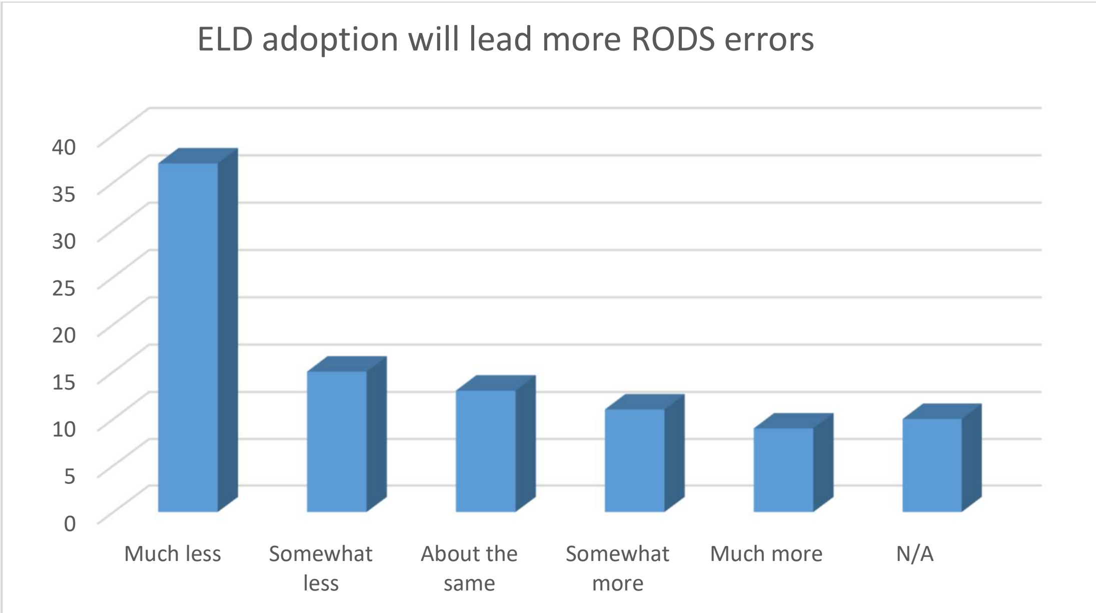

Figure 5.13 ELD perceived to lead to more RODS errors

As it can be observed in Figure 5.8, the results for ELD system breakdown was inconclusive, as drivers had mixed experience with the ELDs installed in their trucks. Post-survey interviews with drivers revealed that depending on how often a driver had issues with their devices they would view system breakdown as a challenge the more breakdowns they experienced. One driver had one major breakdown that lasted a week before it was resolved, although this driver did not have frequent breakdowns, that one event was enough for him to mistrust the device's reliability.

More observable HOS violation was deemed not to be a challenge by survey participants. Figure 5.9 shows that an overwhelming amount of drivers did not view that ELD adoption would lead to an increase in observable HOS violation. During our initial interview with industry experts, managers reported an initial increase in HOS violation; one planner attributed this observed increase as shinnying a light into the entire paper log "fixing" that drivers were previously doing. After the initial bump in HOS violation, drivers re-adapted, and HOS violations would drop back to previous levels.

Figure 5.10 shows that drivers view increased training as a challenge to ELD adoption. A large number of drivers agreed that ELD adoption would lead to an increase in training on the proper operation of the devices. Our initial interview included an interview with a driver trainer who indicated that he included ELD training as a major part of his curriculum. Post survey interviews with drivers corroborated the additional training involved in operating and being acclimated to the devices.

In surveying for the lack of flexibility as one of the challenges of ELD adoption, the results were inconclusive. Figure 5.11 shows that an equal amount of drivers found the lack of flexibility both as a challenge and not as a challenge. Our initial interviews revealed that ELDs enforced HOS regulations with lack for any nuances, whereas with paper logs some drivers tended to “fix” any unexpected issue that might arise. The possibility to “fix” paper logs afforded most drivers the flexibility of carrying out their duties while maintaining the appearance of being in compliance. Post survey interviews also provided a mixed result from participants.

Our literature review showed that ELDs would save time. However, some participants during our initial interview discussed the amount of time wasted entering information into the ELDs. ELDs integrated into an FMS sometimes require the driver to enter information multiple time into different forms within the system. Through further inquiry, we discovered that this inconvenience was limited to a popular brand from a large manufacturer of ELDs and we, therefore, assumed that this inconvenient would in-fact prompt drivers to view this as a challenge. Figure 5.12 shows that drivers overwhelmingly disagreed that ELD adoption would lead to wasted time as a challenge. Post survey interviews confirmed that a few models from this large manufacturer had many inconveniences that automatically led to wasted time. Drivers, however, did not hold these inconveniences against the devices.

During our initial interview, some interviewees discussed how many times the ELDs would incorrectly put them on duty, meanwhile they were off-duty, or sometimes the devices failed to put them on duty when they were coming back from lunch. Figure 5.13 shows that most drivers did not agree with this as being a challenge. Post-survey interviews confirmed the fact that drivers would occasionally have to fix errors within their elogs however, an overwhelming amount of drivers did not see this as being a challenge.

5.2.4 Factors for Successful implementation of ELDs

This study also attempted to determine the best tactics for a successful ELD implementation. Our initial interviews were able to identify multiple factors that assisted with a successful ELD implementation and after our literature review; the list of factors was narrowed to four main factors including: [1] Comprehensive training [2] Qualified trainer [3] User-friendly technology [4] Employer commitment.

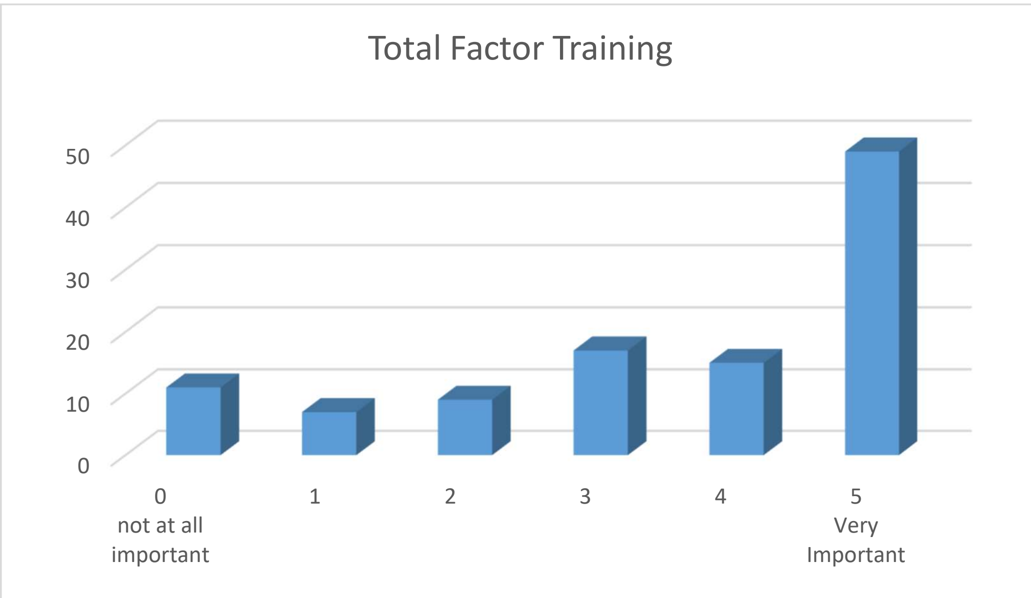

Figure 5.14 Training as a factor for successful implementation

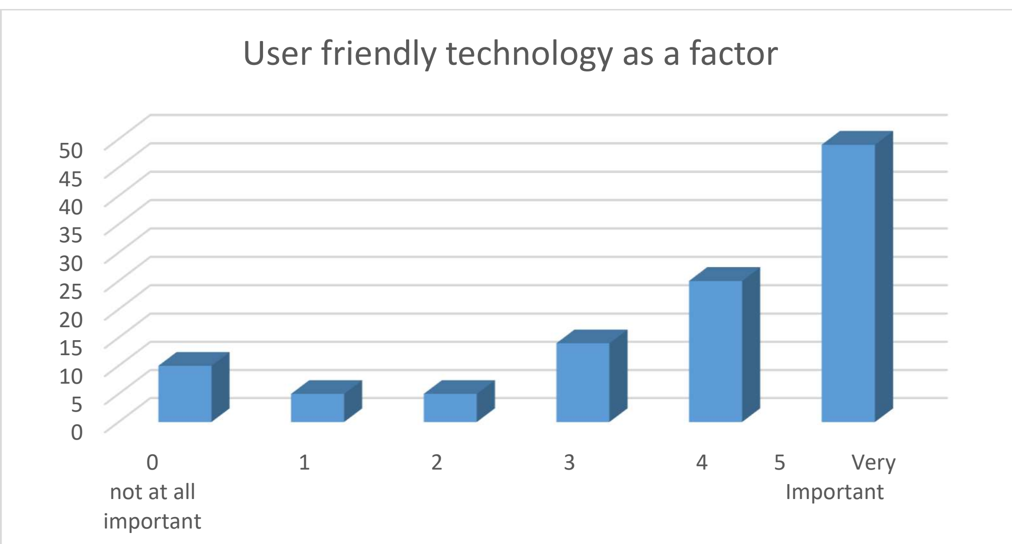

Figure 5.15 User-friendly technology as a factor to successful implementation

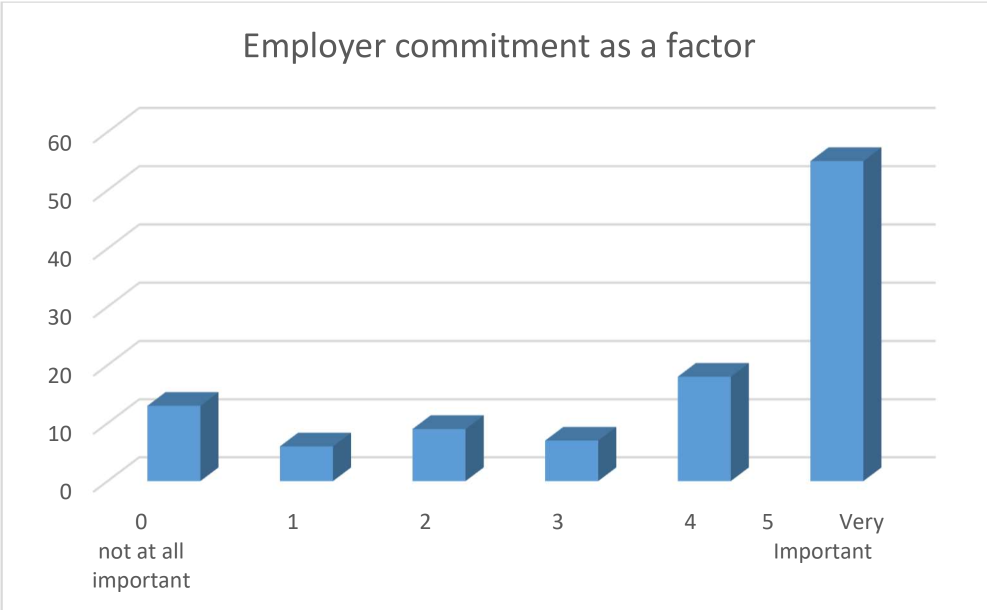

Figure 5.16 Employer commitment as a factor to successful implementation

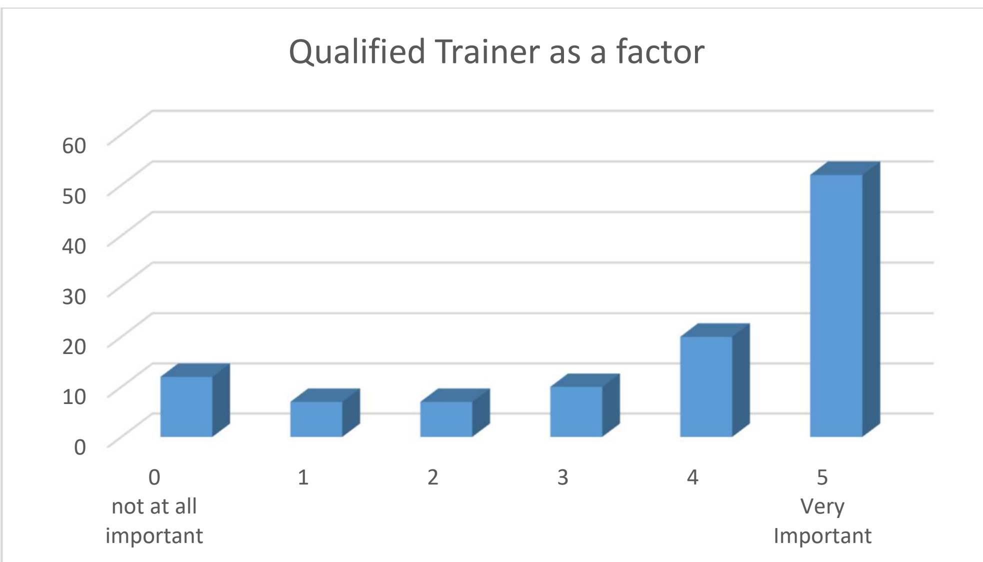

Figure 5.17 Qualified Trainer as a factor to successful implementation

Figure 5.14 through Figure 5.17 show that respondents overwhelmingly agreed that all four factors contributed to a successful implementation of ELD. Post survey interviews revealed that most drivers had received mandatory comprehensive training from their employer. Older drivers that were interviewed appreciated the amount of training they received, and given the current smartphone culture we live in, older drivers were not affected by technology readiness. Parasuraman (2000) defined technology readiness as a person's predisposition to adopt and use new technology for accomplishing their goals at work. The fact that most drivers operated a smartphone prior to receiving training allowed them to quickly embrace the technology despite any negative feelings that they might have against the technology. Unlike in Cantor (2010), who attempted to develop a voluntary compliance model for EOBR adoption, drivers surveyed and interviewed had already operated ELDs, were fully aware of the purpose of ELDs and knew what the capabilities of the devices were. Additionally, figure 5.14, figure 5.16, and figure 5.17 support Cantor's (2016) claim that user training and continued employer support are critical components for successfully implementing employee-monitoring technology.

5.3 ANALYSIS OF RESULTS

The results were analyzed and interpreted with STATA 14.0. The following tables provide a summary of the variables along with descriptive statistics. Tables 5.3 and 5.4 describe the detailed information about the dependent variable and independent chosen from the initial interview and from various literature. As previously mentioned, all of our sample operators used elogs (electronic logbooks) and operated on either a regional basis or a national basis. It should be noted that some of the challenges tested were just the opposite of some of the identified opportunities. This was due in part to the disagreement among industry experts and among some of the available literature.

Dependent variable	Definition	Obs	Means	Std dev
ELOG	Whether or not the user likes using elogs. The variable equals 0 if the user does not like using elogs and equals 1 if the user likes using elogs	101	.7624	.4278

Table 5.3 Definition of dependent variable[3]

[3] The Mean of the variable though not useful were provided for informational purposes

Independent Variables	Description	Obs	Mean	Std dev
TYPE	type of driver 1=Company driver 2=owner operator	100	1.05	0.329
YEARS	number of years of experience as a driver	108	9.351	10.67
PROBLEMS	frequency of problems with ELOG: 1=never 2=once a week 3=occasionally 4=frequently 5=daily	108	1.74	1.202
COMFORT (Time to get comfortable)	Time for the driver to get comfortable using elog : 1=less than month 2= between 1 - 2 months 3= between 2-3 months 4= more than 3 months	108	1.611	1.021
TIMESAVED	amount of time saved using elogs: 1=never used paper log 2=none 3=a little 4=moderate amount 5=a lot 6=a great deal	108	3.852	1.858
TRUCK	The age of the driver's truck. The variable equals numeric value of the age of the truck 1 = 2018/2017 2=2016 3=2015 4=2014 etc…	108	2.888	2.806
LOADS	country in which driver operates most of his loads 1=US 2=Canada	108	1.194	0.587
FACTORTRAINING	detailed & extensive training for successful elog implementation 1=extr useless 2=somewhat useless 3=neither useless or useful 4=somewhat useful 5=extremely useful	108	3.527	1.721
FACTORTRAINER	Qualified trainer for successful elog implementation 1=extr useless 2=somewhat	108	3.62	1.755

	useless 3=neither useless or useful 4=somewhat useful 5=extremely useful			
FACTORTECH	user friendly technology for successful elog implementation 1=extr useless 2=somewhat useless 3=neither useless or useful 4=somewhat useful 5=extremely useful	108	3.722	1.617
FACTORRESOURCES	employer commitment for successful elog implementation 1=extr useless 2=somewhat useless 3=neither useless or useful 4=somewhat useful 5=extremely useful	108	3.629	1.796
CHALLENGEHOURS	elogs leads to more observed HOS violations 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	2.315	1.984
CHALLANGEBREAKDOWNS	elogs are prone to system failures 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	2.657	2.114
CHALLENGETRAINING	elogs will need more training 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	3.064	2.132
CHALLENGEFLEX	elogs provide less flexibility in HOS 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	3.009	2.249
CHALLENGEERRORS	elogs will lead to more errors in RODS 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	2.25	2.001

CHALLENGETIME	elogs waste time 1=much less challenge 2=somewhat challenge 3=about same 4=somewhat more challenge 5=much more challenge	108	2.648	2.171
OPPORTIME	elogs save time 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	4.185	2.070
OPPORPLANNING	elogs provide for faster planning decisions 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	4.194	2.065
OPPORFATIGUE	elog implementation will lead to less fatigue 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	3.481	2.102
OPPORHOURS	elogs will lead to less HOS violation 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	3.546	2.248
OPPORACCURATE	elogs will lead to more accurate RODS 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	4.583	2.167
OPPORSECURITY	elogs will improve the overall security of transportation 1=much less 2=somewhat 3=about same 4=somewhat more 5=much more	108	3.852	2.148

Table 5.4 Definition of independent variable[4]

A logistic regression was also used to analyze the relationship between a participant's preference for electronic logbooks and the other variables being investigated. A logistic regression is a predictive analysis that is used when the dependent variable is binary/dichotomous, and the independent variable is either nominal, ordinal, interval or ratio-level. The independent variable is used as a predictor variable, and it allows one to

4 The Means of the variables though not useful were provided for informational purposes

see if the presence of that variable increases the odds of a given output. Given that our dependent variable is binary, a logistic regression seemed appropriate for modeling

	ELOGS	PROBLEMS	COMFORT	TIME	LOADS	TYPE	TRUCK	MANAGE
ELOGS	1.0000							
PROBLEMS	-0.2933*	1.0000						
COMFORT	-0.0606	0.2215*	1.0000					
TIME	0.4623*	-0.1344	-0.0848	1.0000				
LOADS	-0.0703	0.1250	0.1428	-0.0076	1.0000			
TYPE	-0.0262	-0.2177*	-0.1342	0.1608	0.1734	1.0000		
TRUCK	-0.2587	-0.0246	0.1554	-0.2702*	0.2003*	0.4726*	1.0000	
MANAGE	-0.0223	0.0609	0.1714	0.0109	-0.1468	-0.5677*	-0.2527*	1

* Significant at 5%

Table 5.5 Correlation of study variables

In order to test for multicollinearity, we ran a correlation matrix of the study variables. The results of that correlation matrix can be found in Table 5.5. Although multiple variables were correlated, none of them correlated above 0.70, which is the threshold for strong correlation. We thus concluded that multi-collinearity would not be a problem with our regression models.

begin with full model
p = 0.9034 >= 0.2000 removing YEARS
p = 0.9414 >= 0.2000 removing FACTORTRAINING
p = 0.8528 >= 0.2000 removing CHALLENGETRAINING
p = 0.7462 >= 0.2000 removing CHALLENGEERRORS
p = 0.7955 >= 0.2000 removing LOADS
p = 0.7186 >= 0.2000 removing FACTORRESOURCES
p = 0.5521 >= 0.2000 removing OPPORTIME
p = 0.5168 >= 0.2000 removing PROVINCE
p = 0.4960 >= 0.2000 removing MANAGE
p = 0.4585 >= 0.2000 removing REVENUE
p = 0.4828 >= 0.2000 removing OPPORFATIGUE
p = 0.4302 >= 0.2000 removing POSITION
p = 0.2575 >= 0.2000 removing PROBLEMS
p = 0.3074 >= 0.2000 removing OPPORHOURS
p = 0.3683 >= 0.2000 removing FACTORTRAINER
p = 0.3970 >= 0.2000 removing CHALLENGEHOURS
p = 0.2443 >= 0.2000 removing OPPORSECURITY

Logistic regression	Number of obs	=	101
	LR chi2(12)	=	72.97
	Prob > chi2	=	0.0000
Log likelihood = -18.89645	Pseudo R2	=	0.6588

ELOGS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
OPPORACCURATE	-0.9601	0.5518	-1.74	0.0820	-2.0416	0.1214
TYPE	4.2018	1.7824	2.36	0.0180**	0.7083	7.6953
CHALLANGEBREAKDOWNS	-0.5140	0.3230	-1.59	0.1120	-1.1471	0.1191
TRUCK	-0.7241	0.3117	-2.32	0.0200*	-1.3350	-0.1132
CHALLENGEFLEX	0.8853	0.3764	2.35	0.0190**	0.1475	1.6231
OPPORPLANNING	1.0676	0.5012	2.13	0.0330*	0.0852	2.0500
FLEET	0.0115	0.0072	1.59	0.1120	-0.0027	0.0256
EMPLOYEE	-0.0132	0.0084	-1.57	0.1150	-0.0297	0.0032
FACTORTECH	1.1134	0.4334	2.57	0.0100**	0.2640	1.9629
CHALLENGETIME	-1.2998	0.3759	-3.46	0.0010**	-2.0365	-0.5631
COMFORT	-0.6765	0.5187	-1.30	0.1920	-1.6932	0.3401
TIME	1.0635	0.3982	2.67	0.0080**	0.2830	1.8439
_cons	-1.4938	2.4166	-0.62	0.5360	-6.2302	3.2426

* $p<0.05$ ** $p<0.01$

Table 5.6 Results of Stepwise Regression Analysis 1

Iteration 0: log likelihood = -55.380863
Iteration 1: log likelihood = -42.771628
Iteration 2: log likelihood = -41.656942
Iteration 3: log likelihood = -41.643954
Iteration 4: log likelihood = -41.643943
Iteration 5: log likelihood = -41.643943

Logistic regression		Number of obs	=	101
		LR chi2(2)	=	27.47
		Prob > chi2	=	0.0000
Log likelihood = -41.643943		Pseudo R2	=	0.2480

ELOGS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
YEARS	-0.0503	0.0235	-2.14	0.0320*	-0.0964	-0.0042
TIME	0.7566	0.1850	4.09	0.0000**	0.3939	1.1193
_cons	-0.8531	0.6183	-1.38	0.1680	-2.0649	0.3587

* $p<0.05$ ** $p<0.01$

Table 5.7 Results of Regression Analysis 1

Iteration 0: log likelihood = -55.380863
Iteration 1: log likelihood = -40.884845
Iteration 2: log likelihood = -39.382043
Iteration 3: log likelihood = -39.36049
Iteration 4: log likelihood = -39.360488

Logistic regression		Number of obs	=	101
		LR chi2(3)	=	32.04
		Prob > chi2	=	0.0000
Log likelihood = -39.360488		Pseudo R2	=	0.2893

ELOGS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
TIME	0.7299	0.1896	3.85	0.0000	0.3584	1.1014
YEARS	-0.0514	0.0235	-2.19	0.0290	-0.0975	-0.0054
PROBLEMS	-0.4651	0.2229	-2.09	0.0370	-0.9019	-0.0283
_cons	0.2211	0.7885	0.28	0.7790	-1.3244	1.7666

* $p<0.05$ ** $p<0.01$

Table 5.8 Results of Regression Analysis 2

Iteration 0: log likelihood = -55.380863
Iteration 1: log likelihood = -38.867456
Iteration 2: log likelihood = -37.429703
Iteration 3: log likelihood = -37.412305
Iteration 4: log likelihood = -37.412282
Iteration 5: log likelihood = -37.412282

Logistic regression	Number of obs	=	101
	LR chi2(2)	=	35.94
	Prob > chi2	=	0.0000
Log likelihood = -37.412282	Pseudo R2	=	0.3245

ELOGS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
FACTORTECH	0.7754	0.2145	3.62	0.0000**	0.3550	1.1958
CHALLENGETIME	-0.6597	0.1608	-4.10	0.0000**	-0.9750	-0.3445
_cons	0.6015	0.7098	0.85	0.3970	-0.7898	1.9927

* $p<0.05$ ** $p<0.01$

Table 5.9 Results of Regression Analysis 3

Given the numerous variables, the researcher decided to perform stepwise logistic regression on the data to identify potential predictor variables. Table 5.6 provides the results of that stepwise logistic regression done by STATA on all the variables. The model provided by STATA has a strong global significance with LR chi^2 72.97. It also shows that the global significance of the model is acceptably low with a p-value of 0.0000 meaning that the correlation between the variables and ELD appreciation cannot be explained by chance. As it can be seen from Table 5.6, seven variables were statistically significant at the p<0.05 level. The variables TYPE, TIMESAVED, FACTORTECH, CHALLENGEFLEX, and OPPORPLANNING all have a significantly positive correlation with ELD appreciation, meaning that as these variables increase so does the odds of ELD appreciation increasing. However, variables TRUCK and CHALLENGETIME have a significantly negative correlation with ELD appreciation, meaning that as the variables increase so does the odds of ELD appreciation decreasing. The results of the stepwise logistic regression allowed the researcher to come up with three propositions that were tested using logistic regression. It should be noted that despite the fact that TYPE was statistically significant, not enough owner-operator drivers participated in the study and as such, this study did not attempt to identify any trends between owner-operator or company drivers because such an attempt would have led to a skewed result.

Proposition 1: Older drivers are less likely to adopt the technology.

The result of our first proposition testing appears in Table 5.7. The logistic regression shows that with 101 observations, the model has a medium global test of significance with LR chi^2 27.47. It also shows that the p-value of the global significance is acceptably low (.0000) meaning that the correlation between the variables cannot be explained by chance. From Table 5.7 we observe that TIME (the amount of time a driver saves by using ELDs) is statistically significant and positively correlated with whether they like using ELDs. Meaning that as the amount of time a driver saves by using ELD increases so does the odds of ELD appreciation by that driver. The other variable tested was YEARS (the number of years of experience a driver had in the industry), this was statistically significant at the $p<0.05$ level and negatively correlated to whether drivers liked using ELDs. In other words, the logistic regression showed that newer drivers or drivers with fewer years of experience were more likely to appreciate using ELDs. In other words, the more years of experience a driver had, the odds of ELD appreciation by that driver decrease. Post Survey interviews with industry experts supported this finding. It was generally agreed that a driver who had not known the paper logbook era was more likely to appreciate using ELDs. Drivers who had been driving before the adoption of AOBRD or ELDs seemed to appreciate that point in time within the industry more than today's current environment.

Proposition 2: The more benefits a driver gets from using elogs, the easier they will adopt the technology.

Our second proposition testing sought to examine how the frequency of ELD breakdown affected a driver's appreciation of ELDs. Although, stepwise regression helps identify statistically significant variables when there are too many variables, it inherently underestimates certain combination of variables. For that reason, the researcher reintroduced the variable PROBLEMS even though the stepwise regression model had discarded it. The results of that logistic regression appear in Table 5.8. This logistic regression shows that with 101 observations, the model has a stronger global test of significance compared to our first model with LR chi^2 32.04. It also shows that the p-value of the global significance is acceptably low (.0000) meaning that the correlation between the variables cannot be explained by chance. From Table 5.8 we observe that PROBLEMS (the frequency of problems a driver encounters with their ELDs) is statistically significant at the $p<0.05$ level, and negatively correlated to whether they will like using ELDs, meaning that the more often a driver face problems with their device, the less the odd of that driver appreciating using ELDs. Post survey interviews with industry experts also supported this finding. It was generally agreed that drivers who experienced multiple issues with their ELDs would be less likely to be satisfied with the technology. One driver who disliked ELDs commented that his device would freeze at least once a week, requiring him to frequently reboot the device. This result also falls in line with one of Cantor's (2010) premises that voluntary adoption of EOBR is determined by the user's technology readiness. Cantor (2010) described technology readiness as "the propensity of users to embrace and use new technology to accomplish goals". The logistic regression analysis strongly supports Cantor's (2010) claim. A driver that has less problems with their devices is better able to accomplish goals and hence can easily embrace the use of that technology.

Additionally, from Table 5.8 we observe that YEARS (a driver's years of experience), and TIME (time saved using ELD) similar to Table 5.7 remains statistically significant to a drivers appreciation of using ELDs. However, the model in Table 5.7 was improved by considering the variable PROBLEMS, resulting in the better and stronger model in Table 5.8.

> *Proposition 3: The more a driver likes the device they are using, the easier they will adopt the technology.*

The results presented in Table 5.9 represent the analysis of how FACTORTECH (drivers perception of a user-friendly elog device) and CHALLENGETIME (drivers perception of time wasted using the device) correlate with a driver's appreciation of ELDs. This logistic regression shows that with 101 observations, the model has a strong global test of significance compared to the previous other two models with LR chi^2 35.94. It also shows that the global significance is acceptably low with a p-value of (.0000) meaning that the correlation between user-friendly elogs and the perception of time wasted cannot be explained by chance. In this model, we observe that FACTORTECH (user-friendly elogs) is positively associated with ELD appreciation, and is strongly statistically significant to driver's appreciating ELDs. This means that the more drivers view their elogs to be user-friendly, the more the odds are they will appreciate ELD adoption. The findings of this model corroborate the ideas of Cantor (2016) who suggested that involving key users in the selection of monitoring technology was critical to the successful adoption of that monitoring technology. Having drivers participate in the selection of ELDs will ensure that they select a device that they consider more user-friendly to them.

The model in Table 5.9 also shows that perception of time wasted (CHALLENGETIME) has a significantly strong negative correlation with appreciating ELDs. This means that as the perception of time wasted using ELDs decreases, the odds of appreciating ELDs will increase. Posthoc analysis revealed that most participants viewed that they were saving time by using elogs. This finding confirms the association of time saved to ELD appreciation found in Table 5.7 that is approximately inversely proportionate to time wasted using ELDs found in Table 5.9.

Chapter 6 Implications of ELD adoption to Motor Freight Industry

The purpose of conducting this research was to explore the impact of ELD adoption to the Canadian motor freight industry. The results of this study may provide some insight into what motor freight companies can expect when ELD adoption becomes mandatory, as planned at the beginning of the 4th quarter of 2019 ("What to Know About the Canadian ELD Mandate", 2017). This insight may provide company leaders with strategies to improve company compliance and organizational performance. The population of this study included both management and drivers. The participants who responded to the semi-structured interview questions were purposefully selected to collect better data on how ELD adoption would influence the industry as a whole. Most interview participants addressed their opinion on the implications of ELD adoption by the motor freight industry. Their input enhanced this researcher's literature review and industry experience to shape the following chapter.

The findings of this study revealed four distinct presumptions to the impact on the motor freight industry: [1] decrease in capacity, [2] increase in spot market cost, [3] increase in transit time, [4] reshaping the trucking industry.

6.1 Decrease in Capacity

As of today, the motor freight industry is experiencing a shortage of qualified drivers, and many motor freight companies have noted a reluctance of new student drivers to remain within the driving profession (Ledlow, 2013). In the US, qualified drivers and drivers with many years of experience protested the ELD mandate prior to it being implemented, and some of them even pledged to retire from the profession if the mandate went through (Dills, 2014). It remains to be seen whether the ELD mandate in the US in fact did lead to an increase in drivers leaving the profession, however, if true, the Canadian motor freight industry awaits a similar fate when its own ELD regulation becomes mandatory. Dills (2014) in his article noted that prior threats about quitting the trucking profession when HOS regulations were being proposed were in-fact executed and he advised that current threats should not be viewed as idle treats (Dills, 2014).

Assuming that there is an increase in driver shortage, this would have a cascading effect on the industry as a whole. A shortage in drivers leads to a reduction in the number of trucks running lanes, which in turn means a reduction in industry capacity.

6.2 Increase to Spot Market Cost

The transportation spot market is a market in which unfulfilled and sometimes urgent demands are satisfied (Lindsey, 2017). In this market, shipments are tendered on a load-by-load basis by the shipper and carriers with capacity. The carriers would then offer a quote to fulfill the shipment (otherwise known as a spot quote). The strict enforcement of HOS by ELDs will force many truckers to park their trucks when they reach their driving limit, rather than squeeze the extra mile to reach their final destination (Black, 2018). A parked truck does not make any money for the driver or the motor freight company. This reduction in productivity has direct consequences on a motor freight company's bottom line, and motor freight companies will pass the cost of lost productivity to their shippers by increasing their spot quotes.

Spelic (2017), in his article, noted that US motor freight companies had observed a 15% decrease in productivity due to the fewer miles driven per day. In order to recover from this deficit, US motor freight companies had to increase their spot quotes by 5-10% (Spelic, 2017). Assuming that all conditions remain constant, the Canadian transportation spot market will also notice an increase in spot quotes. This increase will be especially true for companies that have newly implemented ELDs in their operations.

6.3 Increase in Transit Time

Transit time is the time it takes a carrier to transport a load from the shipper to the consignee. With a 13-hour maximum drive time allowed for Canadian truckers, ideally, a driver would drive the full 13 hours per workday. In ideal conditions, those 13 hours of driving would be spent accruing as many miles as possible in a day. However, drivers rarely encounter ideal conditions. Drivers are more than likely to run into traffic, detours, and delays during loading and unloading. These delays increase the likelihood that a driver clocks out before reaching their destination. With paper logs, drivers would keep on driving especially if they were not too far from their destination and these drivers would "fix" their paper logs to omit that violation. However, the ELD mandate strictly enforces HOS regulations forcing them to park thus turning what would be a same-day delivery into a next day delivery.

Cassidy (2018a) noted in her article that U.S motor freight companies had noticed an estimated 15% increase in transit time on deliveries (Cassidy, 2018a). The article noted that the cost to operate the trucks remained unchanged meaning that drivers were losing time because of ELD related disruptions. The increase in transit time is also dependent on the lane distance. Cassidy noted that U.S motor freight that covered lanes that were between 450 and 550 miles saw a 16.6% increase in transit time. However, lanes that were between 750 and 1000 miles saw a 10% increase in transit time. Assuming that all conditions remain constant, the Canadian motor freight industry will also notice an increase in transit times.

6.4 Reshaping the Trucking Industry

Motor freight companies usually have service maps that show the transit time per area of that map. With the increase of transit time and the decrease of driving time, companies have been forced to redraw their service maps favoring specific freight lanes over others. This is especially true for lanes that were once considered same-day delivery but have now been re-categorized as next-day delivery.

Cassidy (2018b) in her article noted that US motor freight companies were splitting themselves between long-haul freight and short-haul freight. Smaller carriers are refusing to do loads that are 450 miles or more. Long-haul freight is now being left for the larger carriers that have the ability to use a mix of line haul and local drivers to minimize the effects of the HOS "rigidity" placed by the ELD regulations (Cassidy, 2018b). These carriers rather than running loads dock-to-dock are now switching trailers in yards near the destinations and having their local drivers complete the last miles of the load. Cassidy (2018b) noted that large US motor freight companies adapted to using ELDs by turning themselves into integrated networks where they could drop and swap trailers at predetermined hubs within their network (Cassidy, 2018b).

The adoption of ELDs within the trucking industry has in effect placed an intense focus on delays or wait times at a shippers docks and their behavior towards those wait times. Rafter (2017) in his article noted that 63% of carriers and owner-operators that were surveyed said some shippers would make them wait more than three hours to get loaded or unloaded (Rafter, 2017). In today's ELD environment, this means that not every shipper will be viewed equally, and shippers that do not adapt to the new realities of the industry will have a hard time locating carriers that are willing to move their loads. Carriers lose productivity when they waste time waiting to be loaded or unloaded, and in an attempt to optimize their productivity some U.S carriers have been dropping shippers that have not adopted practices that speedup freight handling (Rafter, 2017).

CHAPTER 7 CONCLUSION

This study explored the impact of ELD implementation by Canadian motor freight companies by measuring the perception of ELD operators and stakeholders about the opportunities and the challenges of using ELDs within business operations. Through an extensive interview of 14 professionals with multiple years of experience within the motor freight industry, and surveying 108 participants from 6 provinces, this study was able to collect enough data to identify trends within the dataset and draw conclusions about the impact of ELDs within a motor freight company's operations.

The results showed an overwhelming amount of interest in using ELDs within a motor freight company's operation, and operators experienced opportunities in the following areas:

- Faster planning decisions
- Savings in time and paperwork
- Accurate records of duty status

The results also showed that operators experienced challenges in the following areas:

- Increased training
- Less flexibility in HOS

On a small scale, this study was able to corroborate some of the premises in Cantor (2010), and Cantor (2016) concerning the adoption of monitoring technology by truck drivers. Results showed that a driver's years of experience, the amount of time they perceived saving, the frequency of problems encountered with the device, and the user-friendliness of the device were all correlated to a driver's appreciation of ELD. Furthermore, the study was able to identify and validate factors that helped with the successful implementation of ELDs within Canadian motor freight carriers. Factors such as qualified trainers, user-friendly technology, employer commitment, and an effective training program, were all agreed to be essential factors in a successful ELD implementation.

Moreover, the results of this study in combination with industry observation allowed the researcher to make the following prediction of the future of the industry in the wake of mandatory ELD adoption:

- Older drivers and drivers not willing to adopt ELDs will leave the industry resulting in a decrease in market capacity.
- The cost of lost productivity will be passed onto the shipper increasing spot market prices.
- Strict enforcement in combination with real-world traffic condition will increase transit time.
- For carriers to remain productive, carriers will be more selective of their clients requiring the active participation of shippers and receivers.

7.1 STUDY LIMITATIONS

This research had various limitations, of which the clarity of certain questions in the questionnaire could have confused some respondents. Any potential confusion from respondents would have affected their answer to that question. We made every effort to reduce the problem posed by respondent confusion by conducting an extensive questionnaire pre-testing and by encouraging respondents to contact the researcher in the event a question was not clear to them. Notwithstanding our effort to avoid any confusion, it is likely that respondent confusion might still have been a factor in our study.

A second limitation involves how the data was collected during the qualitative interviews. Since all interviews were conducted and interpreted by the author, another researcher may have interpreted the data collected during interviews differently. Finally, the sample size collected for the study was limited, and it was mostly comprised of company drivers from the same company and severely lacked input from owner-operator drivers. Limited sample size and composition may lead to results that do not accurately depict the views of all stakeholders within the industry.

7.2 Future Research

The findings from this thesis have raised several topics that could be examined in the future. Future research could examine how ELDs have influenced the pricing of transportation for the motor freight industry. For example, ELDs have been believed to eventually lead to increased spot pricing in some regions of the country. According to multiple interviewees, the increased regulatory demands placed on motor freight companies would cause companies to increase their prices to remain profitable. This claim was beyond the scope of this research, and as such was not investigated; future studies could examine this claim.

The study predicted that ELD adoption would eventually lead to a transformation of the motor freight industry, especially in shippers playing a more active role in the operational performance of motor carriers by speeding up loading and unloading at their facilities, for example. Future studies could examine the changes and to what extent these changes have transformed the Canadian motor freight industry.

The study also predicted that ELD adoption would also lead to a decrease in market capacity and a drop in carrier productivity. Future studies could examine the drop in market capacity and the decrease in productivities and to what extent changes could be attributed to ELD adoption.

Another track for further studies generated by this thesis relates to how motor freight company managers use specific features of FMS technologies to improve operational performance. Future research could examine how managers act on the information provided by such technologies in their decision-making effort to improve organizational performance.

7.3 Summary

We drew on past research literature on EOBRs to theorize, strategize and investigate the influence of ELDs on the business operations of Canadian motor freight carriers. By focusing on Canadian motor freight companies that have already implemented ELDs in their daily operations, we were able to isolate the influence of ELDs on organization operations. The results of the data collected provide some fascinating insight into the extent of ELD influence in organization operations and performance. We found that implementation of ELDs within a motor freight operation increased organization performance and a driver's positive perception of the device. This finding, while antithesis to what we had expected, is not completely surprising. Roetting (2003) in their literature review, provided evidence that despite concerns of privacy from drivers and operators, they were open to systematic monitoring if the technology monitoring them was adequately designed and implemented.

APPENDIX

APPENDIX 1: INTERVIEW GUIDE

Interview Plan

Introduction of interviewer

Hello, my name is __________________________, During the interview, I would like to discuss the following topics: electronic logging deices, hours of service, driver fatigue, elog implementation, operational performance and planning decisions. With these topics in mind…

Electronic logging deices

Main Questions	Additional Questions	Clarifying Questions
• What are some of the challenges that elogs has over paper log? OR • What are some of the advantages that elogs has over paper log?	• How has that affected operations? • What improvements could be made to the system? • How do you explain the problem?	• Can you expand a little on this? • Can you give me some examples? • Can you tell me anything else?
• In your experience what are the factors that lead to elog violations?	• Why?	
• In your opinion, what are some of the factors to successfully implement elogs?	• Why?	
• In your opinion, why would respondents answer this particular question this way?	• Can you give me some examples?	
• Can you tell me about the how elogs has impacted operation?	• How much of an impact would this have on operations?	
Conclusion of Interview		
• Are there any other factors that you think could help reduce the violations OR • Do you want to add anything else on the impact of elogs to operation?		• Can you expand a little on this? • Can you give me some examples? • Can you tell me anything else?

APPENDIX 2: SURVEY QUESTIONNAIRE (ENGLISH PAPER VERSION)

Operational Impact of elogs

Dear valued member of the trucking industry, HEC Montreal School of Business is performing a Canada-wide study of the operational impact of electronic logging devices in the trucking industry. The goal is to identify the advantages and disadvantages of implementing ELogs in the operation of motor carriers. We need to know what your perception of different opportunities and challenges of interacting with this technology.

What type of Driver are you?

Company Driver ☐ Owner Operator ☐

What year is your truck ___________

How long have you been in that position?_________

What is the size your company's fleet?

- ☐ Less than 10 vehicles
- ☐ Between 11 and 50 vehicles
- ☐ Between 51 and 100 vehicles
- ☐ Between 101 and 500 vehicles
- ☐ More than 500 vehicles

Approximately, how many employees are there in your company?

- ☐ Less than 100
- ☐ Between 11 and 50
- ☐ More than 500

What are you company's revenues annually (roughly)?

- ☐ Less than $10 millions
- ☐ Between $10 million and $50 million
- ☐ Between $50 million and $100 million
- ☐ More than $100 million

Most of your loads are in?

☐ Canada | ☐ US

How much time have you saved using ELD vs paper log?.

☐ A great deal ☐ A lot ☐ A Moderate amount ☐ A little ☐None at all ☐ Never used paper log

How much time did it take you to be comfortable using the ELD?

Less than 1 month ☐ 1 – 2 months ☐ 2 – 3 months ☐ 3+ months ☐

How frequently do you encounter problems with the ELDs?

☐ 3-5 times per month ☐ 1-2 times per month ☐ Never

☐ Once every 2 months ☐ Other _______________

Do you prefer electronic logs to paper logs?

☐ Yes | ☐ No

What extent were these factors helpful in successfully training for ELDs?

	Extremely useless				Extremely useful	N/A
Detailed and extensive training	☐	☐	☐	☐	☐	☐
Qualified trainer	☐	☐	☐	☐	☐	☐
Easy to comprehend and user friendly technology	☐	☐	☐	☐	☐	☐
Commitment from employer with adequate resources (additonal traning, user manuel, phone support)	☐	☐	☐	☐	☐	☐

Continued

What do you perceive as the limiting factors for utilizing ELDs in your organization?

	Much less	Somewhat less	About the same	Somewhat more	Much more	N/A
More Hours of service violation	☐	☐	☐	☐	☐	☐
System breakdowns	☐	☐	☐	☐	☐	☐
Increased training	☐	☐	☐	☐	☐	☐
Less flexibility in hours of service	☐	☐	☐	☐	☐	☐
Errors in Records of Duty status	☐	☐	☐	☐	☐	☐
Wasted time	☐	☐	☐	☐	☐	☐

What do you perceive as the main opportunities for utilizing ELDs in your organization?

	Much less	Somewhat less	About the same	Somewhat more	Much more	N/A
Saving in time and paperwork	☐	☐	☐	☐	☐	☐
Faster planning decisions	☐	☐	☐	☐	☐	☐
Less Fatigue	☐	☐	☐	☐	☐	☐
Less hours of service violations	☐	☐	☐	☐	☐	☐
Accurate records of Duty status	☐	☐	☐	☐	☐	☐
Improve security	☐	☐	☐	☐	☐	☐

What are the most inconvenient factor about ELD that you have encountered? ____________________

Please share any additional comments or suggestions? ____________________

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APPENDIX 3: SURVEY QUESTIONNAIRE (FRENCH PAPER VERSION)

Impacts opérationnels des appareil ELog

En ce moment, HEC procède à une étude à l'échelle canadienne sur l'impact opérationnelle de l'introduction de l'Elog dans l'industrie du transport. Notre objectif principal est de mettre en lumière les avantages et désavantages de l'implantation de cette technologie dans les opérations des transporteurs. Nous voulons savoir ce que vous, en tant que premiers utilisateurs et membres touchés par les implications, pensez des différentes opportunités et défis apportés par cette nouvelle technologie.

Quel type de chauffeur?

Pour une compagnie ☐ À votre compte ☐

Année de votre camion ___________

Depuis combien de temps?___________

Quelle est la taille de la flotte de votre entreprise?

- ☐ Moins de 10 véhicules
- ☐ Entre 11 et 50 véhicules
- ☐ Entre 51 et 100 véhicules
- ☐ Entre 101 et 500 véhicules
- ☐ Plus de 500 véhicules

Approximativement, combien d'employés y a-t-il dans votre entreprise?

- ☐ Moins que 100
- ☐ Entre 101 et 500
- ☐ Plus de 500

Quels sont les revenus annuels de votre entreprise (environ)?

- ☐ Mois de $10 millions (Petit entreprise)
- ☐ Entre $10 million et $50 million (entreprise moyenne)
- ☐ Entre $50 million et $100 million (grande entreprise)
- ☐ Plus de $100 million (grande entreprise multinational)

La majorité de vos voyages sont à quel endroit?

☐Canada | ☐États-Unis

Combien de temps sauvez-vous grâce à l'utilisation du Elog versus le log papier?

☑Enormément ☐Peu beaucoup ☐Moyennement ☐Peu ☐Pas du tout ☐Jamais utilisé le log papier

De combien de temps avez-vous eu besoin avant de vous sentir à l'aise d'utiliser votre appareil ELog?

Moins de 1 mois ☐ 1 - 2 Mois ☐ 2 – 3 Mois ☐ 3+ Mois ☐

À quelle fréquence rencontrez-vous des problèmes avec votre ELD?

☐ Quotidiennement ☐ 2 - 3 fois par semaine ☐ Jamais

☐ 4 - 6 fois par semaine ☐ Une fois par semaine

Quelle est votre preference?

☐Log électronique | ☐Log papier

Jusqu'à quel point les facteurs suivants ont-ils contribué à votre apprentissage de appareils ELog?

	Extrêmement Inutile				Extrêmement Utile	N/A
Sessions de formation détaillées et approfondies	☐	☐	☐	☐	☐	☐
Entraineurs qualifiés	☐	☐	☐	☐	☐	☐
Technologie facile à comprendre et à utiliser	☐	☐	☐	☐	☐	☐
Implication de l'employeur à l'aide de ressources adéquates (formation supplémentaire, manuel d'utilisation, support téléphonique)	☐	☐	☐	☐	☐	☐

Continued

Que percevez-vous comme étant des facteurs limitatifs de l'utilisation des appareils ELog?

	Beaucoup moins	Un peu moins	À peu près le même	Un peu plus	Beaucoup plus	N/A
Augmentation des violations d'heures de service	☐	☐	☐	☐	☐	☐
Pannes ou erreurs du système	☐	☐	☐	☐	☐	☐
Augmentation du besoin de perfectionnement	☐	☐	☐	☐	☐	☐
Diminution de la flexibilité des heures de service	☐	☐	☐	☐	☐	☐
Erreurs d'enregistrement des heures de service	☐	☐	☐	☐	☐	☐
Pertes de temps	☐	☐	☐	☐	☐	☐

Que considérez-vous comme étant les principaux avantages de l'utilisation des appareils ELog?

	Beaucoup moins	Un peu moins	À peu près le même	Un peu plus	Beaucoup plus	N/A
Économie de temps et de papier	☐	☐	☐	☐	☐	☐
Planification plus rapide	☐	☐	☐	☐	☐	☐
Réduction de la fatigue	☐	☐	☐	☐	☐	☐
Réduction des violations d'heures de service	☐	☐	☐	☐	☐	☐
Registre précis des heures de service	☐	☐	☐	☐	☐	☐
améliorer la sécurité	☐	☐	☐	☐	☐	☐

Quel est le plus grand inconvénient que vous avez rencontrez lors votre utilisation des appareils ELog? ____________

____

____

____

Tous autres commentaires ou suggestions sont bienvenus et appréciés? ____________________

____

____

____

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