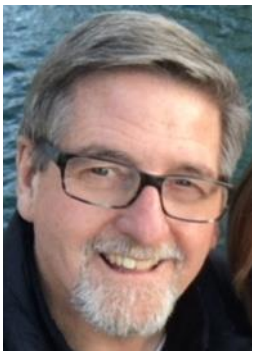
INTEGRATING SAFETY TECHNOLOGY AND MANAGEMENT PRACTICE FOR IMPROVED FLEET SAFETY



J.H. WOODROOFFE
Woodrooffe
Dynamics Ltd
Research Scientist
Emeritus University
of Michigan.

Abstract
This paper examines driver assessment of onboard truck safety technology and management practice including oversight and coaching to estimate the relative effectiveness of technology and management practices on safety performance. The effectiveness assessment is based upon clinical analysis of seven fleets having strong record of safety technology investment. The study examined fleets with good safety performance to understand what technologies bring greatest benefit and what management practices maximize the return on safety technology investment.

The various technologies are assessed by driver opinion and correlated to fleet safety performance. The study found strong correlations between safety technology investment, driver attitude and company management practice with fleet safety performance.

Keywords: Commercial vehicle, truck, safety, safety technology, management, risk assessment, crash avoidance, in-cab camera, driver performance, safety culture, best practice.

1. Introduction

This paper examines seven truck fleets that invested in vehicle safety technology and investigates what internal policies and company characteristics yield the best safety outcome. The author was given access to executives and drivers to understand the operations, safety equipment used and the safety policies in place. Information obtained included safety programs, incentives and award systems, policy implementation history, driver performance information, crash, and distance travelled data.

A formal written survey of 1,010 drivers was conducted in accordance with the University of Michigan University of Michigan Health Sciences and Behavioral Sciences Institutional Review Board approval process and the completed surveys were coded by the University of Michigan Institute for Social Research. The findings from the company interviews and safety system analysis were combined with the results of the survey to determine what safety technologies were considered most effective and to determine what safety policies and practices provide the best safety outcome. The study also provided an estimate of the relative benefits associated with safety technology and active safety management practices. The study found that one of the key elements driving safety outcome of these fleets was the strength of safety culture.

1.1 Safety Culture

Safety culture is defined as the "norms, attitudes, values, and beliefs held by members of an organization." It is developed by leadership, not only through one-on-one interaction, but also through official policies, memos, e-mails, mass communication. Studies that show that the desired safety culture has to be communicated and developed intentionally (Short, Boyle et al. 2007). Organizations that value safety and communicate that value effectively through supervisors and managers to drivers, operate more safely and have drivers with higher motivations to drive safely (Newnam, Griffin et al. 2008; Peng, Boyle et al. 2010)

Safety is broadly defined as the condition where adverse events are avoided, and actions and procedures are implemented to prevent them (Short, Boyle et al. 2007). Developing a safety culture begins with the understanding that all "adverse events," be they traffic crashes or slip-and-falls, can be prevented or at least mitigated. Some authors have claimed that the term "accident" implicitly carries with it the implication of an event that cannot be prevented. The evidence is weak and the insistence on purging the word a distraction, but the point that there must be a commitment and purpose to eliminate all accidents, or hazardous events, is entirely valid and well-supported throughout the literature as critical to developing a safe work environment.

Finally, driver selection, training, and retention is identified as aa key strategy for improving safety outlined by (Knipling, Hickman et al. 2003).

1.2 Safety Technology

The following safety technologies were considered in this study. The technologies were treated as generic with no special consideration for brand or trade name.

1. Stability control – This includes electronic stability control (ESC) and Rollover Stability Control (RSC). These technologies work in the background and will automatically de-throttle the engine, and initiate braking without driver involvement when the system detects loss of control or vehicle over-speed in a curve.

2. Lane keeping/departure – Monitors vehicle lateral position in the travel lane and issues a warning if the vehicle begins to leave the travel lane. The system becomes inactive when the driver uses the turn signal indicator during a lane change maneuver.
3. Over-speed alert system – This system uses an electronic map containing posted speed limit data and issues an alert if the driver exceeds the posted speed limit on a particular road section.
4. Adaptive cruise control – Uses radar and in some cases integrated vison systems to monitor the traffic ahead of the vehicle containing the technology. The driver selects a cruising speed and the system monitors the gap to the lead vehicle. When the following distance become too small, the engine is de-throttled and if necessary brakes are applied automatically.
5. Forward collision control and braking – This technology uses the same sensors and control systems as adaptive cruise control. These systems are packaged together. Forward collision control and braking operates in the background. When a potential forward collision is identified, the technology warns the driver. If the condition persists and a collision is imminent, the system will apply the foundation brakes to reduce the impact speed.
6. Electronic log book - Electronic Logging Devices (ELDs) monitor driver hours of service to improve compliance with the safety rules that govern the number of hours a driver can work.
7. Automated transmissions – These are often referred to as automated manual transmissions. They eliminate the need for the driver to change gears while in forward motion. These systems behave similar to an automatic transmission in an automobile.
8. Disc brakes – Disc brakes use a rotor disc and a set of friction pads in place of the old-style brake-drum and brake-shoe systems often referred to as "S" cam brakes. They have superior brake performance and do not have the brake out-of-adjustment problems associated with the "S" cam brake systems.
9. In-cab cameras – These cameras are focused on the driver and are triggered during hard braking or significant lateral- or steer-events. Fleets have the option of having film clips associated with triggered events captured for review, which may be used for study, driver coaching, and legal defense.
10. Forward cameras - These cameras are focused on the road ahead of the vehicle. The systems are triggered during hard braking or significant lateral- or steer–events, or by driver request. Fleets have the option of having film clips associated with triggered events captured for review, study, driver coaching, and legal defense.

2. Measuring Safety Performance

The companies participating in this study are heavily invested in safety technology and have active safety management programs. Consequently, these companies have very few crashes. To assess the safety performance of exemplary companies, it was determined that crash frequency and travel exposure data were not robust enough to generate reliable crash rates. As an alternative means of assessing safety performance, selected CSA Behavior Analysis and Safety Improvement Categories (BASICs) were used. These measures are generated by Federal Motor Carrier Safety Administration (FMCSA) as part of their safety compliance and enforcement program. They provide a reliable independent means of assessing safety performance that can be applied to any fleet for comparative analysis (FMCSA "Safety Measurement System).

To assess company safety performance for this study only the following select BASIC measures were used:

- Unsafe driving
- Hours of service
- Vehicle maintenance.

For this study these metrics are the most direct and reliable for quantifying company safety performance over a broad spectrum of carriers. For example, it allows direct comparison using identical metrics for carriers hauling hazardous materials and non-hazardous materials. The comparative safety score metric was defined as the aggregate of the selected BASICs listed above.

Safety Score = unsafe driving + hours of service + vehicle maintenance

3. General Findings

The following are the findings from the company characteristics and the written mail-in survey of 1,010 drivers distributed over seven different fleets. The responses were categorized by fleet and referenced to the safety score of the fleet.

3.1 Technology Investment

There is a strong correlation between investment in technology and safety outcome. Figure 1 indicates that the greater the number of types of technology deployed by a fleet the better the safety outcome.

Figure 1 – The number of types of safety technology deployed relative to safety outcome

3.2 Influence of Fleet Size

The data in Figure 2 shows a step correlation between truck fleet size and Safety Score. The reason for this relationship is almost certainly not that fleet size predicts safety, but that larger

fleets are more likely and capable of having more resources focused on safety. Smaller companies are less likely to have the resources to provide staff devoted exclusively to safety.

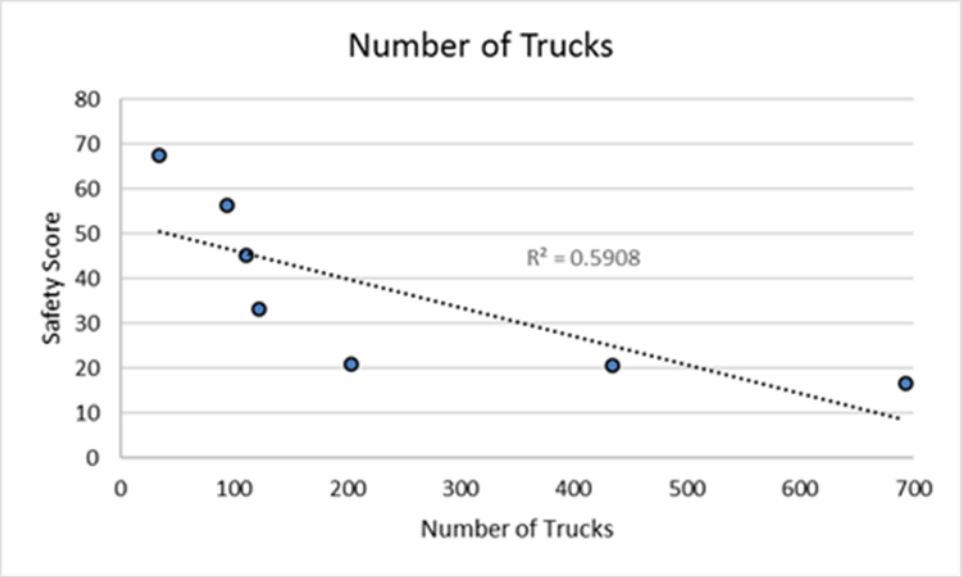


Figure 2 – Relation of fleet size to safety performance

4. Driver Survey Results

The following are finding from the truck driver survey.

4.1 Demographics

1. Driver population was overwhelmingly male with a median driver age of 53 years. The median driver age was approximately the same for all companies.
2. Distance travelled per week is correlated with safety outcome. The greater the distance travelled, the lower the safety performance.
3. Percent driving time per day does not appear to be correlated to safety outcome.
4. Driver familiarity with safety policies, is weakly correlated to safety performance improvement.

4.2 Thoughts, Feelings and Attitudes

Stronger correlation to safety performance.

1. Strongly agree: Confident in your ability to avoid a crash (R-squared 0.33).
2. Strongly agree: Certain you can drive safely (R-squared 0.40).
3. Strongly disagree: Many traffic rules must be ignored to ensure traffic flow (R-squared 0.30).
4. Strongly disagree: It makes sense to exceed the speed limits to get ahead of slow drivers. (R-squared 0.58).
5. Strongly agree: Traffic rules must be respected regardless of road and weather conditions. (R-squared 0.44).
6. Strongly disagree: Speed limits are exceeded because they are too restrictive (R-squared 0.23).

7. Strongly disagree: Taking chances and breaking a few rules does not necessarily make bad drivers (R-squared 0.51).
8. Strongly disagree: It is acceptable to take chances when no other people are involved (R-squared 0.47).
9. Strongly disagree: If you are a good driver it is acceptable to drive a little faster (R-squared 0.68).
10. Strongly agree: Punishments for speeding should be harsher (R-squared 0.54).

The responses to "Thoughts, Feelings and Attitudes" part of the survey reveal that drivers who are risk adverse are strongly associated with fleets having higher safety performance. These attitudes may have been developed through company policy and coaching. They may also be the result screening during the hiring process.

4.3 Driver Perceptions

Driver perceptions of the value and priority given to safety by the company appears to be weekly correlated to fleet safety performance. This is likely because most drivers from the fleets studied strongly value safety irrespective of fleet safety performance therefore there is insufficient differentiation to generate a strong correlation.

Weak correlation to safety performance

1. Strongly agree: My company places a strong emphasis on truck safety (R-squared 0.08).
2. Strongly agree: Truck safety is given a high priority by my company (R-squared 0.07).
3. Strongly agree: My company acknowledges safe driving (R-squared 0.10).
4. Strongly agree: My company respects and values safe drivers in the organization (R-squared 0.12).
5. Strongly agree: My company respects and values safe drivers in the organization (R-squared 0.15).

The pool of drivers participating in the survey were in strong agreement that their companies have a strong safety focus.

4.4 Immediate Supervisor

This section examined driver opinion regarding the immediate supervisor who oversees truck driving.

Stronger correlation to safety performance

1. Strongly agree: My immediate supervisor frequently checks to see if drivers are all obeying the safety rules (R-squared 0.40).
2. Strongly agree: My immediate supervisor emphasizes safety procedures when drivers are working under pressure (R-squared 0.27).
3. Strongly agree: My immediate supervisor frequently talks about driver safety issues throughout the work week (R-squared 0.23).

Weaker correlation to safety performance

4. Strongly agree: My immediate supervisor makes sure drivers receive all the equipment/resources needed to drive safely (R-squared 0.13).
5. Strongly agree: My immediate supervisor discusses how to improve safety with drivers (R-squared 0.18).
6. Strongly agree: My immediate supervisor refuses to ignore safety rules when work falls behind schedule (R-squared 0.09).
7. Strongly agree: My immediate supervisor says a "good word" to drivers who pay special attention to safety (R-squared 0.13).
8. Strongly agree: My immediate supervisor respects and values me as a driver and a person (R-squared 0.17).

Stronger correlations to fleet safety performance are associated with questions related to supervisor oversite and constant communications about safety practice. Weaker but significant correlations exist between, provision of safety equipment, coaching, respect and encouragement of drivers.

4.5 Safety Policies and Communication

This section examined driver opinion regarding company safety policies and safety communication.

Stronger correlation to safety performance

1. Strongly agree: Truck safety policies and procedures are in place for preventing crashes (R-squared 0.26).
2. Strongly agree: Safety policies and procedures relating to the use of trucks are complete and Comprehensive (R-squared 0.30).

Weaker correlation to safety performance

3. Strongly agree: The truck safety policies and procedures in this organization are useful and effective (R-squared 0.14).
4. Strongly agree: Sufficient opportunity to discuss truck safety (R-squared 0.11).
5. Strongly agree: There is open communication about truck safety issues (R-squared 0.11).
6. Strongly agree: Drivers are regularly consulted about truck safety issues (R-squared 0.01).

Driver perception that fleet safety policies and procedures relating to the use of trucks are complete, comprehensive and are in place to prevent crashes is strongly correlated to fleet safety performance. There is sufficient diversity of opinion among drivers from particular fleets regarding the completeness, comprehensiveness and communication of safety policies and procedures relating to the use of trucks. The stronger the driver agreement as to the complete and comprehensive nature of policies, the better the fleet safety performance.

4.6 Behavior

This section examined driver opinion regarding about driver use of a cell phone and other behaviors while driving.

Stronger correlation to safety performance

1. Never - On average, how often do you use your mobile phone when driving your truck? (R-squared 0.46).
2. Never - On average, how often do you text while driving your truck? (R-squared 0.60).
3. Always wear a seat belt in the terminal yard (R-squared 0.36).

The use of cell phones and texting while driving is very strongly correlated to fleet safety performance. Fleets with drivers that do not use cell phones or text while driving have significantly better safety performance.

Seat belt wearing in terminal yards is also strongly correlated to better safety outcome. Terminal yards are not intrinsically dangerous places in terms of crash severity and it would be expected that many drivers would elect not to wear seat belts in terminal yards. The data clearly show that fleets that convince drivers to wear seat belts irrespective of location have succeeded in establishing a safety culture which yields overall improved safety performance.

4.7 Work Satisfaction

This section examined driver opinion regarding overall satisfaction with work.

Stronger correlation to safety performance

1. Strongly agree: Most days I am enthusiastic about my work in this company (R-squared 0.35).

Weaker correlation to safety performance

2. Strongly agree: I am seldom bored with my work in this company (R-squared 0.09).
3. Strongly agree: I feel fairly well satisfied with my work in this company (R-squared 0.05).

No correlation to safety performance

4. Strongly agree: I find real enjoyment in my work with this company (Not positively correlated).

Driver enthusiasm about work is strongly correlated to fleet safety performance. The more enthusiastic that a driver is about work, the better the fleet safety performance. This is likely a reflection of well-developed workplace culture and environment.

5. Technology Ranking

Driver assessment of the acceptance satisfaction and ranking of the technology is found in Table 1. Disk brakes were the highest ranked technology followed by automatic transmissions and electronic log books. The least favored technologies were lane keeping systems and in-cab cameras. Disk brakes, automatic transmissions and electronic log books are frequently used by drivers therefore they would be familiar with their function. Technologies that function in the background such as stability control are rarely activated and may be poorly understood by drivers. The ranking of the technology is by driver opinion and not necessarily by technical function or safety effectiveness therefore care is required when interpreting Table 1.

Table 1 – Driver assessment of technology acceptance, satisfaction and ranking.

Technology	Acceptance of technology (Percent)	Satisfaction with technology (Percent)	Technology Ranking (1 is best)
Disk Brakes	91	86	1
Auto Transmission	79	71	2
Electronic Log Book	91	69	3
Stability control	74	59	4
Cruise Control	74	57	5
Forward Cameras	77	55	6
Over Speed Alert	66	52	7
Forward Collision Control	66	49	8
Lane Keeping	65	43	9
In-Cab Cameras	48	32	10

Table 2 contains consensus opinion of fleet safety executives on the effectiveness of safety technology. The technologies are categorized and highly effective, effective and less effective technology. Not surprisingly there is disagreement between driver and safety executive assessment of technology value and satisfaction.

Table 2 – Company executive consensus on technology effectiveness

Safety Technology
Highly Effective Technology
Stability control
Forward collision control and braking
Disk brakes
In-cab and forward-facing cameras with coaching
Adaptive cruise control
Electronic log book
Speed monitoring with GPS (identifies speed zones)
Effective Technology
Lane keeping/departure
Automatic transmission
Forward cameras only with coaching
Less Effective Technology
In-cab and forward-facing cameras no coaching
Forward cameras only no coaching

5.1 Onboard Cameras

Onboard cameras were the least favored technology by truck drivers. The following are findings from the survey that explore driver attitudes and opinions on in cab cameras.

Stronger correlation to safety performance

1. Strongly agree: Agreement with the use of front facing cameras (R-squared 0.25).
2. Strongly agree: Agreement with the use of in-cab facing cameras (R-squared 0.20).
3. Strongly agree: Agreement Front facing cameras are useful for collecting data to defend the driver (R-squared 0.66).
4. Strongly agree: In-cab facing cameras are useful for collecting data to defend the driver (R-squared 0.27).
5. Strongly agree: Front facing cameras is useful for managing the safety of truck drivers (R-squared 0.25).
6. Strongly agree: In-cab facing cameras is useful for coaching and managing the safety of truck drivers (R-squared 0.22).

There is strong correlation between drivers who value the presence and benefits of forward looking and in-cab cameras with fleet safety performance. Diver response data showed that while cameras are not universally appreciated by drivers, fleets with drivers who support their use tend have better safety performance. This suggests that fleets with strong safety performance have successfully educated their drivers on the benefits of cameras. It also suggests that the associated policy governing the use of cameras diminishes driver concern. Figures 3 and 4 show the relationship between driver understanding of the defensive merits of front facing and in-cab facing onboard cameras and fleet safety performance.

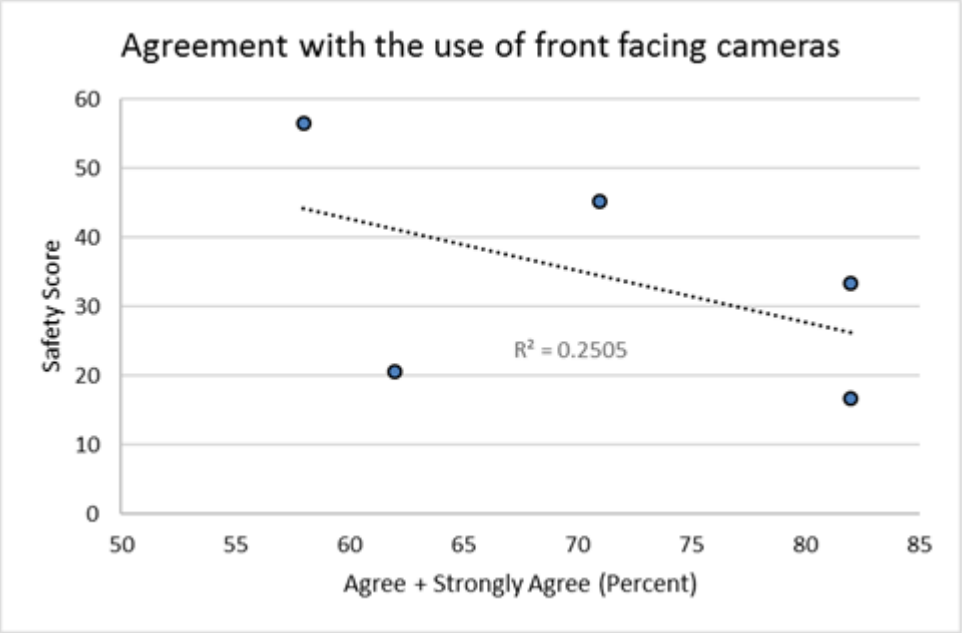


Figure 3 – Driver opinion of onboard front facing cameras and safety performance

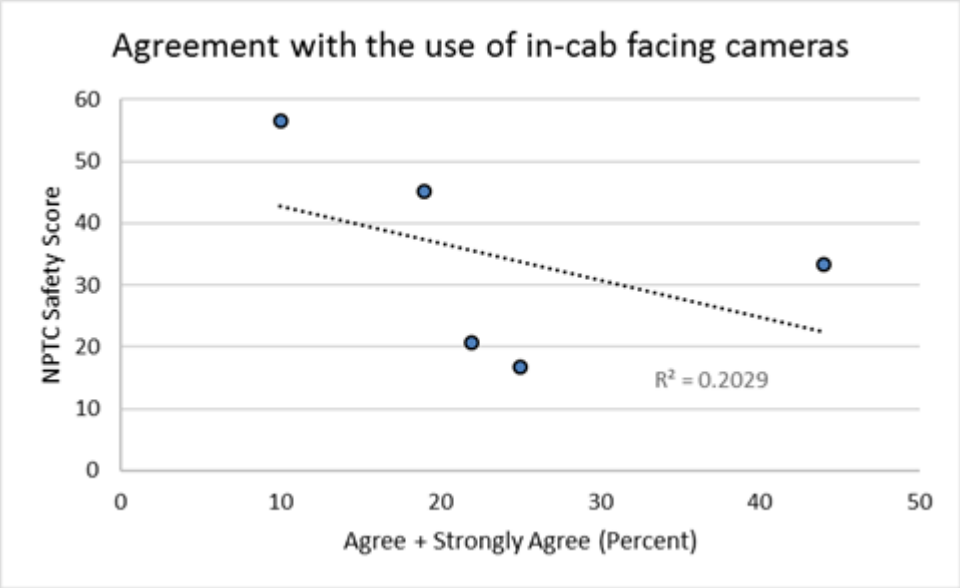


Figure 4 – Driver opinion of onboard in-cab facing cameras and safety performance

6. Summary

The driver survey showed strong and constant association with driver safety culture and knowledge with fleet safety ranking. Strong associations were present in the following areas:

- Thoughts, feelings and attitudes with regards to truck driving safety
- Perceptions of the value and priority given to safety by the company
- Relationship and perceived conduct of the immediate supervisor
- Perceptions of truck safety policies and safety communication in the company
- Overall satisfaction with work

These perceptions and opinions are likely a reflection of the effectiveness of company safety culture and policy implementation. The significant differences in safety scores among companies with similar types of safety technology content are likely related to the success of company safety policies, including the attitude towards drivers, the level and the quality of driver coaching and the ability to effectively integrate these elements into safety management practices. This finding strongly suggests that company safety policy dominates safety performance outcome. This is not to suggest that the role of safety technology is secondary, rather it is the combination of safety technology investment combined with strong safety policies, management and coaching the produces the best safety outcome.

7. Conclusions

1. The amount of safety technology investment per truck is a strong indicator of overall fleet safety performance. Safety technology investment will have direct safety benefit on its own merits, but it may also be a surrogate for commitment to safety by the fleet owner. It is likely that in addition to the investment in technology these fleets also deploy leading safety management practice analytics that promote improved safety culture and performance.

2. The data show a correlation between truck fleet size and safety score. A probable reason for this relationship is that larger fleets are more likely and capable of having more resources focused on safety.

3. Safety conscious driver attitude is strongly associated with fleet safety performance. Management practices that promote safe driving attitudes and selecting for risk adverse driver behavior during the driver hiring process and are important contributors to safety outcome.

4. The role of supervisor as a messenger of safety encouragement and company respect towards drivers is correlated to fleet safety performance.

5. The use of cell phones and texting while driving is very strongly correlated to fleet safety performance. Fleets with drivers that do not use cell phones or text while driving have significantly better safety performance.

6. There is strong correlation between drivers who value the presence and benefits of forward looking and in-cab cameras with fleet safety performance. Diver response data showed that while cameras are ranked low in terms of driver acceptance, fleets with drivers who support their use have better safety performance. This suggests that fleets with stronger safety performance have been more successful in educating their drivers on the benefits of cameras.

7. Driver enthusiasm about work is strongly correlated to fleet safety performance. The more enthusiastic that a driver is about work, the better the fleet safety performance. This is likely a reflection of well-developed workplace culture and environment.

8. Drivers and safety executives rank the perceived the value of particular safety technologies differently. Drivers tend to value technologies that are used frequently as part of their driving task.

8. References

1. FMCSA "Safety Measurement System" Federal Motor Carrier Safety Administration. Available at https://csa.fmcsa.dot.gov/about/basics.aspx

2. Knipling, R. R., J. S. Hickman, et al. (2003). Effective commercial truck and bus safety management techniques. Washington, D.C. :, Transportation Research Board.Commercial Truck and Bus Safety; Synthesis, 1544-6808 ; 1

3. Newnam, S., M. Griffin, et al. (2008). "Safety in Work Vehicles: A Multilevel Study Linking Safety Values and Individual Predictors to Work-Related Driving Crashes." Journal of Applied Psychology 93(3): 632-644.

4. Peng, Y., L. Boyle, et al. (2010). Management's attitudes toward safety in commercial vehicle operations. Human Factors and Ergonomics Society 54th Annual Meeting.

5. Short, J., L. Boyle, et al. (2007). The Role of Safety Culture in Preventing Commercial Motor Vehicle Crashes. Commercial Truck and Bus Safety Synthesis Program. Washington, DC.