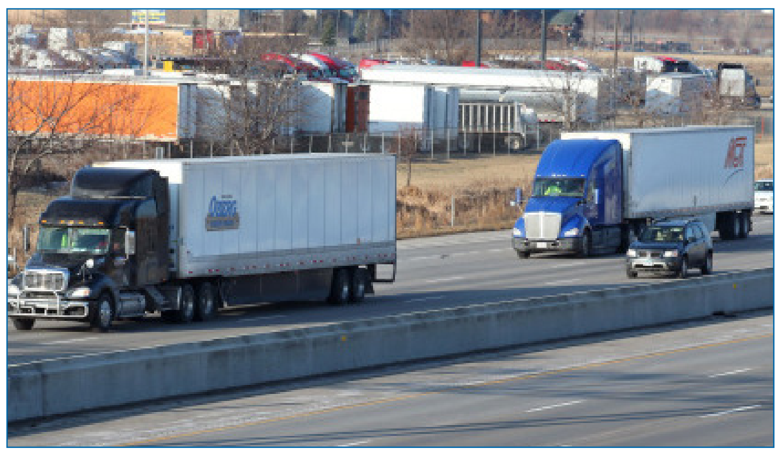
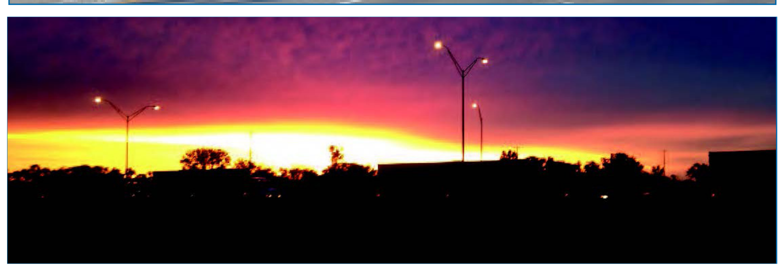
Development of a Transportation Real-Time Technology Readiness Framework

Final Report
March 2017





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16. Abstract

The purpose of this study was to develop a proof-of-concept carrier technology readiness framework. While substantial investment has been made into the Iowa Department of Transportation (DOT) Traffic Operations Center, scant attention has been paid to how carriers that operate in the state are currently collecting, monitoring, and routing commercial traffic based on real-time or near real-time highway traffic conditions.

This study represents an initial step to understand to what extent carriers are ready to utilize real-time traffic operations data and the associated business, technical, and regulatory challenges with using the data. The team developed a technology framework that captures the types of traffic operations data that carriers could gain access to and the associated business and technical challenges that carriers face when attempting to integrate the data into their business operations.

Furthermore, the study uncovers some of the benefits that carriers can derive from access to real-time data feeds. A unique opportunity exists to explore the benefits and challenges associated with providing the motor carrier industry with access to real-time data transportation feeds.

This study helped evaluate how data maintained at state traffic operations data centers could prove to be useful to the motor carrier industry. In combination with in-cab and centralized information technology capabilities, it is possible that the traffic operations data could lead to safety, operational, and financial benefits to the industry. This study increases our understanding of the issues that several industry stakeholders identified during the course of our investigation.

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Principal Investigators
David E. Cantor, Associate Professor
College of Business, Supply Chain and Information Systems, Iowa State University

Neal Hawkins, Associate Director
Institute for Transportation, Iowa State University

Neal "Skip" Foster Jr.
Freedom Express, Inc.

Research Assistant
Matthew Tekippe
College of Business, Supply Chain and Information Systems, Iowa State University

Authors
David E. Cantor, Neal Hawkins, and Neal "Skip" Foster Jr.

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A report from
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 / Fax: 515-294-0467
www.intrans.iastate.edu

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1. INTRODUCTION

A continued topic of great concern in the U.S. motor carrier industry is the serious fatal and non-fatal crashes occurring on our nation's highways. Beyond the unfortunate consequences associated with motor carrier crashes, there are also negative financial and operational consequences (e.g., traffic delays and impact on the continuity of the supply chain) because of poor safety performance.

Traffic congestion is also a subject that is commonly discussed at the national, state, and local levels. The American Transportation Research Institute (ATRI) reported that traffic congestion resulted in 728 million hours of delays at a cost of about $49.6 billion to the trucking industry (Brewster et al. 2015). Stated otherwise, lost trucking productivity amounts to 264,781 commercial trucks sitting idle for an entire year.

These safety and congestion situations occur for a variety of reasons. Increasingly, these adverse events occur due to the lack of real-time, accurate, and timely information about road conditions, adverse weather situations, road and bridge maintenance, etc. The advanced notification of this and other road condition information could prove to be useful in the re-routing of commercial traffic away from traffic congestion and potentially hazardous situations.

Indeed, there is a proliferation of the use of information technology solutions in the U.S. motor carrier industry. Many commercial motor carriers are implementing in-cab technologies to facilitate operational and safety improvements in the industry. For example, several companies in the industry have adopted global positioning system (GPS) technology to track the movement and security of freight in the supply chain (Husley 2014). Because of a mandate by the Federal Motor Carrier Safety Administration (FMCSA), a large number of carriers will soon be required to adopt electronic logbook devices (ELDs) to record the operating and non-operating time of commercial drivers for hours of services (HOS) purposes.

Given the vast volume and complexity of transportation management transactions that occur on a daily basis, many firms are implementing information technology capabilities to coordinate the flow of freight. In fact, several large motor carriers are implementing enterprise software applications to facilitate the management of the customer order and fulfillment process. Oracle Corporation is a vendor that provides software to handle transportation management services.

With support from the Iowa Department of Transportation (DOT) Office of Traffic Operations, this study focused on exploring some of the factors associated with the future adoption of real-time data feeds from Iowa's Traffic Operations Center. Briefly, the Iowa Traffic Operations Center monitors in near real-time the operating status of many road segments across national, state, and local roadways.

Using closed circuit cameras and road sensors, the Iowa Traffic Operations Center monitors and records road speeds, crashes, traffic delays, and other events. The information is then routed to appropriate state and local officials for planning and emergency response purposes. The public is also provided access to a subset of this information on Iowa’s 511 website.

This study helped evaluate how data maintained at the state’s traffic operations data center could prove to be useful to the motor carrier industry. In combination with in-cab and centralized information technology capabilities, it is possible that the traffic operations data could lead to safety, operational, and financial benefits to the industry.

A brief review of the academic literature follows. We will then present the methodology employed that enabled us to explore some of the factors associated with the future adoption of real-time data feeds from the Iowa Traffic Operations Center. We then present our research findings. Recommendations for future research next steps are discussed after that, followed by a brief conclusion for this study.

2. LITERATURE REVIEW

A steady stream of academic literature exists on the topic of information technology adoption and usage patterns in the motor carrier industry. We present a brief discussion on some of this literature to demonstrate that very few research studies exist regarding the interface of real-time technology data feeds and commercial trucking operations.

2.1 Mobile Technology Literature

One important stream of motor carrier technology research focuses on mobile technology adoption practices. Manrodt et al. (2003) discuss the benefits derived by both shippers and carriers on the use of mobile communications technology by motor carrier firms. Rishel et al. (2003) conducted interviews of multiple shippers and present findings on the benefits that result from carrier use of satellite communication technologies. Hubbard (2003) provides empirical evidence that on-board computers have increased available capacity in the U.S. motor carrier industry. Giaglis et al. (2004) propose a new vehicle routing system based on the potential benefits from vehicle routing technologies in distribution management.

2.2 EDI Connectivity

Electronic data interchange (EDI) is another area of motor carrier research interest. Johnson et al. (1992), Millen (1992), and Crum et al. (1998) discuss EDI usage practices in the motor carrier industry.

2.3 Technology Productivity

Some researchers have examined the role of information technology and productivity in the trucking industry. Golob and Regan (2002) identify operational characteristics that influence motor carrier decisions to adopt information technology practices. Ellinger et al. (2003) content analyzed motor carrier websites to illustrate the changing internet practices of the trucking industry’s information technology (IT) capabilities. Belman and Monaco (2001) discuss how only one factor has resulted in increased truck driver wages: information technology. Researchers have also examined to what extent IT impacts firm productivity (Starr McMullen 2010).

2.4 Safety Technologies

Several studies have focused on the role of IT and safety in the motor carrier industry. At the time of their study, Cantor et al. (2006) found that motor carriers were at an early stage of adopting safety technologies. In a subsequent study, Cantor et al. (2009) identified several factors that affected safety technology adoption. Likewise, Cantor et al. (2009) presented theoretical and empirical evidence that electronic logbook adoption affects firm-level safety performance. Because perceived fairness issues may affect the benefits provided by safety technologies, Cantor et al. (2011) investigated how procedural justice surrounding the proposed electronic logbook mandate may affect driver-level behavior. McDonald and Brewster (2008) conducted a survey on issues that affect use of speed-limiting devices on large trucks.

2.5 Gap In Academic Literature

Based on our review of the literature, and to the best of our knowledge, we are unaware of any previous peer-reviewed studies that have examined the factors associated with the use of real-time data from a state government's traffic operations center in the U.S. motor carrier industry. We believe a unique opportunity exists to explore the benefits and challenges associated with providing the motor carrier industry with access to real-time data transportation feeds. Therefore, this study attempts to increase our understanding the issues that several industry stakeholders identified during the course of our investigation.

3. RESEARCH METHODOLOGY

Because the purpose of this study was to develop initial insights into the motor carrier industry's readiness to use real-time transportation data in their business operations, we developed an initial set of open-ended questions to learn more about a firm's interest in adopting real-time technology feeds from the Iowa Traffic Operations Center. A four-step process was followed to develop the company-level interview questions.

The first step consisted of reviewing the motor carrier literature. Based on the literature review, we found that limited insights exist on motor carrier technology adoption except for that in a small number of studies. After careful consideration of the limited existing research, the research team proceeded to create interview questions that were directly relevant to the purpose of this study.

The next step involved developing a list of preliminary questions in consultation with Iowa State University faculty and staff and Iowa DOT representatives. The questions developed were categorized into four broad areas including transportation technologies and providers, organizational technology practices, freight management practices, and predictive analytics.

The list of transportation technologies was generated based on the existing motor carrier technology literature. The organizational technology practices items were added to the survey in order to understand how difficult it is for firms to respond to changes in the motor carrier industry. The freight management practice items seek to understand the process and challenges associated with the order management and delivery dynamics associated with moving freight in the industry.

A third step entailed consulting with an industry expert who reviewed the refined survey instrument. The industry expert had 40 plus years in the industry and managed his own trucking operation. In addition, the research team solicited feedback on the focus of the study from an industry association and from the Iowa DOT Freight Advisory Council. Based on the feedback received, the interview questions were modified to ensure for external validity.

After collecting feedback, a final version of the open-ended list of interview questions was produced.

Due to the dynamics of the motor carrier industry, the research team desired a sample of motor carrier companies that was diverse in nature. Stated otherwise, the team preferred a sample of companies that was composed of carriers of varying size, technology capability, and geographic scope of operations. The sample did not need to be restricted to firms that only operated in the Iowa.

The research sample consisted of motors carriers that represent a cross section of the industry including van, temperature controlled, flatbed, and intermodal. In addition, we reviewed carriers that exclusively used owner-operators, company power units, and a combinations of both types of operations. We also included firms that provide third-party logistics (3PL) services.

The interviews were conducted between May 2016 and July 2016. Each interview lasted about 30 minutes on average. The interviews consisted of first describing the purpose of the study followed by the interviewer presenting the pre-defined questions. Answers to the questions were immediately transcribed into written responses.

4. FINDINGS

This chapter describes the main findings of the study. We first provide background information about the freight management process to illustrate the complexity that exists in the motor carrier industry. Then, we describe the real-time technology adoption issues.

4.1 Background on Motor Carrier Freight Transportation Management Business Process

Prior to the deregulation of the U.S. motor carrier industry, trucking companies operated a regular route system of local and line-haul operations. A commercial motor carrier driver would pick up and bring a load back to a staging area or terminal, and then another commercial driver would provide a line-haul operation from terminal to terminal. At the destination, a different driver would deliver the freight to its final destination/customer. This transportation network, although not efficient, did spread the total freight transportation of products over a longer span of the 24-hour day. The current less than load (LTL) industry still utilizes this model.

For the long-haul, over-the-road, irregular route, the motor carrier is now performing two or all three of the functions described above. The irregular route carrier faces the challenges of complying with the HOS regulations. Without turning the clock back, what can be done to extend these hours of operations to enhance safety and also performance within the time perimeters required by the shipper/receiver? The common suggestion from all carriers, here, is to allow some reform to the current HOS regulations to help spread out the congested periods. Clearly this is a federal government policy issue, but what can be done by the states to help this reform happen?

At this time, it is also informative to illustrate the operational complexity of the freight management process. As shown in Figure 1, the freight management process involves multiple steps, each with potential connections to the use of real-time technology and data. We discuss these issues in more detail in the remainder of this section.

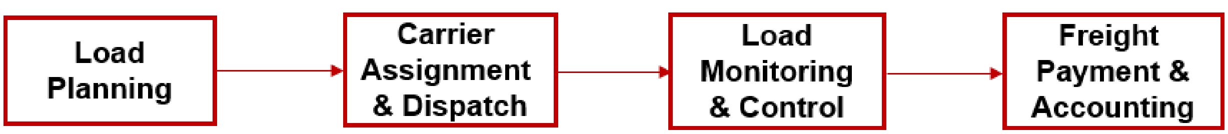

Figure 1. Freight management business process

4.1.1 Receiving and Consolidation of Customer Orders

Step 1 involves the receiving and consolidating of customer orders for load planning purposes. The motor carrier or 3PL partner receives and consolidates multiple orders to move freight for planning purposes. The carrier can receive those orders electronically and begin the load management process using enterprise applications such as Omnitracs (fleet management systems and software), Oracle Transportation Management (OTM), SAP Transportation Management

Software, or other transportation management solutions. Our findings indicate that many carriers are using Omnitracks as a software solution. Most of the existing software solutions enable the carrier to manage the process associated with determining origin, destination, and terminal location and routing decisions.

4.1.2 Order Tending Process

Step 2 consists of tendering the load to a specific motor carrier company and commercial truck. In our interviews, we found that most orders are tendered from shippers 3 or 4 days in advance to the ship date. Even though the final piece, assignment of the power unit (commercial truck), does not happen until between 4 and 12 hours before shipment, a number of processes occur in the first 2 days without knowing what may happen. Those variables are, to name a few, weather delays, traffic delays, shipper delays, receiver delays, and mechanical delays—all which contribute to HOS regulations and changes of a plan. Also, carriers are selected based on service-level expectations, special equipment requirements, and cost (rates).

4.1.3 Movement of Customer Orders

Step 3 entails receiving confirmation that the freight was picked up by the carrier. Unfortunately, most carriers do not have the ability to determine optimal pick-up times based on road congestion data, warehouse worker utilization data, and other environmental data points. Several carriers are utilizing GPS and related technologies to monitor the movement of the freight, which could prove to be useful for transportation planning purposes. Currently, we did not find any evidence that real-time arrival data is integrated into existing enterprise transportation platforms, such as software applications like Omnitracks.

4.1.3.1 Driver Discretion on Route Selection Decisions

Our findings on route selection decisions varied by carrier. Some carriers offered the driver latitude in terms of the route followed. We speculate that carrier management believes drivers are more knowledgeable about which routes are preferable as far as extent of congestion, traffic delays, etc. However, another carrier that the dispatcher controls is the route that is driven.

4.1.4 Freight Payment

Finally, Step 4 involves the final freight payment and reconciliation stage. Unfortunately, another casualty of deregulation is the fines some shippers and receivers are assessing motor carriers for late deliveries. A number of carriers have expressed that when schedules are extremely tight, a delay can make the driver late, and then the carriers incur fines. We have heard of fines of up to $500 for late arrivals exceeding 1 hour, when all that has happened is that the driver ran into an unforeseen delay.

4.2 Impact of Congestion on Commercial Driver Available Capacity and Retention

Several carriers commented that highway congestion is having a negative impact on commercial driver capacity and retention. As mentioned in the introduction, the ATRI recently conducted a national study, which examined the most prominent locations where highway congestion is extremely problematic. Without access to real-time traffic-congestion data, the commercial drivers are routed into high traffic areas and face unwarranted stress and safety hazards, and thus become frustrated with working in the industry.

Because of the congestion issue, the average commercial driver sits idle in traffic and does not have sufficient time to earn income moving freight. This issue is especially concerning for several reasons. First, many commercial drivers are generally paid on a per mile basis. When available driving time is reduced because of road congestion issues, commercial drivers are not able to earn income. As a result, commercial drivers become frustrated and less motivated to remain employed in the industry.

A further subsequent issue is less available capacity for the movement of freight. Indeed, one third-party logistics firm commented that they are experiencing capacity issues. Thus, a real-time technology solution is needed to assist the industry in avoiding congested areas so that the commercial driver capacity problem can be addressed.

4.3 Technology Capabilities

The motor carrier industry is becoming increasingly technology-sophisticated. However, some carriers commented that the “playing field” is not very level for all trucking operations. There are more than 500,000 motor carriers in the industry. Since the industry is dominated by very small carriers operating with 100 power units or fewer on average, the small carrier is at a competitive disadvantage in terms of technology capabilities. Furthermore, it is estimated there are more than 70,000 new entrants into the industry annually (Cantor et al. 2017).

Because of the high technology costs, large motor carriers are most likely at a competitive advantage in the area of technology adoption compared to small carriers. Large carriers are more likely to have implemented transportation management systems (TMS) compared to small carriers. Small carriers tend to rely on mobile devices for transportation management and route coordination issues.

Small carriers are heavily dependent on mobile technology; while larger companies have implemented TMS in addition to mobile devices. Carriers increasingly need access to TMS to manage the end-to-end business processes associated with running a trucking operation competitively. TMS software is used by carriers, shippers, and 3PL companies to facilitate the planning and execution of the movement of goods across a supply chain network. Adoption of a TMS is critical to operating in the industry given the complexity associated with the large volume of customer transactions and other value-added partners who are needed to track and manage the volume of freight.

Depending on length of haul and the critical value of the good that needs to be moved, supply chain companies will need to use TMS software to facilitate the coordination with multimodal capabilities, including the variety of shipping modes such as truck for hire, fleet, rail, intermodal, air, and ocean. Thus, small carriers who do not use TMS software are at a competitive disadvantage.

In 2017, most carriers will have implemented ELDs to track hours of service. The interview results suggest that a real-time data solution could integrate very well with the forthcoming ELD mandate. Because of the ELD mandate, the industry will need to figure out how ELD data can interface with real-time data information about parking, travel time, and the rest breaks necessary for compliant operation. We currently believe that the real-time data will be of most value for carrier planning and dispatch purposes.

Our findings indicate that the technology platform needs to be open-access, and that the solution should utilize application programming interface (API) standards so that any carrier can interface with the technology. One central repository of the transportation data is needed, and the database needs to reside in a location that is accessible by the entire transportation community.

4.4 In-Cab Real-Time Technology Solution

Several companies commented that a real-time transportation solution should be provided directly to the commercial driver using existing in-cab technology devices. Currently, a carrier's dispatching team sends instant company and transportation notifications using in-cab technology devices. Some carriers have experimented and implemented navigation systems into their motor carrier fleets. For these and other reasons, an in-cab technology solution was identified as a feasible solution. It should be noted, however, that some carriers run regular routes, and carriers that run regular routes are not using in-cab navigation tools.

Several in-cab technology solutions are currently being used in the industry. It is estimated that 70% of this mobile communications market is controlled by two companies (Omnitracs and PeopleNet fleet management solutions). For example, Omnitracs (previously owned by Qualcomm) provides applications that facilitate driver management activities. The vendor's application can facilitate the tracking of hours of service, navigation capabilities, fuel management, driver workflow, and other productivity and maintenance services. The interfacing of real-time data into the existing in-cab technology solutions could prove to be very valuable to the industry.

Regardless of the in-cab real-time solution, the industry needs to address driver distraction concerns. The Virginia Tech Transportation Institute (VTTI) recently reported that driver concentration for the road diminished 85% for a handless phone (Bluetooth) going off when a conversation is starting and infringing on the concentration for the road. Because driver distraction is a serious concern, one company that we interviewed commented that they could envision a solution integrating with Qualcomm units that sends out audio notification of road conditions. Thus, there continues to be serious implications associated with use of technology while driving and the industry needs to exercise caution when implementing truck driver alerting systems.

4.5 Business Analytics

Several of the carriers mentioned that they currently derive value from business analytics capabilities. Several carriers interviewed use business analytics for financial management purposes, but they would like to make advancements in the use of business analytics for traffic operations purposes. For example, one carrier mentioned that it would be beneficial to see an analysis of the effect of length of delay on customer service levels.

Some carries would also find value in how use of alternative transportation routes would impact cost and on-time delivery rates. The analytics capability could also provide insight on history of delays per days of the week and hours of the day. Such information would enable carriers to improve their transportation planning efforts.

Interestingly, one carrier interviewed performs data analytics on historical routes run, type of driver, age of driver, and many other variables. Their analysis found that more experienced drivers are involved in more accidents.

4.6 Parking Availability Information and Technology

We explored to what extent parking capacity and reservation information would be useful to the sample of firms interviewed as a part of this study. Briefly, as a part of the transportation management process, truck drivers must comply with the FMCSA's HOS rules. As such, the commercial drivers need to adjust their hours accordingly, so that they can find an available place to obtain rest. Because there are limited public and private truck stops in the U.S., several drivers find it difficult to obtain rest at a safe location.

Indeed, many truck stops reach capacity especially in the early evening hours. Therefore, two fundamental issues are associated with the trucking parking problem: to what extent can real-time traffic operations data be used to help drivers plan to arrive at a truck parking location when the driver is about to reach their maximum allowable hours of service and what are the existing solutions that will enable truck drivers to reserve a space at the desired truck stop location?

Based on the interview results, we believe the carrier community would find value in the integration of truck parking location and capacity information into a real-time traffic operations data solution. Truck drivers would develop a more accurate understanding on how they would need to plan their routes to better comply with the HOS rules.

Our interview results also suggest that some drivers are developing their own business solutions to identify parking locations and reservations. Indeed, some drivers do call ahead for parking reservations. This approach does work in some cases. Apparently, there are existing commercially available truck stop applications to reserve a spot, and drivers pay for the service.

There is some debate as to how to communicate parking space availability information to the commercial truck driver. Because of driver distraction concerns, some carriers believe that up-to-date parking availability information should be communicated via road signs rather than mobile devices. However, this perspective was not shared by all participants in the study.

4.5 Nationwide Real-time Technology Availability

Our interview findings suggest that the real-time traffic operations data need to be available on a nationwide basis to be of most value. This perspective was expressed by carriers that operate on an inter-state basis. Our findings from the smaller carriers suggest the coordination of freight movement operations is very manual in nature with carriers having to access data from lots of disparate systems and diverse data sources.

Corporate representatives indicated that transportation data needs to be available in a central repository so that the firms can improve their transportation forecasting and coordination abilities. For example, carriers want to have the ability to incorporate information on congestion, weather, availability of equipment, pricing, and driver HOS on potential rates that are quoted. Many of these data feeds have nationwide implications.

Carriers further commented that they need weather data at the road segment level in order to develop more granular forecasting estimates. There was some debate as to whether the real-time data would be more helpful on LTL or truckload (TL) routes.

4.6 Partnership with Technology Vendor

A real-time transportation data feed should be distributed to the motor carrier industry through partnerships with one or more third-party technology vendors. The researchers do not recommend that state DOTs attempt to develop transportation data distribution technology or applications on their own. This finding is presented for several reasons.

First, the industry is dominated by many small firms that lack the financial resources to invest in their own real-time technology platform. These firms are struggling to run their operations on a daily basis and, thus, don’t have the in-house expertise to maintain real-time data feeds. Second, the real-time data needs to be sourced from several different data sources from across the U.S. (e.g., national, state, and local road segment data, parking availability data, safety incident data). Third, the data needs to be maintained and distributed into a format that is easily interpreted by motor carriers and commercial drivers. The technology vendor would be responsible for “bundling” the real-time data into a useful format that would then be delivered to a carrier’s TMS and/or driver’s navigation program.

4.7 Interface with Intermodal Partners

Several motor carriers interface with railroad carriers on the pick-up and delivery of freight. For example, motor carriers need a “gate reservation” to deliver a container at an intermodal yard.

Once the carrier has the gate reservation, a carrier may deliver the freight within 48 hours prior to train departure. If the motor carrier is running late, the railroad carrier cannot hold the train; however, the late arriving container will be placed on the next available train. It is important to note that train capacity is heavily utilized.

With this in mind, the opportunity to use real-time data is mainly for the motor carrier. Through technology interface solutions with their intermodal partners, the motor carrier can increase their productivity and customer service levels. In the total intermodal lifecycle, real-time data feeds can enhance the motor carrier's ability to deliver to the origin ramp on a timely basis.

4.8 Benefits of Real-Time Data and Technology

Our interview results demonstrate there is strong interest in the use of real-time transportation data in the industry. The industry participants suggest there could be several benefits associated with the use of the real-time traffic operations data. These benefits include the following: 1) improved transportation planning, 2) improvement in on-time delivery rates, 3) improved safety performance, 4) improvements in driver retention and capacity, and 5) reduction in cost.

4.8.1 Improved Transportation Planning

The ATRI traffic congestion study suggests it is critical for motor carriers to gain access to historical and real-time congestion data for improved planning and real-time routing purposes (Brewster et al. 2015). Real-time transportation technology will serve as a critical input in this regard.

Use of the traffic congestion data can help drivers avoid highly congested traffic zones. However, some of the carriers that we spoke with said that, depending on the weight of the load, their trucks can't travel on some secondary roads. Thus, re-routing options become problematic because of weight restrictions.

Also, some carriers are using external systems such as a state Traffic Operations 511 websites during winter months to avoid severe weather conditions and thus re-route traffic accordingly. We spoke with one carrier that monitors a state 511 website multiple times a day in the winter months.

4.8.2 Improvement in On-time Delivery Rates

Some of the carriers expressed that their customers want improved alerts should the commercial driver face traffic delays in the movement of their freight. Customers want updates concerning estimated time of arrival so that they can allocate resources when and where needed, such as at their warehouse and distribution centers. This technology feature represents a big opportunity to leverage traffic operations data. Currently, it is a challenge for carriers to provide updates on expected time of arrival because future congestion patterns are difficult to predict.

Not all carriers shared this perspective. One firm mentioned that the company doesn't necessarily see operational or driver retention benefits from real-time technology feeds. The company runs regular routes at 50 mph. The firm further expressed that a major reason why the company doesn't meet on-time delivery performance is because of equipment breakdown and drivers oversleeping. Therefore, this company believes that an integrated solution wouldn't necessarily save time.

4.8.3 Safety Performance

We were provided with several stories concerning how a carrier was involved in an accident/crash because of road conditions that could have been avoided. For example, one carrier described how unfavorable weather conditions was a major contributing factor of a crash that they were involved in. Another incident was described to us on how a road construction situation led to a carrier's involvement in a crash. Real-time traffic condition information could have enabled the carrier to make more informed decisions and, thus, reduced the probability of crash involvement.

4.8.4 Driver Retention and Capacity

As mentioned earlier, drivers are at an economic disadvantage when they become involved in traffic congestion problems. Commercial drivers (and the traveling public) could benefit from the use of real-time traffic data by locating alternative routes of travel. Because of the difficulty in recruiting qualified drivers, it is imperative that carriers find ways to improve the utilization of their existing workforce (e.g., minimize truck drivers who are traveling into congested markets). The real-time data could be very helpful with re-routing from congested locations.

4.8.5 Reduction in Cost

The last potential benefit discussed with the carriers was cost reduction. Beyond the ATRI industry-level study that we discussed, most carriers have not examined the financial impact of traffic delays. Stated otherwise, the industry possibly needs to better understand the cost associated with the congestion before we can add value with the potential cost of access to real-time information. We believe value can be added with this data/information, but to be fully used, we need to develop a way to point out the cost savings to the motor carriers. Of note, carriers did express a desire to understand the cost of delays in more detail.

As noted, given that small carrier operations are very manually driven, we believe it would be more difficult for these small businesses to incur the cost of real-time technology. Many of these firms utilize the existing information solutions such as state 511 traffic operations data, especially in winter driving seasons or when road conditions are most hazardous due to weather.

Furthermore, for carriers that rely on owner-operators exclusively, existing navigation technology system costs are typically passed on to the owner-operators.

5. RECOMMENDATIONS

This chapter describes several recommendations made to the Iowa DOT.

5.1 Conduct and Present Financial Cost-Benefit Analysis of Real-Time Initiative

Our first recommendation is that a financial and operational analysis of the start-up and on-going maintenance costs associated with the adoption of the real-time traffic operations technology solution needs to be provided to the industry before wide-scale technology adoption can occur. Our discussions with several firms clearly show that motor carriers are interested in learning more about how the real-time technology will work and how this solution could provide financial savings to the carriers. However, these firms want to know more about the benefits and costs associated with technology implementation and adoption (e.g., improvement of on-time delivery rates, reduction in transportation costs, improvement in safety performance).

A detailed financial analysis is needed before the motor carriers will start to embrace the use of the real-time technology. Such a cost-benefit analysis would explore such issues as the following: 1) analysis of current transportation network cost due to traffic congestion and delays, 2) potential transportation savings by optimizing available resources on established routes (refueling stations, truck parking, etc.) and/or using alternative transportation routes, and 3) technology upgrade costs to support in-cab and/or dispatcher provided real-time transportation data. A quantitative cost-benefit analysis can be used to garner wide spread real-time technology support.

5.2 Develop Real-Time Technology Partnership with State DOTs in Neighboring States

In a next step, the Iowa DOT should consider developing a partnership with neighboring state traffic operations offices. As noted earlier, several carriers commented that real value can be derived from a real-time traffic operations solution that shares traffic operations data across state borders. Many firms in the U.S. motor carrier industry operate on an inter-state basis. Thus, it becomes critical to show how the real-time traffic operation is scalable across multiple state boundaries. By partnering with state DOT offices in neighboring states, the Iowa DOT can facilitate the development of similar real-time traffic capabilities across Midwest state DOT traffic operations offices.

As an initial next step in this regard, a study could be conducted to determine the percentage of commercial miles that originate, are destined, or bridge miles through Iowa. This information may confirm the need for a multi-state coalition.

5.3 Create a Coalition of Real-Time Technology Industry and Government Leaders

The Iowa DOT should champion the adoption of real-time technology in the motor carrier industry by creating a coalition of industry and government leaders. In partnership with industry leaders, the Iowa DOT can set an agenda on how to promote the use of the real-time technology.

In so doing, the Iowa DOT can facilitate collaboration among carriers and industry regulators. Moreover, the Iowa DOT can influence the industry's commitment to the technology through participation in a formal coalition. A starting point could include working with the Iowa Motor Truck Association (IMTA) and related associations.

We believe that a formal coalition can also provide an important mechanism through which carriers, regulators, and other industry stakeholders can become more interdependent and thus encourage the growth and adoption of the real-time technology. Likewise, through the coalition support structure, motor carriers are more likely to contribute their own suggestions, internal resources, and information to support the real-time technology efforts. As such, the formation of the coalition not only decreases risk that motor carriers might incur but also increases the legitimacy of the real-time technology initiative. As such, we suggest that a coalition can directly address the social, economic, and political interests that might otherwise inhibit the likelihood of success.

5.4 Pilot Real-Time Technology Solution in Iowa

The Iowa DOT Office of Traffic Operations has emerged as a leader in the development of a real-time traffic operations solution. We recommend that this office continue the development of the technology solution and begin piloting its use with carriers that run dedicated lanes within the state. In so doing, the Office of Traffic Operations can learn in a controlled environment about technology integration challenges and any associated financial and safety concerns.

5.5 Market Real-Time Technology Service to Industry Participants through a Formal Partnership with Technology Vendors

The real-time technology solution is very important to the trucking industry, but not as a service solely hosted by the Iowa DOT. This technology service must be integrated into a technology vendor's navigation program that considers multiple transportation parameters and data sources when trip planning is conducted. Commercial motor carrier technology providers probably have the expertise and resources that can be leveraged to make the real-time data available in a usable format for the industry to use.

A partnership with technology vendors can facilitate the distribution of the real-time technology to a large market segment the fastest. Commencing shortly, many commercial motor carriers will be required to comply with the FMCSA's ELD mandate. As such, the real-time technology solution could interface with the ELDs that are required for operation in the trucking industry.

Additionally, at the time of this study, we believe that fleet mobile communication providers Omnitracs and PeopleNet have the largest commercial motor carrier market share. There is also a smaller market segment where commercial carries are using smartphones or nothing at all to manage the routing of transportation cargo. To address the technology adoption barriers that some carriers face, Omnitracs is working on an Android application in addition to their current set of fleet-mobile solutions. We believe that the technology vendors are in a stronger position to determine how to distribute the real-time technology data between fleet mobile and Android communications.

5.6 Lead an Effort to Create Real-Time Technology Data and Functional Capability Standards

The next step would be to establish real-time technology data and functional capability standards. As mentioned earlier, the structure of the data needs to be in an open source format, so that the data is easily usable and interpretable by multiple technology vendors (e.g., Amazon Cloud, Google Waze, or other third-party platform). To further encourage the scalability of the data, the Iowa DOT could partner with one or more technology vendors that would be responsible for "bundling" the real-time data with other relevant data into a useful format that would then be delivered to a carrier's TMS and/or driver navigation programs.

From a functional capability perspective, the Iowa DOT should create standards governing the capabilities of the real-time technology solution. For value creation purposes, the technology solution must contain multiple functional capabilities including predictive analytics concerning traffic flow, identification of truck safe roads, truck parking capacity and reservation data, current and forecasted weather conditions, and hours of service availability. This functional list includes some of the functionalities that should be considered.

5.6.1 Explore In-Cab Technology Road Map

Several carriers commented that notifications of traffic conditions should be available to the motor carrier driver through in-cab technologies. Indeed, there is a rapid infusion of mobile applications and related technologies in the U.S, motor carrier industry. Many commercial drivers use smartphone devices to conduct daily business transactions. Ward (2015) reports a wide-range of truck apps are being used by drivers, including the following:

- Crowdsourcing solutions that facilitate searching for available loads to haul (e.g., Cargomatic)
- Weigh station and inspection solutions that enable commercial drivers to bypass commercial vehicle inspection sites (e.g., Drivewyze)
- Truck stop solutions that provide "stops, rest areas or weigh stations based on other users adding locations into the system, rating them and giving feedback" (e.g., Trucker Path)

We envision an in-cab mobile device solution that could bring together the above mentioned solutions with data that interface with traffic congestion data provided by vendors such as Inrix and Here.

5.6.2 Explore How Real-Time Technology Can be Useful for Autonomous Connect Vehicles

The real-time data will be crucial to autonomous connected vehicle systems. We define autonomous connected vehicles as driverless vehicles that are able to operate without direct human intervention. These vehicles are able to coordinate and communicate with other vehicles and roadside infrastructure located in the immediate vicinity. The marriage of these real-time data and autonomous vehicles should enhance the safety of passenger and commercial vehicles. Safety and productivity levels should improve because driverless vehicles provide the industry with driving time (e.g., increased capacity). Previously, commercial driving time was limited due to the hours of service (HOS) regulation. By not needing to be compliant with the HOS rules due to the capabilities provided by autonomous vehicles, we may be able to stretch out the available time associated with operating on roadways for motor carrier operators. We can utilize the entire clock by nocturnally moving inter city traffic, therefore helping ease congestion periods. This will allow us to focus on local and last mile traffic.

Weather issues could be addressed proactively rather than reactively. Because of HOS issues, we still have commercial vehicles operating through dangerous weather conditions, because drivers feel the need to comply with all regulations and also deliver on time. By integrating real-time data with autonomous vehicles, we will take the driver out of the decision-making process, and thus travel decisions could be move to safer operating conditions.

Using real-time data can provide greater levels of control over bottlenecks simply by reducing and spreading out the supply of vehicles to the system. A case in point might be the airline industry. Years and years ago, it was important to comply with departure times. An airline carrier would protect the departure time and, upon arrival at their destination, have air congestion or weather congestion and need to circle for a period of time. Now, with systems available, the industry has worked to smarten up and hold the flight on the ground before departure until direct arrivals can be achieved.

6. CONCLUSIONS

This study focused on exploring some of the factors associated with the future adoption of real-time data feeds from Iowa's Traffic Operations Center. The center monitors, in near real-time, the operating status of many road segments across national, state, and local roadways. This study evaluated how the state's traffic operations data could prove to be useful to the motor carrier industry.

We provided a set of our findings for the purposes of providing guidance on how Iowa could move forward with its real-time technology initiative. Based on our findings, we presented six recommendations on next steps that the Iowa DOT could implement to encourage further adoption of this technology.

Undoubtedly, we believe that the vast number of motor carrier firms will impact the rate of diffusion of real-time technology into the motor carrier industry. Indeed, a vast amount of new entrant motor carriers obtained interstate operating certificates for the first time on an annual basis between 2013 and 2015 (Keane 2016). Cantor et al. (2017) points out that the industry is dominated by firms with 10 or fewer power units. It is estimated that more than 500,000 motor carriers operate in the industry on an annual basis.

Because the industry is dominated by new entrants and carriers with very few power units, many firms face serious pressures in how to meet the on-time delivery expectations of shippers, while at the same time operating safely. Cantor et al. (2016) present empirical evidence that new entrant carriers face a "safety learning curve" on how to achieve performance improvement. In comparison, established carriers have significant competitive advantages compared to the new entrants (Cantor et al. 2017)

Given the industry is very fragmented and carriers have many levels of technology sophistication, we believe that the Iowa DOT can assume a leadership position in meeting the diverse real-time technology needs of the industry. Undoubtedly, the adoption of real-time technologies will be easier to achieve by established carriers and larger firms compared to new entrants and the smaller firms.

Established and larger carriers have the necessary resources to adopt real-time technologies. Larger firms have superior access to the human and physical resources necessary to assimilate real-time technologies. These firms also have access to financial resources that can be used to fund the integration of real-time technologies into their operations. Larger firms also benefit from economies of scale and scope.

However, to create a level playing field, the Iowa DOT and other DOTs can assist the industry by providing further information and support services that could be beneficial to multiple carrier industry segments. By providing clarity on the financial and operational costs and benefits, motor carriers can become more informed on how this technology solution can meet their transportation needs.

Similarly, the Iowa DOT and others can facilitate national access to real-time data through the formation of industry coalitions and technology partnerships with national transportation technology vendors.

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