

**CANADIAN COUNCIL OF MOTOR TRANSPORT ADMINISTRATORS
(CCMTA)**

**ADDRESSING HUMAN FACTORS IN THE
MOTOR CARRIER INDUSTRY IN CANADA**

By

Pierre Thiffault (Ph.D.)

Chair, Human Factors in Motor Carrier Safety Task Force

May 2011

An important note for the reader

The views expressed in this report are the result of independent research and do not necessarily reflect the views of CCMTA. The content of the report should not be construed as representing the official policy of CCMTA or of its government members. CCMTA may use the report, however, as a reference tool in the development of policy and programs.

Executive Summary

The work of this task force was initiated in 2008 in the context of Road Safety Vision 2010, Canada's former national road safety plan. The goal of the Vision was to make Canadian roads the safest in the world by 2010. In order to reach this goal, the Vision called for a 30% decrease in the average number of road users killed or seriously injured during the 2008-2010 time period compared to the 1996-2001 baseline period.

The Vision targeted eight specific road safety problems and presented objectives for each of them. Motor carrier safety was one of these targets, and the objective sought was to achieve a 20% decrease in the number of road users killed or seriously injured in crashes involving commercial vehicles (CMV). Working towards this objective became a priority for CCMTA's¹ standing committee on Compliance and Regulatory Affairs (CRA), which is mainly focused on managing regulatory and operational processes within the motor carrier industry.

At the 2007 CCMTA meeting in Edmonton, CRA members were presented with the Vision's mid-term report which indicated that for the 2003-2005 period, CMV related fatalities remained virtually unchanged (0.4% lower than baseline) and serious injuries actually increased by 11.6% over the 1996-2001 period. In light of these findings, CRA members felt that there was a need to explore new approaches to enhance the safety of the motor carrier industry in Canada. Consistent with numerous research findings being brought forward at the time, driver behavior was identified as a priority for action.

Transport Canada was mandated to draft a paper to discuss driver behavior issues, review the situation in the U.S., examine how National Safety Code (NSC) standards address these issues and suggest a preliminary action plan (Thiffault, 2007). The paper was presented to CRA members in October 2007, and it was decided that a task force formed of government and industry stakeholders would be put in place to pursue this action plan further. The Human Factors and Motor Carrier Safety Task Force was given a 3-year time frame (February 2008 to February 2011) to achieve the following mandate:

- Phase I** Conduct an in-depth assessment of the human factors associated with commercial vehicle crashes (for drivers of both light and heavy vehicles) as well as the most efficient interventions addressing these issues;
- Phase II** Investigate how human factors involved in commercial vehicle crashes are currently addressed by Federal and Provincial programs and regulations, as well as by voluntary initiatives within the motor carrier industry in Canada;
- Phase III** Formulate a strategy for interventions addressing human factors for light and heavy vehicle drivers involved in commercial vehicle crashes. This strategy will consist of the best practices identified in phase I but adapted to the Canadian situation, as reviewed in phase II.

¹ Canadian Council of Motor Transport Administrators

Phase I was conducted by means of an extensive literature review as well as an examination of a subset of data stemming from the Canadian National Collision Database (NCDB) relative to CMV related crashes during the 2003-2007 time period. Numerous sources, using various methodologies, indicate that the most significant causation factors for CMV crashes relate to drivers recognition and decision errors rather than performance errors or the use of drugs and alcohol. This does not mean that there are no problems in these latter areas, however it implies that from a risk-based perspective, addressing recognition and decision errors should be a priority.

A comprehensive review was conducted of the factors and processes that are potentially responsible for these driver errors, as well as of the mechanisms, or behavior modification principles, that could be used to influence them. Next, the main classical interventions in use today were assessed according to the extent that they make use of these mechanisms or principles. Various observations were then made with regards to leads that could be followed in each of these domains.

In phase II, 56 motor carriers, 6 industry associations and all Canadian provincial governments were surveyed in order to identify the interventions currently in place to address recognition, decision, performance and non-performance errors in the country. While the information gathered was mostly high-level and did not provide in-depth descriptions of programs and regulations, it nevertheless comprised valuable contextual and descriptive data. A review of NSC standards was also conducted.

In phase III, the findings of phases I and II were merged in a form of gap analysis in order to generate a strategy. The resulting discussion presents a set of 44 action items to address fatigue, distraction and risky driving. Note that these recommendations are put forward from a purely scientific perspective. Practical issues such as the operational needs of the industry, the structural makeup of jurisdictions overseeing road safety in Canada as well as within CCMTA, the scarcity of financial resources and research facilities in the country, etc., still need to be taken into consideration.

The suggested actions are meant to be taken as a starting point intended to encourage new discussions among stakeholders. They should help in structuring our efforts as we strive towards evidence-based, theory driven and scientifically sound interventions to mitigate driver errors. What options will be retained, how they can be prioritized or regrouped, how these projects should be managed, by whom and with what resources, are all questions that remain to be answered. These issues will be addressed in later stages of the process. The results of phase III are presented below.

Results

Recognition errors

Recognition errors mainly relate to inattention as it is caused either by fatigue (hypovigilance) or distraction. The prevention of recognition errors therefore involves mitigating the effects of the factors that contribute to fatigue and distraction.

Fatigue

The main contributors to fatigue were presented and risk factors specific to the motor carrier industry were documented. As noted, hours of service (HOS) regulations theoretically address important risk factors, even though they have significant limitations. The case is made that HOS regulations are necessary but not sufficient to address fatigue in the motor carrier industry. There is therefore a need to make stakeholders understand this reality: HOS rules form the foundation of fatigue management, but they need to be complemented by various initiatives to generate a comprehensive and efficient fatigue management approach. This conclusion is important given the fact that many jurisdictions report HOS rules as the sole and primary means to address driver fatigue. Considerations with regards to complementary initiatives are presented below. But first, with regards to HOS per se:

Hours of service

- HOS rules are necessary but they are far from being perfect, nor sufficient. They therefore need to be part of a more comprehensive fatigue management strategy that should be recognised and endorsed by industry and governments;
- HOS rules should be enforced with tamper-proof equipment such as Electronic On-Board Recorders;
- The operational and safety effects of the new HOS rules in Canada should be evaluated.

The determinants of the decision to keep driving while drowsy

Even though drivers have good knowledge about fatigue and fatigue countermeasures, they tend to resist and try to fight fatigue with effort - which is clearly ineffective and very risky. This implies that behavioral determinants other than knowledge are at play and that identifying these determinants for Canadian CMV drivers could help develop efficient strategies to influence this decision making process. It is therefore suggested that a study investigating the psychological determinants of the decision to keep driving while experiencing fatigue be conducted. This could be done with the support of a theory such as Theory of Planned Behavior (TPB), as detailed in the report.

Macroergonomics of the motor carrier industry

On a corollary note, the discrepancy between drivers' actions and knowledge with regards to the self-management of alertness most certainly has to do with how the macroergonomics of this industry (e.g. compensation schemes, company policies, shippers) are shaping drivers motivations and attitudes. For example, the way the pay structure is designed is most likely a significant determinant of the decision to keep driving while drowsy. It is premature to formulate any recommendations without entering into a formal in-depth investigation. However given the importance of this issue, it is necessary to recommend that such an examination take place in the Canadian context.

Training, testing, licensing

As seen in phase II, 69% of carriers acknowledge that fatigue is part of their driver training activities. Governments also identify training as a central piece in their approach to driver fatigue. What is important therefore is to make sure that these training initiatives include specific high-level knowledge elements with regards to driver fatigue. The scientific review suggests that the following areas should be covered in both training and testing:

- The focus should not only be on endogenous risk factors such as time-of-day, time-on-task, time-awake and sleep needs but also on exogenous factors such as road monotony as well as the impacts of various individual differences;
- Drivers should be made aware of the risks of night driving and given proper strategies to deal with them;
- Drivers should be convinced of the superior efficiency of pre-trip fatigue management (getting enough sleep, properly planning journeys with opportunities to rest and take regular breaks, proper food and exercise, etc.) compared to in-transit countermeasures. Training with regards to the self-management of alertness should focus on these pre-trip strategies;
- Drivers should be made to understand the proximal relationship between signs of drowsiness, microsleep and falling asleep per se. This would reveal to them the real level of risk associated with trying to fight drowsiness with effort;
- Drivers should be made to understand the significant impact of early fatigue on attention, which leads to inattention errors. The key is to insist on the fact that early fatigue signs are not felt as drowsiness but rather as mood fluctuations and boredom. Drivers should be convinced that these early fatigue states are associated with crashes that are related to inattention and that there are effective countermeasures that can be adopted while experiencing these early symptoms;
- Drivers should be made to understand the relative efficiency of fatigue countermeasures and they should be taught exactly what is best to do in various specific fatigue inducing contexts.

Globally, there is a need to scrutinize existing driver-training curricula and the various training practices available to CMV drivers to assess if the above-mentioned items are covered and to promote their inclusions if it is not the case. An option would be to develop fatigue-related material that would abide with these principles and to make it available to the training community and the industry. Note that these issues should also be covered in testing and licensing procedures.

Fatigue Management Programs

The North American Fatigue Management Program (NAFMP), which will be made available to motor carriers throughout North America on a web-based platform in 2012, represents an important scientifically developed complement to HOS regulations. It is recommended that governments and industry stakeholders vigorously promote the voluntary adoption of the program by motor carriers of all sizes.

As a reminder, the NAFMP is comprised of education components for drivers, dispatchers, company management, family members etc, OSA screening and treatment guidelines, procedures and tools, scheduling guidelines and tools as well as recommendations with regards to the use of fatigue monitoring technologies. Note that all of these interventions, which are central to fatigue management, are not part of HOS regulations. This provides further support to the notion that an approach solely based on respecting these rules - and especially pushing them to the limit - falls short in terms of oversight and most likely effectiveness.

Scientific napping/recovery guidelines

It is widely understood that sleep is the most efficient way to address fatigue. Naps and recovery periods are therefore central to a comprehensive approach to manage fatigue. Some of the North American stakeholders that brought forward the NAFMP are currently involved in a combined field/lab research project to develop, test and validate various napping and recovery guidelines that will take into considerations factors such as day/night driving as well as individual differences in fatigue susceptibility.

The results of this research are intended to: 1) improve highway safety and driver well-being, 2) maximize the potential for schedule flexibility to better accommodate operational and driver needs, and 3) provide improved means for rapid and safe recovery from fatigue in the event of unforeseen schedule variations. It is therefore emphasized that the results of this important research project should be taken into account in further developments of a comprehensive Canadian approach to manage the fatigue of CMV drivers. An efficient way to make this possible will be to incorporate these guidelines into the NAFMP framework.

Fatigue monitoring technologies

Carriers, industry associations as well as jurisdictions have expressed the need for easy access to affordable and efficient fatigue monitoring technologies. Back in 2003 Transport Canada conducted a study entitled Fleet demonstration of technological aids for the management of fatigue among commercial motor vehicle drivers. There have been many developments in the field of fatigue monitoring since then however, with different technologies based on various approaches entering the market.

There is therefore a need to update the 2003 study in order to test various new technologies in an operational setting and to assess their efficiency in detecting early signs of fatigue. Issues related to user acceptance and behavioral adaptation also need to be investigated further. Depending on the results, a strategy for the widespread inclusion of these technologies in the motor carrier industry could be developed and recommended. The use of various forms of incentives to stimulate the adoption of these technologies should also be considered.

Crash avoidance technologies

It is becoming increasingly clear that crash avoidance technologies such as electronic stability control (ESC), forward collision warning systems (FCWS), lane-departure warning systems (LDWS) and blind-spot cameras can be beneficial for safety. It is therefore recommended that their utilisation be promoted in the motor carrier industry. Government-issued incentives like the ones given in the U.S. to help carriers to equip their fleets should be considered. However, issues such as user acceptance and behavioral adaptation also need to be studied further in this context. This could lead to the development of driver-based interventions that could be implemented as a complement to these systems, in order to mitigate potential negative safety impacts.

Obstructive sleep apnea

Carriers, industry associations and jurisdictions have expressed the need for an easy access to OSA screening procedures. While OSA screening and treatment is a component of the voluntary NAFMP, this issue nevertheless needs to be addressed more globally. Note that the current situation in the U.S. whereby rulemaking is in development, as well as the discussions of the CCMTA OSA working group, should make the issue progress in 2011. No immediate action items are therefore suggested for the moment, aside from promoting the NAFMP, monitoring what the U.S. does and waiting for the deliverables of CCMTA's OSA working group. Once all of these pieces in place, a reassessment of the situation should be conducted.

Rest areas

Assessing the current situation with regards to rest areas in Canada is critical for the development of a comprehensive fatigue management approach. Transport Canada is currently conducting a study to assess the supply and demand for truck parking. The study will determine truck drivers' parking habits and preferences, identify areas where designated truck parking might be difficult to find, and determine how any possible shortages of parking might impact on safety, productivity, and personal well-being. The results of this study will help to identify the magnitude of the problem, which is the first step for the development of effective long-term solutions. Once the study is completed, a strategy should be drafted. Note that since Quebec is revamping its global rest area structure, their experience in this process could be documented and made available to the other jurisdictions.

Rumble strips

Rumble strips represent a proven countermeasure to mitigate the effects of driver fatigue. Studies indicate decreases of 21% and 25% in single vehicle crashes by lateral and central rumble strips respectively. There is therefore a need to promote the installation of lateral and central rumble strips across the country. Reviewing the Canadian situation and developing safety and business cases are logical next steps that could help promote improvements in this area.

Distraction

The determinants of the decision to use distractors while driving

Studies have shown that drivers tend to use distractors while driving even knowing this seriously increases crash risk. It was also shown in experimental settings that drivers tend to use distractors impulsively, without considering variations of demands from the driving tasks, even if they are made aware of such variations in advance. These studies indicate that the decision to use distractors while driving is influenced by determinants other than knowledge. Assessing these determinants for the Canadian CMV driver population is an important first step for the development of targeted interventions. There is therefore a need to conduct a study to better understand the determinants of driver distraction in the motor carrier industry in Canada. Based on a representative sample of drivers, the study would assess the impacts of attitudes, motivation, personality dimensions and risk perception on the decision to engage in distracting behaviors while driving. Once completed, such a study would inform the development of interventions based on education, training, awareness, enforcement and company safety programs.

Training, testing, licensing

Driver education is seen as a key component of driver-based interventions to address distracted driving. There is however a need to assess current educational material and to run a gap analysis on the basis of the specific recommendations expressed in phase I with regards to issues that should be covered. As mentioned, a special focus should be put on high-level goals, motives, and strategic functions.

Given the increased penetration of telematics and communication devices in the task environment of CMV drivers, they need to understand the basics of attention processes as well as the notions of workload and task demands. CMV drivers should be made aware that their attention runs on a single channel mode and that simultaneous tasks with fluctuating workloads may create a situation where attention capacity is overloaded, resulting in severely increased crash risk. Once they really understand this dynamic, it is likely that drivers will be more motivated and better equipped to self-manage their attention and to more efficiently plan their use of distracting devices while driving. A legitimate option would be to develop distracted driving material that would abide by the various scientific principles discussed in phase I and to make it available to the industry.

STEP programs

Strategic enforcement (STEP) programs were shown to be efficient in dealing with DWI, seat-belt use as well as aggressive driving around large trucks and buses. They could also be used to address the use of distractors, including hand-held cell phones and texting, for both the general driving population and CMV drivers. Such alternatives are currently being developed in the U.S. as a follow-up to the Distracted Driving Summit. This avenue needs to be seriously considered in Canada as well.

Fleet level interventions

The following recommendations are presented in the report with regards to carrier-based interventions to mitigate distracted driving:

- Employers should limit the availability of distracting technologies and devices;
- Employers should provide drivers with vehicles equipped with technologies designed to minimize distraction;
- Employers should have clear policies to limit exposure to distractors;
- Employees should be provided with guidance as to when it is acceptable to engage in distracting activities and when it is prohibited;
- Employers should provide education and training to teach drivers how to self-regulate behavior with regards to driver distraction. Education should detail the risk associated with the different types of distractors and provide guidance as to how it can be mitigated;
- Carriers should implement systems to quantify the role of distraction in crashes;
- The efficiency of policies should be monitored with proper indicators.

Distractors-oriented countermeasures

- There is a need to make an inventory of current in-vehicle technologies with the potential for distraction in contemporary heavy vehicles in Canada (includes both OEM and nomadic devices, for both driving and non-driving tasks);
- There is a need to assess the distracting potential of these devices - taken both independently and in combination – and to establish their effects on driving performance;
- There is a need to assess how telematics devices (OEM and nomadic) are being developed. More precisely, the government should evaluate whether human factor guidelines are being used and how devices are being tested to determine if they are suitable to be safely used while driving or not;
- Given difficulties in applying design standards (rapidly evolving technology) and performance-based standards (no widely accepted standardized assessment methods), government needs to ensure that industry is following human factor design processes promoting *comprehensive, systematic and traceable application of human factors considerations throughout the whole development cycle*. Just how prescriptive this approach should be needs to be determined;
- Research in the field of real-time distraction countermeasures should be monitored and encouraged (funded);
- Special attention should be given to fleet dispatching devices and fleet communication devices. These systems should be using workload managers and lockdown functions while the vehicle is in motion, and these functions should be uniformly utilised by the industry. Further R&D is needed in this context and should therefore be encouraged (funded);
- Special attention should be given to instrument panels, which should also be using workload managers and lockdown functions;
- Texting by drivers needs to be banned from all trucks and buses in Canada.

Other things to consider

Reflecting on the action items that came out of the Distracted Driving Summit and the recommendations/action items of CCMTA's Expert Working Group on driver distraction, it appears that most elements are covered in the actions suggested above. The following points however, could be emphasized further:

- Information should be shared between governments on legislative and regulatory options for driver distraction;
- CCMTA should determine and recommend best practices for provincial regulations to address dangerous instances of driver distraction and the use of after-market devices.

Decision errors

Decision errors mainly relate to risky driving behaviors. Again, this is not to say that there are no other decision issues with CMV drivers, but rather that from a risk-based perspective risky driving should be prioritized. It was demonstrated that while passive interventions such as crash avoidance technologies as well as vehicle and infrastructure-oriented interventions still hold significant promise and should remain central to our priorities, active driver-oriented interventions also represent an essential component for a comprehensive and systemic approach to the problem.

The case was also made that current driver-oriented countermeasures are rarely based on scientific theories of driver behavior and behavior modification and that they are seldom evaluated. There is therefore a need for a significant R&D push to incorporate the vast body of scientific knowledge that currently exists on these issues into new operational interventions, or to use it to revamp existing ones. Naturally, these interventions, once developed and implemented, should be periodically evaluated with sound methodologies so that they can be continually improved on the basis of solid empirical data.

Carriers have a central role to play with regards to interventions aimed at mitigating decision errors. There is therefore a need to work with the industry in this respect. The development of scientifically sound and validated safety programs that can be made available to the industry and adopted by carriers on a voluntary basis appears to be a legitimate option. The development of safety and business cases should also be conducted in order to stimulate the adoption of these programs.

Risky driving has traditionally been addressed under different theoretical approaches in the fields of risk and traffic psychology. These different approaches bring complementary understandings of these issues and underline the use of various levers for behavior modification. The central themes were discussed and specific observations were made concerning the use of each of these approaches to address the problem of risky driving in the motor carrier industry. The first set of suggested actions are therefore *theory driven*. Observations regarding options for traditional means of interventions will follow.

Theory driven recommendations to address risky driving

The psychosocial approach

Given the interrelationships between risk-taking and health-risk behaviors and given the documented significant prevalence of these problems among CMV drivers, it is recommended that the Problem Behavior Theory (PBT) be used to investigate these issues further and to develop a program to promote a healthy lifestyle targeted specifically at this population. As per the theory, the adoption of a health-enhancing lifestyle should decrease the frequency of risky-driving behaviors.

The Theory of planned Behavior (TPB) has important implications for the evaluation of the determinants of risky driving as well as for the development of tailored interventions aimed at altering drivers' behavioral intentions. The TPB in fact generates various leads regarding the development or the revamping of safety interventions. These applications cut across several domains, which are regrouped in the following statements:

- It is suggested to use the TPB to evaluate the determinants of various risky driving behaviors for CMV drivers in Canada (attitudes, subjective norms, perceived behavioral control - as well as underlying behavioral, normative and control beliefs). Once we have a better understanding of what motivates risky-driving amongst the different sectors of the industry, scientifically sound interventions to alter behavioral intentions should be developed and evaluated;
- It is suggested to include TBP factors in a validated test battery that could be used:
 - By training schools at entry level, to orient trainees towards specific “training clinics” targeted at particular determinants of risky driving as defined in the theory;
 - By carriers in the context of driver improvement programs, to orient drivers with safety performance issues towards such specific “training clinics”, and/or;
 - In the context of a government-based intervention scheme such as the one Quebec is currently putting in place, where drivers who reach specific thresholds in terms of safety performance would be assessed and funnelled into tailored interventions corresponding to their particular profile and psychological makeup.
- It is further suggested to use the TPB in an effort to develop these new approaches or to revamp existing driver-oriented interventions to address risky driving behaviors. This work could have implications for a large variety of interventions, especially large-scale awareness campaigns, driver training, driver improvement programs as well as interventions aimed at improving carrier safety culture.

The personality approach

Personality is at the origin of a complex chain of behavioral production factors. Although it is distally related to actual safety performance, it nevertheless has a central role to play since it somewhat defines or conditions the utility of risky driving for individuals who share specific personality dimensions. Furthermore, while personality indeed cannot be changed, it associates with factors that can (attitudes, beliefs, subjective norms, risk perception) and it is in fact through these associations that it generates risky driving.

Therefore, since personality outlines different subgroups of risky drivers, it is important to address this issue by (1) assessing these dimensions, and (2) developing tailored interventions aimed at changing what can be changed for these individuals. Consequently, the implications of the personality approach relate to driver assessment, driver training and driver improvement programs.

Driver assessment:

As mentioned, it is suggested that a driver assessment test battery be developed and validated. The rule of thumb for driver assessment with regards to risky-driving is that it should be multidimensional, including personality dimensions (sensation seeking, aggression/social deviance) attitudes (using TPB and PBT frameworks), risk-perception (computerized hazard perception testing) and actual driving style or driving performance data (on-board monitoring data, vehicle parameters, driver records, driving simulators, etc.). Given the intense ongoing activity in the field of driver assessment, conducting an updated review of these variables and tools seems highly relevant. Also, given their limitations, it appears more appropriate - scientifically speaking - to use these measures in the context of driver training and improvement programs rather than in decision-making processes for hiring or licensing purposes.

Behavior modification:

In terms of behavior modification, the objective is to change what can be changed within the factors that interact with personality dimensions to produce risky driving. Central to these factors are the psychological determinants identified under the TPB as well as risk perception issues. Therefore, the first step is to assess the attitudes, subjective norms, perceived behavioral control, and risk perception skills for both sensation seekers and aggressive drivers. This can easily be done by adding personality measures to the above-mentioned study on the psychological determinants of risky driving.

Once this is done, the observations made earlier concerning the use of the TPB to develop tailored interventions aimed at altering behavioral intentions would also be applicable here, but adapted to these two specific personality subtypes. In other words, there is a need to develop specific means to alter the attitudes, beliefs, subjective norms, risk perception, etc., of sensation seekers and aggressive drivers, and the TPB offers interesting potential in this respect. This mainly has implications in terms of driver training and driver improvement programs, as reviewed in the report.

The risk perception approach

- It is suggested that a study be conducted to investigate hazard perception skills amongst CMV drivers and how it relates to actual risky driving behaviors;
 - This study should include the notions of confidence and over-confidence;
 - It could be merged with the above-mentioned study on the determinants of risky driving.
- Hazard-perception skills should be part of driver assessment test batteries, possibly using interactive computer-based driving tasks and/or driving simulators;
- Hazard perception training programs should be included in both entry-level training and driver improvement programs.

Traditional interventions

The previous sections presented theory driven options to mitigate risky driving. The following observations will use another angle, which is to focus on traditional means of addressing decision errors in the motor carrier industry. This includes training, safety culture, incentive programs, safety technologies, programs targeting CMV/LV interactions as well as government-based initiatives.

Training, testing, licensing

Driver training is clearly identified in the literature as a central piece in driver-based interventions to address risky driving. Phase II also showed that carriers, industry associations as well as government stakeholders identify training as one of the main interventions for decision errors in Canada. There was however no information provided as to the content of training curricula or training methods. In this respect, an ongoing project lead by the CTHRC will provide important results with regards to the efficiency of training content and methods. It is therefore emphasized that these results should be factored into future discussions as they become available.

Commercial driver training in Canada is not mandatory and drivers are in fact trained with a view to succeed in testing and licensing processes. According to various observers, this may not be sufficient to ensure that they will become safe drivers. As discussed in phase I, it is paramount - from a safety perspective - that efficient training components address fatigue, distraction and risky driving, which are the main crash causation factors. It is also of prime importance that these issues be covered in testing and licensing processes, since the content of testing somewhat dictates the content of the training curricula. The report lists various topics that should be included regarding each of these issues as well as observations about strategies that could be used to trigger attitudinal change through training. Note that these training elements should also be central to driver improvement programs, either from a carrier or a government stand point.

The following points should be taken in consideration when reflecting on the relevance of training to address risky driving per se:

- Based on a significant body of studies on the predictors of safety performance, different authors underline that there is a need to address *driving style*, rather than focussing only on *driving skills* in driver education. The question is therefore to determine how driver training can influence the way drivers *choose* to drive. In other words, how can driver education be used to target the predictors of risky driving (personality, attitudes, subjective norms, lifestyle, risk perception, etc.)?
- A sound strategy to answer this question would be to use the results of the proposed study on the determinants of risky driving to identify the factors that predict behavioral intention, that can be changed and be targeted through driver education (attitudes, beliefs, risk perception, etc.);
- In terms of how these factors could be changed, a preliminary review of literature identified the leads listed below. It is however recommended that a comprehensive review of attitudinal change models be conducted, with a special focus on their successful applications within various public health and health promotion domains.
 - Training elements should be developed to alter drivers' behavioral, normative and control beliefs with regards to specific high-risk driving behaviors;
 - Training should involve active issue-relevant thinking from participants (*central route persuasion*). A classroom format ideally conducted by an individual that shares significant characteristics with the peer groups would be indicated;
 - Amongst other things, such sessions should target normative beliefs by depicting a reality where positive safe behaviors are the norm and where risky-driving is marginal and clearly linked with increased crash risk;
 - With regards to personality an option is to include high-level information that would make drivers really understand how sensation seeking and aggression impacts on driving behaviors, while giving them precise alternatives as to how they should cope with these personal influences;
 - As mentioned, a strategy would be to use the study on the determinants of risky driving to correlate personality dimensions with attitudinal factors and identify the beliefs associated with sensation seeking and aggressive driving that could be changed and therefore should be targeted through driver education;
 - In terms of attitude changes, as per the TPB, driver training could also be used to promote a positive health-enhancing lifestyle that would positively impact on CMV drivers' health as well as their safety on the roads;
 - Lastly, driver training should include hazard perception skills.

Safety culture

CMV safety culture has been identified as a critical issue with regards to decision errors. It was shown that the culture of an enterprise or group (carrier) has a direct effect on individuals' beliefs, attitudes and safety motivations. Since these concepts have been confirmed as the main

predictors of risky driving in risk psychology, programs to implement a positive safety culture - or to improve the existing culture of a company - are recognized as legitimate scientifically sound interventions to mitigate risky driving behaviors.

The Safety Management System (SMS) approach, widely used throughout the world to manage safety risks, particularly in transport operations, represents a strong strategy to improve carriers' safety culture and to impact on numerous predictors of risky driving at the individual level. Furthermore, elements of SMS can be adapted to carriers of any size, including owner operators. It is therefore suggested that:

- A state-of-the-art SMS especially crafted for the motor carrier industry in Canada be developed and made available to the industry on a voluntary basis;
- This program should be complemented by safety and business cases that would stimulate buy-in from the industry;
- The SMS should be adapted to carriers of various sizes with tools made available for the whole spectrum of the truck and bus industry in Canada.

Applied Behavior Analysis

Incentive programs were identified as scientifically valid interventions to address risky driving behaviors. As per their impacts on motivation, incentive programs represent a strong strategy to change drivers' desire to be safe, which is a central factor in risk taking behaviors. The trucking and bus industry can therefore use incentive programs to its advantage in terms of increased safety, enhanced profitability, better company morale, greater productivity, reduction in personnel turnover, etc. These improvements can be achieved either by developing new incentive programs or by analysing and revamping existing ones on the basis of precise scientific knowledge relative to behavior modification.

Even though there is little scientific literature on the use of incentive programs within the trucking and bus industry, it appears that they are widely used, but often in an intuitive carrier-specific mode. As reported in phase II, 71 % of the carriers who completed the survey acknowledged the use of some sort of safety incentives. However, in the absence of comprehensive scientific guidelines, it is likely that some of these programs may not reap the desired results and may even bring about unintended negative impacts. This was also echoed in phase II, as many carriers asked for clear scientific guidelines for the development and implementation of incentive programs. It was also central in the recommendations of the 1998 Transport Canada study.

Given the complexity and the subtleties of such a behavior modification approach, it is suggested that a state-of-the-art incentive program, based on cutting-edge scientific knowledge emanating from the field of applied behavior analysis (such as the use of cues, prompts, feedback, commitments and rewards), be developed and thoroughly evaluated. Once developed and proven to be efficient, this program could be presented to the industry, either to be adopted on a voluntary basis or to serve as a template - or a general set of guidelines - that could be used by carriers to develop their own programs or to test the scientific soundness of existing ones. Such a

program should be accompanied by strong safety and business cases that would be used in order to stimulate the use of the approach within the bus and trucking industry.

Safety technologies

As mentioned in the fatigue section, crash avoidance systems such as FCWS, LDWS and RSC should be part of a comprehensive package to mitigate driver errors. As shown in phase II, stakeholders at every level expressed the need for these technologies. The tools however remain largely absent from fleets, with less than 10% of carriers currently reporting their use. The main reasons for this appear to be related to the costs of these devices as well as their availability to the industry at large. This is why carriers are asking for incentives such as tax rebates to facilitate their inclusion in operations.

Given the potential for safety benefits associated with crash avoidance technologies, it is suggested that stakeholders recognize this potential and engage in a policy development process that could set the stage for their large-scale inclusion in heavy vehicle fleets. This process should include looking at incentives that would motivate the industry to adopt these technologies. This process should also include studying behavioral adaptation and driver trust issues and how these phenomena could be mitigated.

The use of low cost Driving Behavior Management Systems (DBMS) that record parameters of driver behavior when a critical safety situation occurs is a good opportunity to implement interventions to coach drivers with regards to their safety performance. As mentioned before, the recorded information can also serve as a primary indicator of driving style and could be coupled with other psychometric measures in a driver assessment perspective. Drivers could then be directed through an intervention algorithm that would contain specific options related to different types of risky-driving, or different types of risky drivers.

The phase II survey also indicated that carriers are actually calling for easy access to low-cost driver behavior monitoring solutions. It is therefore suggested that stakeholders should recognize the potential of DBMS and engage in a policy development process that could set the stage for a large-scale inclusion of these technologies. DBMS could be used in the context of driver assessment processes and driver improvement programs, both from a carrier or a government perspective.

Interactions between light and heavy vehicles

Interactions between light and heavy vehicles have been identified as a central crash causation factor. Comments received by carriers clearly underline the fact that light vehicle drivers often do not understand the reality of CMV driving and that interventions should be implemented to address these issues. Two programs were reviewed: Ticketing Aggressive Cars and Trucks (TACT) and Operation Safe Driver (OSD). This assessment led to the following observations:

- The TACT program appears to represent an appropriate and scientifically valid approach to address LV/CMV interactions;

- The implementation of theory-driven attitude assessment and attitude modification approaches could improve the awareness raising/education component of the intervention, but this remains to be determined.
- While the TACT approach is well documented and evaluated, less material is available to support the efficiency of OSD. However, since both programs have important similarities, and given the massive support that CVSA gets from government and industry players, OSD also needs to be supported;
 - It would be relevant to document the intervention and its underlying behavior modification principles and to have it scientifically evaluated periodically.
- The idea that both programs should take a blitz format could be revisited. As discussed, numerous alternatives are possible. It could be a good thing to analyse these programs and their delivery on the basis of solid behavior modification principles and to assess how they could be improved in order to adhere to these principles.

Options for government-based initiatives

NSC standards 7, 12, 14 and 15 all relate to the core of safety programs for motor carriers in Canada. When reflecting on the efficiency of this framework with regards to decision errors, the important issues to consider are (1) the ability of these programs to identify high-risk drivers in a short timeframe and (2) the type of interventions that are implemented to address driver errors.

In light of the work being conducted in the U.S. with regards to CSA-2010, it is suggested that a review be conducted to assess the capacity of the NSC framework to identify high-risk drivers and to flag them for interventions. With regards to the interventions per se, it appears like the traditional carrier-based paradigm is set to stay. In Canada - like in the U.S. - it is mainly up to carriers to come up with driver improvement initiatives aimed at high-risk drivers. The case was therefore made that governments could help the industry in this endeavour by providing expertise, scientifically developed and validated programs as well as incentives.

Another possibility is to develop, in parallel, a government-based approach like the one currently being implemented in Quebec. With the new Politique d'évaluation des conducteurs de véhicules lourds, high-risk drivers meeting various negative safety performance thresholds need to meet with the government's Commission des Transports in order to be evaluated. Remedial interventions will then be prescribed on the basis of the results of this evaluation. This framework appears like an excellent opportunity to apply scientifically sound driver-oriented interventions in a government-based intervention framework. Therefore, it is suggested to explore with Quebec the possibility of using the instalment of this new regulatory framework to (1) study the profile of high-risk drivers and (2) develop and validate new scientifically sound interventions.

Note that such options for government-based driver-oriented interventions are not intended to replace the carrier-based framework currently in place, but rather to complement and potentially improve it. Such an approach could have the advantage of (1) ensuring a greater uniformity in driver-based interventions, (2) ensuring that driver-based interventions are scientifically sound and (3) ensuring that these interventions are monitored, and evaluated.