Strategies for Effective Implementations of Vehicle Driver Performance Tracking Technologies in the Workplace

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In scores of vehicle fleets, telematic tracking systems provide fleet managers with information regarding energy consumption, the obedience of safety regulations and driver performance. Telematic tracking systems are information technology systems that collect data on driver behaviors such as braking, speeding, acceleration, idling time, and seat belt usage, and transmit that data to a management system where it can be stored and analyzed. Recently, in-vehicle performance monitors have become a popular tool for tracking driver behavior, especially among vehicle fleet managers. For example, many insurance companies have started using telematic data to classify driver risk and adjust premiums accordingly (Chen & Jiang, 2019). One study that sought to evaluate the use of in-vehicle monitors as an effective method of improving driver performance found that “risky driving behaviors declined significantly,” when drivers were coached on optimal habits in parallel with feedback received from the monitors (Bell et al., 2017).

Extensive opportunities exist within commercial vehicle fleets for safety and environmental improvements. In-vehicle technologies are a logical solution to the problem of identifying specific areas where fleet safety improvements can be made, especially on an individual driver basis. However, effective strategies for implementing such technologies have not been well-established as of yet. This research paper evaluates various implementation methods and recommends strategies for alleviating potential negative impacts of the use of in-vehicle tracking technologies. In addition to an extensive review of prior research, the claims made in this paper are largely based on a technical project focused on the use of Geotab telematic tracking devices within The University of Virginia's Facilities Management (UVA FM) commercial vehicle fleet. UVA FM partnered with a team of UVA Engineering students to investigate the optimal usage of telematic data obtained from Geotab devices installed on FM vehicles. A complete technical description of the project can be found in the conference paper titled "*Safe and Sustainable Fleet Management with Big Data Analytics and Education*," but this research paper will only address elements of the project relevant to the implementation of in-vehicle tracking devices.

Due to the lack of established strategies for effectively implementing in-vehicle tracking technologies, our technical project's team needed a methodological approach for formulating potential solutions. The complex relationships between a multitude of relevant tangible and intangible factors led to the use of Actor-Network Theory (ANT). Using ANT to map relationships between human and nonhuman actors revealed a number of elements on which the success of in-vehicle monitor implementation heavily depended. These elements were determined to be relevant within the context of the technical project and UVA FM's vehicle fleet. However, this research paper seeks to generalize the following claims for increased applicability to other commercial vehicle fleets. <u>Most influential is the level of transparency between management and drivers surrounding the use of the drivers' data</u>. Additionally, <u>the inclusion of drivers in the development of any training or educational materials resulting from the use of the drivers' data plays a major role in the effectiveness of implementation</u>. Finally, <u>a high degree of motivation or "buy-in" on behalf of influential actors such as high-level management and experienced drivers is essential to effectively implementing in-vehicle tracking technologies</u>.

Problem Definition

The Need Within Commercial Vehicle Fleets to Improve Driver Safety and Sustainability

The leading type of fatal work-related events in the United States is highway accidents (Horrey et al., 2012) and driver behavior has been shown to be a major causing factor of these incidents (Toledo & Lotan, 2008). The estimated direct cost of car crashes in the United States was over two hundred billion dollars in the year 2000. In the year 2000 it was also estimated that 20-65% of company vehicles are involved in car crashes each year (Toledo & Lotan, 2008). There is a need for vehicle driver safety analysis and training, but sustainability concerns are also prevalent. In the European Union, approximately twenty five percent of carbon dioxide emissions are produced by the transportation industry (Abrell, 2010). In urban environments, commercial vehicle fleets account for nearly twenty percent of total transportation distance (Kanaroglou & Buliung, 2008).

In 2018, the transportation sector accounted for 28.2% of greenhouse gas emissions primarily including "burning fossil fuels for cars, trucks, ships, trains, and planes" which accounts for the greatest proportion of emissions in the United States (US EPA, 2018). To lower these emissions, eco-driving programs have emerged to influence changes in driving behavior around topics such as braking, driving speed, and the impacts of idling on overall fuel consumption (Huang et al., 2018). Such changes in behavior can lead to a decrease between 5-20% in overall fuel consumption which helps drivers both save money and lower their carbon

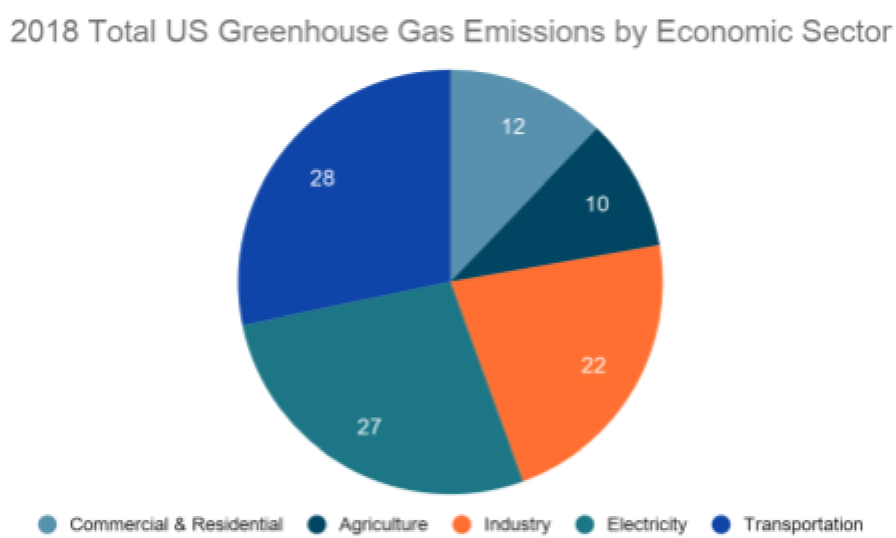

Figure 1. Sources of Greenhouse Gas Emissions. Total Greenhouse Gas (GHG) Emissions by Economic Sector (US EPA, 2018).

footprint (Rakotonirainy et al., 2011). A reduction in overall fuel consumption of this magnitude translates to significant improvements in fleet performance, especially concerning sustainability.

Lack of Prior Research

While the efficacy of the use of in-vehicle monitors with regard to improving vehicle fleet safety has been established, the psychological and interpersonal effects of performance tracking technology on individual drivers requires further exploration. For example, "location-based tracking and monitoring" (a category in which in-vehicle performance monitors fall) shows profound social impacts in "four key areas: control, trust, privacy and security." (K. Michael & M. Michael, 2011). These technologies have potentially major social implications, yet little research has been conducted to explore how this can occur within commercial vehicle fleets. As such, effective implementations of driver performance tracking technologies remains a largely trial-and-error based field.

Implementation Barriers

Crucial to the effectiveness of technologies that seek to improve driver performance is the acceptance of the devices by drivers, and their willingness to work within a system that relies on technology to measure and alter driver behavior (Brookhuis et al., 2001). Not only is acceptance of the technology by drivers necessary, but fleet operators, those that employ the drivers, must also have a willingness to allow technology to track, analyze, and aid in altering their employees' behavior. In many ways, the employer-employee relationship relevant in this context is similar to a parent-child relationship. When asked about their feelings on installing a performance tracking device in their child's vehicle, responses from parents differed widely with regard to both comfort-level and motivation. "Most parents thought parents should feel obligated to install the [tracking] technology," while others worried "such a system might serve to erode their [the parent's] relationship with their son or daughter," (Guttman & Lotan, 2011). Applying this research to the relationship between fleet managers and vehicle drivers, the motivations for stakeholders with decision making power of implementing driver performance tracking technology are evident, but reservations about the potential impacts on drivers are also clear.

Central to the argument against implementing vehicle tracking technology is the potential "erosion of trust and confidence in drivers." (Guttman, 2011). In the context of the technical project, this means the community and camaraderie built between and among drivers could be threatened by the use of in-vehicle tracking technologies. Thus, the impacts of tracking technology on drivers should be analyzed with regards to driver perception of their employer as well as the personal impacts on individual drivers. Data that can be used to scrutinize the effects of tracking technology on drivers within a specific commercial vehicle fleet primarily comes in two forms. Telematic tracking data (data obtained from the monitoring device) can be used as a quantitative measure of driver acceptance of the usage of performance tracking by their employer. Improved performance resulting from the usage of performance trackers indicates a generally positive impact on drivers. Qualitatively speaking, impacts of the usage of in-vehicle trackers on drivers can be evaluated through surveys and longer-form discussions with drivers whose employers have implemented such technology. The goal of surveying drivers and conducting feedback sessions is to gauge the general perception of in-vehicle tracking technology and the employers who implement it by drivers. Our team employed these strategies with UVA FM drivers in our technical project.

Additionally, the unique nature of each individual commercial fleet presents another barrier to implementation. For example, gaining acceptance of in-vehicle performance tracking technologies without eroding trust between drivers and fleet management presented an unexpected challenge within UVA Facilities Management. The level of trust and confidence between management and drivers was so high from that outset that the project leaders worried additional use of tracking sensors would gnaw away at those relationships. It was thus decided that the most optimal use of the data obtained from in-vehicle monitoring would be a training program, curated specifically for, and developed with UVA FM drivers.

Lack of Standardized Education Methodology Despite Efficacy of Use

Fleet managers are responsible for ensuring departmental adherence to regulations, tracking and maintaining fleet vehicles, and optimizing organizational costs. With the duty to continually improve safety and sustainability metrics of the fleet, eco-driving has emerged as a novel approach. Eco-driving encompasses driving behaviors and habits that help mitigate sustainability concerns. Eco-driving can be classified into three particular groups: strategic decisions (vehicle selection and maintenance), tactical decisions (route planning and weight) and operational decisions (driving style) (Huang et al., 2018). Historically, tactical and strategic decisions have traditionally been the prime function of fleet managers, but with the rise of telematics, in-vehicle sensors that capture driving behavioral metrics and faults data, managers are now capable of monitoring driver performance individually and holistically as a fleet. Eco-driving education has proven to be effective in reducing fuel consumption by up to 20% and decrease crash risk in prior research studies (Rakotonirainy, 2011). However, there is no standardized methodology for a successful educational program given the range of differences (vehicle types, country of origin, driving routes, etc.) across each past study. In order to adapt behavior to drive safer and more sustainably, information collected from telematic sensors on incident counts of harsh braking, speeding, acceleration, cornering, idling, and seat belt violations must be provided to drivers. As fleet managers have constrained resources and analytical skills, and the cost to replace a vehicle increases, harnessing the data and producing valuable insights would bring benefits pertaining to operational efficiency immediately to a fleet.

Methods/Analytical Approach

Actor-Network Theory as an Analytical Framework

A useful framework for better understanding the complex problem of the sociotechnical effects of performance tracking on employees such as vehicle drivers is Actor-Network Theory (ANT). Developed by Bruno Latour alongside Michel Callon and John Law, ANT "contains within it concepts that, when abstracted from the multiple trajectories of ANT, can be used as tools to better reveal the complexities of our sociotechnical world," (Cressman, 2009). This research paper seeks to apply Cressman's contention in the context of mitigating the behavioral and social implications of using technology to track, measure, and modify employee performance. In order to utilize ANT, actors must first be defined. In the context of commercial vehicle fleets, there are three most relevant actors to consider. The first two, fleet managers and vehicle drivers, operate within their own network of social relationships and interpersonal dynamics. As the employers of the drivers and the implementers of the tracking technology, fleet managers hold a considerable amount of power over the drivers. At this point it is important to note that fleet managers should be considered a single actor, one decision-making body that controls the fleet's drivers. On the other hand, drivers are a collection of many actors, each of whom may be impacted differently by the usage of performance tracking technology. The third actor to consider is the performance tracking system itself. This system is comprised of the physical monitoring device, as well as the collected telematic data and the analytical system used to interpret that data for the purposes of measuring driving performance.

As described by Cressman, 2009, " a network in the ANT sense should not be confused with the conventional sociological or technical applications of this concept: ... "we are concerned to map the way in which they [actors] define and distribute roles, and mobilize or invent others to play these roles" (Law & Callon 1988, p.285)." Therefore, the problem presented by this research paper is best viewed through the lens of Actor-Network Theory by examining the roles played by each of the relevant actors, fleet management, drivers and the performance tracking technology. A common critique of ANT is the difference in interpretation of actor roles within the network by both outside observers and internal actors. In order to avoid potentially detrimental conflicting definitions of roles, expectations and requirements of human actors must be clearly established before any implementation of training. Providing actors with a solid and consistent understanding of their responsibilities will ensure both a better chance of increased training program efficacy and a more appropriate situation in which to apply ANT. Not only is each driver within a fleet unique, but no entire vehicle fleet is the same as another. The implementation of in-vehicle tracking technologies is likely to affect each fleet in a novel way. Thus the development of a training program through analysis of telematic data must be personalized to a fleet's unique operational characteristics.

Specific Technical Project Methodology

The in-vehicle sensors installed on each UVA FM vehicle constantly collect and compile a broad range of driver performance metrics such as harsh acceleration, hard braking, hard cornering, speeding, fuel consumption and seat belt usage. This data is then stored on a server where management can access the raw data directly, or choose to produce scorecards which highlight the number of incidents that occurred based on specified criteria and thresholds. These incident counts are then normalized based on distance driven, and standardized between zero and one hundred (Geotab, 2018). Finally, a weighting system is applied to these metric scores to obtain a single vehicle score that can be used to classify and compare the performance of different vehicles. The lack of prior research detailing effective applications of in-vehicle tracking data left our team without much direction early on. We decided that the best use of our data analysis would be the development of a training program with the overall objective of increasing the mindfulness of drivers about the safety and sustainability of their driving behavior. More specifically, we hoped the training would reinforce positive driving behaviors while providing alternatives to behaviors with more negative safety and sustainability implications.

Facilities Management specified that vehicle drivers must comply with seatbelt laws and speed limits at all times. Therefore, driver compliance was measured by the frequency of speeding and seatbelt misuse incidents. As a result, driver safety was measured by both the degree of driver compliance along with the frequency of harsh acceleration, hard braking and cornering incidents. In terms of measuring sustainability, or "eco-driving" driving speed and idling have been shown to be among the most crucial metrics to consider in regard to fuel consumption (Huang et al., 2018). In the context of this technical project, vehicle speed and idle fuel consumption were used to classify driver behavior in terms of their contribution to the sustainability of the overall fleet.

In addition to a variety of discussions with FM leadership and experienced drivers, a focus group was conducted before training program development, as well as multiple driver surveys. Our team analyzed focus group discussions and survey responses from drivers in which we asked about their values and favored methods of learning. Because our team's goal was to improve the safety and sustainability of UVA FM's vehicle fleet through behavioral changes in drivers, understanding how they best absorb information was essential. The large variance in responses furthered our belief that a training program would be the most effective method of driving those changes in behavior.

Using these various methods of classifying driver behavior, the developed personalized training program was curated to identify opportunities for improvement for individual drivers. In order to evaluate the efficacy of a personalized training program, a multi-week pilot test was conducted with a selection of UVA drivers and vehicles. Driver performance was measured before, during, and after the implementation of the training program. Results of the pilot test were compiled and analyzed with the intention of improving the training program through further iterations. This project's final deliverable was the fully developed training program that could be implemented across UVA Facilities Management's entire vehicle fleet to improve the fleet's safety compliance and eco-driving behavior.

Fortunately, gaining approval of our proposed method for instigating safety and sustainability improvements from FM leadership was achieved without much pushback. The determined pursuit by FM to achieve a higher Sustainable Fleet accreditation, coupled with the lack of documented effective implementation methods for the technology, made FM leadership eager to attempt our proposed method. Not only was internal FM sentiment highly positive, but leadership was also excited to release our efforts to the public. Evidence of this was seen on Tuesday, March 25th when Facilities Management released a story on the UVA website highlighting the success of our project thus far.

Figure 2. Mindful Driving - Students contribute to new FM training that will support safety and sustainability. University of Virginia's Facilities Management - Home. https://www.fm.virginia.edu/about/news/mindful-driving.html

Results/Your Contributions

Throughout our development of the training program and our frequent discussions with FM employees, I sought to apply my STS research and ANT approach to the development of our training program. In doing so, I have identified three essential elements that were highly influential in the effectiveness of implementation. Those elements were transparency, inclusion, and motivation.

Transparency Between Drivers and Management

In my experience, vehicle drivers were unlikely to be benefited by overloading them with information about the performance tracking system itself. Technical definitions are especially a topic to avoid as drivers are unlikely to fully comprehend and apply concepts unrelated to their daily work habits. Drivers are much more concerned with what data is being collected, and how it's being used to alter their behavior. Thus it is essential that management is open and transparent with their employees (drivers) about the use of their data.

First and foremost, drivers must know that the tracking devices are installed on their vehicles and monitoring their performance at all times. The metrics by which performance is measured and tracked should also be explained to drivers in ways that can be applied to daily work. For example, in our training program rather than giving a technical definition for harsh braking and acceleration incidents, we calculated the time allowed for a vehicle of a certain size and weight to accelerate (brake) from 0 (25) miles per hour to 25 (0) miles per hour, without the monitor recording an incident. This strategy instills in the drivers a much better understanding of the types of data collected by the tracking technology, without inundating them with technical concepts that have little use in the real world.

The manner in which management is transparent with its drivers is also vitally important. Tracking technologies must be the carrot, not the stick, in attempting to motivate drivers to change their behavior. This reveals another benefit of selecting a training program as the ideal use of our analysis - a data driven training program shows the commitment of management to helping the drivers improve their performance. Management that is motivated by a desire to help their employees improve rather than punish them for poor performance is far more likely to gain the buy-in necessary for a successful program.

Inclusion of Drivers in Developing Applications of Their Data

No commercial vehicle fleet is the same as another, and no driver within any fleet is the same as another either. As such, applications of telematic tracking data should be personalized to their audience as much as possible. In the development of our training program, surveys played a key role in indirectly including drivers in the development. Hearing from the drivers themselves about the ways they learn best allowed us to include elements in the training that would be relevant to every type of learner in the audience. We also allowed some drivers to sit in on meetings where we presented selections from the training throughout its development. Gathering first hand feedback from drivers throughout several iterations of our training program gave them a sense of ownership over their data, while also revealing to our team small tweaks to the program that proved to be highly influential in its effectiveness.

Motivation or "Buy-in" By Relevant Actors

Any undertaking without sufficient motivation throughout an organization is far less likely to succeed than one that does. In the case of our project, the high amount of motivation on behalf of FM management was clear through their continued support and encouragement of our team's efforts. This was crucial as an organization cannot expect buy-in from its employees if its leaders don't do so themselves. The public support of our project by leaders within FM played a vital role in obtaining the level of commitment from drivers that we did.

Extracting the motivation required to get drivers to alter their behavior can be a much more difficult task than the endorsing of a project by management. However, a training program that does not motivate drivers to want to be mindful about their driving behavior serves little purpose. This is where consulting a training expert really showed its value for our project. Sandra, the expert, helped our team craft a training program that was interactive, engaging, and applicable to real world situations. Doing so allowed the drivers to truly understand not only what behaviors they need to modify, but how they can enact behavior changes on a daily basis. Experts such as Sandra can have a huge influence on obtaining the necessary buy-in from drivers.

Conclusion

In conclusion, the need for commercial vehicle fleets to improve the safety and sustainability of their drivers is evident. In-vehicle performance tracking technologies have been shown to be effective, however effective implementation strategies remain a largely unresearched field. Despite this lack of relevant prior research, an extensive literature review aided in developing techniques for telematic data analysis and the identification of relevant safe and sustainable driving metrics. Perhaps most crucial to the research documented in this paper was the technical project involving a partnership between The University of Virginia's Facilities Management, myself, and three other UVA Engineering students.

Initial qualitative results of this project have been very promising. On the management side, FM leadership has expressed their support for our work time and time again. So much so that UVA FM has committed to implementing our training and further iterations of it across their entire fleet of drivers and vehicles. From the driver perspective, results are also largely positive. The level of attentiveness and willingness to learn displayed by the drivers selected for the most recent implementation of our training was highly encouraging.

Through an application of Actor-Network Theory in addition to my own experience with Facilities Management at The University of Virginia, I've arrived at the following conclusions surrounding effective strategies for implementing vehicle driver performance technologies within commercial fleets. First, fleet managers must be as transparent as possible with their employees about data collection and its use. Drivers do not need a comprehensive understanding of technical definitions and a breakdown of the technology, but rather a firm grasp on what specific data is being collected and how its analysis is used. Drivers should also be included in the development of any applications resulting from the collection of their driving performance data, such was the case in the development of our training program. Including drivers in content development is aso highly beneficial in personalizing the content to fit the specifications of each fleet and its individual drivers. Finally, arguably most important to the efficacy of in-vehicle tracking technologies is the "buy-in" on behalf of relevant actors. Without the motivation to change on behalf of drivers, and without the willingness of fleet managers to allow their drivers to change, no improvements can be made. While these results are promising, here is by no means where this research ends. There is much to still be investigated about how to effectively implement in-vehicle tracking technologies. However, I hope that research such as this paper and technical project serve as a solid foundation for further exploration.

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