

## 10.0 Human Factors, Structured Interview Questionnaire Outcomes: Canada Phase and U.S. Phase

Drivers were administered a Human Factors Questionnaire at the end of the 2-week NO FEEDBACK period, and again at the end of the 2-week FEEDBACK condition period. The questionnaire (developed by Dr. G. Krueger and administered by him to all drivers) was completed in a structured interview format to increase the chances of obtaining a full dataset on drivers' reactions to the technologies. This was successful, as most questions were answered by  $n = 26$  Canadian drivers and  $n = 12$  U.S. drivers. The Questionnaire and Interviewer asked drivers to answer specific questions and provide their perspectives on the following interventions: *Alertness and Fatigue Management Training Course*; *SleepWatch®*; *SafeTRAC®*; *Copilot®*; *Howard Power Center Steering®*; *Psychomotor Vigilance Task (PVT)*; and the combined *Fatigue Management Technologies* used in the study.

The objective in summarizing these responses here is not to either criticize or promote any of the specific technologies used in the study, but rather to provide a summary of drivers' reactions to the various devices. It is important to keep in mind that drivers' reactions (positive and negative) to any one technology were a function of many factors,<sup>16</sup> including (1) how the technology performed relative to their alertness and fatigue, (2) where the technology was located (keep in mind that all technologies required modifications to the trucks and were not "built into the trucks" in a manner that optimized ergonomics), (3) the durability and reliability of the technology in the harsh environment of over-the-road trucking, and (4) protocol requirements that often limited drivers' abilities to alter technologies in ways that best suited them. In addition, the few differences found between Canadian and U.S. drivers in their reactions to the various FMT devices may reflect the different tractor/trailer configurations used in each phase (e.g., single trailers in Canada versus tandem trailers in the U.S. phase), which affected among other things, the location of the FMT equipment, the different roads traveled in each study phase, and different work schedules, as well as other differences between the companies and countries (hours-of-service). It was not the intent of the study to untangle the contributions of each of these factors in drivers' use of and reactions to the suite of FMT technologies studied. ***In fact, as subsequent sections reveal, despite all the differences between the two trucking operations, drivers from the two countries had—with rare exception—remarkably similar reactions to each of the technologies, and to other aspects of the fatigue management procedures and protocol.***

### 10.1 Drivers' reactions to the alertness and fatigue management training course

Tables 59 (Canada) and 60 (U.S.) summarize drivers' responses to questions 1 through 7 (from the Human Factors Structured Interview Questionnaire), which concerned drivers' reactions to the Alertness and Fatigue Management Training Course given by Dr. Krueger, prior to their initial drives in the FMT study, in the NO FEEDBACK condition (see Appendix F-1 and Appendix F-2 for detailed responses from Canadian and U.S. drivers, respectively). There were no differences apparent in response to specific questions between the Canada study phase drivers and the U.S. study phase drivers (compare Tables 59 and 60). Drivers generally rated the course content and knowledge they gained as being from good to very helpful (highest rating) and felt that the course was applicable to their jobs. From 83% to 96% of drivers indicated the course lessons were used by them during the FMT study, and that they intended to continue use them. ***Both their positive ratings of the course and their qualitative comments (Appendices F-1 and F-2) support the conclusion that drivers benefited from the course and wanted more of this type of didactic to help teach them how to manage their fatigue. This is impressive given that these were largely seasoned long-haul drivers, who appeared not to be inhibited about reporting that they can still learn about fatigue and ways to manage it. These positive views towards fatigue management training suggest that some segments of the trucking industry are likely to welcome fatigue management programs.***

### 10.2 Drivers' reactions to the SleepWatch®

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<sup>16</sup> For example, the smaller and more austere truck cabs in the U.S. Study phase made the FMT technology ergonomically more problematic, relative to the larger truck cabs used in the Canada Study Phase.

Tables 61 and 62 summarize drivers' post-study responses to questions 8 through 18 from the Human Factors Structured Interview Questionnaire, which concerned drivers' reactions to the *SleepWatch®* (Appendices F-1 and F-2). Drivers generally reported wearing the *SleepWatch®* greater than 90% of the time during the 4-week period, removing it for showers and other transient events, but 92% of U.S. drivers and 65% of Canadian drivers also reported it was bothersome to wear it continuously. Other than a greater proportion of U.S. drivers than Canadian drivers indicating the *SleepWatch®* was bothersome to wear, there were no clear differences between the two groups of drivers in their reactions to and ratings of the *SleepWatch®*. For example, their average rating on a 1 to 5 scale where 1 is "disappointing" and 5 is "very helpful," regarding how well the *SleepWatch®* "performance readiness" (P) numerical rating actually mirrored the way they felt, was between neutral and good (mean = 3.50). The average rating of whether the *SleepWatch®* provided help for their sleep planning during the study (mean = 3.08 to 3.27), was closer to neutral. Consistent with this was the fact only 46% of Canadian drivers and 42% of U.S. drivers indicated it provided useful information for managing sleep schedule. However, 73% of Canadian drivers and 83% of U.S. drivers liked the *SleepWatch®* alertness scale (i.e., 1-99). Only 38% of Canadian drivers and 50% of U.S. drivers indicated they would like a *SleepWatch®* for themselves and 50%-58% indicated they would recommend it to fellow drivers. The most common type of comment from drivers was that this technology was a problem to wear because many do not wear watches of any kind. Comments about the *SleepWatch®* being too big and cumbersome, as well as the band being uncomfortable, were also made by drivers (Appendices F-1 and F-2).

### **10.3 Drivers' reactions to the *SafeTRAC®* lane tracking monitor**

Tables 63 and 64 summarize drivers' post-study responses to questions 19 through 32 from the Human Factors Structured Interview Questionnaire, which concerned their reactions to the *SafeTRAC®* system (see Appendices F-1 and F-2 for detailed responses). Canadian and U.S. drivers generally agreed that *SafeTRAC®* numeric display was easily read (96% and 83%, respectively) and frequently got their attention while driving (73% and 100%). Proportionately fewer of them felt that it helped them drive more safely (69% and 42%). While 85% of Canadian drivers indicated that *SafeTRAC®* "helped me avoid a potential accident" (question 29), 0% of U.S. drivers indicated this was the case. This may have been due to the fact that U.S. drivers had much less traffic to contend with during their predominantly night driving periods. Less dramatic differences, but in the same direction, were found in response to question 30 ("SafeTRAC's alertness index helped me decide when to take rest breaks")—46% of Canadian drivers and 16% of U.S. drivers endorsed this statement positively. Similarly for question 28 ("SafeTRAC helped me drive more safely"), the respective proportions were 69% and 42%.

It is uncertain what may have created differences between Canadian and U.S. drivers' reactions to *SafeTRAC®*. It did not appear to be due to major differences in their attitudes toward the technology. Although 88% of Canadian drivers answered affirmatively to question 19 ("The *SafeTRAC* camera position in the windshield distracted me") while no (0%) U.S. driver answered it affirmatively; the two groups had very similar responses to all other questions about *SafeTRAC®*. Thus, the majority in each study phase felt its operation was consistent and understandable (77% and 58%); and that its location and controls were

good (65% and 75%). Their average ratings of how well the *SafeTRAC*'s "crossing the lane" alert feature could be trusted was just above neutral (Canada mean = 3.36; U.S. mean = 3.25), and the reliability of the displayed information regarding lane tracking was similarly rated (Canada mean = 3.50; U.S. mean = 3.25). Ratings averaged slightly lower for whether *SafeTRAC* warned them of poor lane tracking when they thought it was appropriate (Canada mean = 2.96; U.S. mean = 3.25). Half of Canadian drivers (50%) and proportionally fewer U.S. drivers (42%) indicated they would like *SafeTRAC* installed in their trucks, but more of them indicated they would recommend it to fellow drivers (65% of Canadian drivers; 50% of U.S. drivers). One commonly registered observation of drivers about *SafeTRAC* was that the volume control on the audible alert was set too high and not under their control. This was not a limitation of the technology, but rather of the protocol, which prohibited drivers from changing settings on *SafeTRAC*. It likely influenced some of the drivers' reactions to *SafeTRAC* and other technologies. Appendices F-1 and F-2 contain many comments about how drivers viewed *SafeTRAC*.

#### **10.4 Drivers' reactions to the *Copilot* (PERCLOS) monitor**

Tables 65 and 66 summarize drivers' post-study responses to questions 33 through 43 from the Human Factors Structured Interview Questionnaire, which concerned drivers' reactions to the *Copilot* (PERCLOS) monitor system (see Appendices F-1 and F-2 for detailed responses). Virtually all drivers in both study phases felt the PERCLOS display could be easily read (92% Canada, 100% U.S.); and that it was consistent and understandable (81% and 83%). Somewhat fewer of them felt it did not distract them (65% and 50%). However, drivers' ratings (on the 5-point scale where 1 was disappointing and 5 was very helpful) of whether the *Copilot* "alertness index information was helpful" for monitoring their alertness or drowsiness was on average neutral (Canada mean = 3.00; U.S. mean = 2.75). Their ratings of whether the PERCLOS digital display information was usually accurate and reliable was also rated about neutral (Canada mean = 2.91; U.S. mean = 3.42), as was the average rating of whether the *Copilot* alertness index display was usually a pretty good match to the way they felt (Canada mean = 2.92; U.S. mean = 3.33). Very few drivers indicated they would like *Copilot* installed in their trucks (27% Canada; 0% U.S.), and only a minority indicated they would recommend it to fellow drivers (35% Canada; 25% U.S.). Virtually all drivers in both study phases offered comments on the *Copilot* (Appendices F-1 and F-2).

#### **10.5 Drivers' reactions to *Howard Power Center Steering* (HPCS) system**

Tables 67 and 68 summarize drivers' post-study responses to questions 44 through 57 from the Human Factors Structured Interview Questionnaire, which concerned drivers' reactions to the *Howard Power Center Steering* (HPCS) system (Appendices F-1 and F-2). A clear majority of drivers in both study phases felt the HPCS operation was consistent and understandable (Canada 88%, U.S. 100%); that HPCS steering assistance was helpful in driving (Canada 77%, U.S. 83%); that it made the workload easier (73% and 75%); and that they were comfortable using it (77% and 75%). A majority of drivers also felt the *Howard Power Center Steering* system was helpful in crosswinds (Canada 81%, U.S. 67%), and helpful in straight-aways (77% and 100%), but proportionally fewer felt it helped on curves (Canada 38%, U.S. 17%). On the other hand, a majority of drivers felt it

improved truck steering or helped maintain direction (Canada 69%, U.S. 75%), and most felt it “always worked in a helpful manner” (69% and 75%). While just 50% of Canadian drivers liked the location of the HPCS controls, 83% of the U.S. drivers liked the location in their trucks.

On the critical question of whether HPCS reduced driver fatigue, 54% of Canadian drivers felt it did, compared to 75% of U.S. drivers. There were many positive comments on the HPCS from drivers (Appendices F-1 and F-2). ***Most drivers indicated they would like the Howard Power Center Steering® system installed in their trucks (Canada 77%, U.S. 83%), and that they would recommend it to fellow drivers (Canada 85%, U.S. 83%). These were highest proportions of affirmative responses found on these two questions in both study phases for any of the four FMT technologies (see questions 55 and 56 in Tables 67 and 68).*** It is noteworthy that as an already commercially available product, HPCS was built to specifically operate in the truck environment. This was not yet the case for some of the other technologies.

### **10.6 Drivers’ reactions to the *Psychomotor Vigilance Task (PVT-192)***

Tables 69 and 70 summarize drivers’ post-study responses to questions 58 through 63 from the Human Factors Structured Interview Questionnaire, which concerned drivers’ reactions to the *Psychomotor Vigilance Task (PVT-192)* test device (Appendices F-1 and F-2). It is important to keep in mind that the PVT was not utilized in this project as a fatigue management tool, but rather its purpose was to serve as an independent objective evaluation on drivers’ alertness/sleepiness at the midpoint and at the end of each trip. Relative to PVT normative data, drivers’ performances on the PVT-192 (see Sections 6.2 and 8.3, Tables 12 and 23, and Appendices D-1 and D-2) and their comments about it (see Appendices F-1 and F-2), indicate that they took the test very seriously and generally attempted to do their best when performing it. This conscientiousness was impressive considering that a majority of drivers (58%) in both study phases felt the PVT-192 was intrusive to their duty days (Tables 69 and 70). The intrusiveness is not surprising, since they had to stop driving and take 10 minutes to perform the task midway in a workday, and at the end of the workday, and do this on every workday for the entire month each was empanelled in the study.

The majority of drivers in both study phases felt the PVT matched their own perceptions of their reaction times (Canada 73%, U.S. 83%), and when their PVT reaction times were slower, most drivers felt the PVT times reflected their own overall assessment of fatigue (Canada 73%, U.S. 92%). Although the PVT was not discussed with drivers as a fitness for duty device, they were asked in the post-experimental questionnaire if it “could be used as a personal checking system on driver *fitness for duty* system (e.g., to check for a driver’s readiness to drive as he/she reports for duty, or at rest stops half way through a long trip)” (Tables 69 and 70, and Appendices F-1 and F-2). Surprisingly, a modest majority of drivers answered affirmatively to this question (Canada 54%, U.S. 58%). Since the Psychomotor Vigilance Task was not one of the Fatigue Management Technologies used in the study, but rather, purely an assessment tool for drivers’ behavioral alertness, drivers were not asked if they would like their own personal PVT device, or whether they would recommend it to fellow drivers, as was done for the four FMT technologies. One of the more frequent comments from drivers about the PVT was that the test was too long and

hence too time-consuming and demanding (Appendices F-1 and F-2). *These comments and drivers' somewhat positive view of the PVT as a potential fitness for duty device, suggest that efforts should be made to attempt to validate the sensitivity and positive and negative predictability of a shorter-duration PVT test (e.g., 3-5 minutes) relative to truck driver fatigue.*

### **10.7 Drivers' reactions to the combined *Fatigue Management Technologies***

Tables 71 and 72 summarize drivers' post-study responses to questions 64 through 69 and questions 72 through 84 from the Human Factors Structured Interview Questionnaire, which concerned drivers' reactions to the combined *Fatigue Management Technologies* (Appendices F-1 and F-2). *In general, drivers agreed that commercial drivers would benefit from fatigue management aids (Canada 88%; U.S. 100%) and they rated the usefulness of FMT aids to themselves closer to helpful than neutral (Canada mean = 3.76, U.S. mean = 3.75).*

Three of the technologies provided on-line digital feedback on alertness (*Copilot*®, *SafeTRAC*®, and *SleepWatch*®). *Copilot*® and *SafeTRAC*® feedback were visible to drivers as they drove. In questioning drivers post-experimentally about the validity of the feedback they received from these devices, many drivers felt that there was not enough warning from the alertness monitoring devices' numeric displays to alert them to the fact that they were driving while very drowsy and/or that they might becoming too sleepy to continue driving safely (Canada 38%, U.S. 58% in Tables 71 and 72). A slightly higher proportion of them felt that when they received low alertness or drowsy driving indicators on the digital displays, the displays generally seemed to accurately match what they were experiencing at the time (Canada 54%, U.S. 67%). It is possible that the much higher proportion of driving time at night in U.S. Study Phase 2 relative to Canada Study Phase 1 accounted for the somewhat higher percentage of U.S. drivers who felt the digital feedback was accurate relative to how they felt. Some drivers noted problems caused by contradictions among devices giving feedback—that is, one device would indicate they were drowsy, while another did not. This occasional lack of agreement over alertness/drowsiness level among the technologies, as well as the issue of the various types of feedback provided by different technologies to drivers, will require additional research attention, if an ensemble of technologies is to be integrated for practical use.

The limited resources for this pilot study necessarily required ad hoc instrumentation of truck cabs with technologies, rather than full integration of each system with specific truck manufacturers. For example, the FMT feedback displays were mounted on the dash rather than in the dash. This was not ideal from the drivers' perspectives. As Tables 71 and 72 reveal, many of the drivers indicated that some aspects of the technologies distracted them from driving (Canada 42%, U.S. 58%); that FMT devices sometimes shut down while they were driving (Canada 35%; U.S. 50%); and that they noticed “unsafe” aspects of the FMT equipment installed in their trucks (Canada 27%, U.S. 8%). Nearly all of the drivers' comments about technologies being distracting or creating a potentially unsafe situation had to do with the location of the FMT equipment (Appendices F-1 and F-2). As presented in Tables 73 and 74, when drivers were asked if during the study “anything in the fatigue management instrumentation that distracted you from performing your driving duties or interrupted your concentration on your driving tasks,” five Canada drivers and three U.S.

drivers (total n = 8 drivers out of 38) made comments about the *SafeTRAC®* system being distracting, and 3 Canada drivers and 1 U.S. driver commented about the *SafeTRAC®* system being unsafe as installed. Several drivers commented on the distraction caused by the *Copilot®* PERCLOS monitor's flashing red lights. Two drivers commented on the *Howard Power Center Steering* system controller being in the wrong location. Several drivers commented on lack of time for the *PVT* tests. Not surprisingly, no driver made comments about distraction or unsafe installation relative to the *SleepWatch®*, since it was attached to the drivers, not the trucks. While half (54%) felt the FMT devices accurately reflected when they were drowsy, only 38% felt they received adequate warning from the devices when they were getting sleepy.

### 10.7.1 Accidents and law enforcement citations

As questions 79-82 in Tables 71 and 72 reveal, no driver in either study phase reported a citation for a logbook violation during project participation, and no driver indicated that they had received a law enforcement citation for an action that occurred in the context of an accident during project participation. However, 15% of Canada drivers and 8% of U.S. drivers reported receiving a citation for a moving violation during their participation in the project, while no U.S. drivers and two Canada drivers (7%) reported being involved in an accident or crash during the study—one occurred when the brake was not set while parked, and the other was a collision with a fence post that the driver attributed in part to sleepiness during the NO FEEDBACK condition. *Thus, there was no evidence that FMT FEEDBACK contributed to citations or accidents.*

## 10.8 Drivers' comparisons of the *Fatigue Management Technologies*

Tables 75 and 76 summarize drivers' relative rankings of the FMT technologies that purported to measure alertness/drowsiness (*Copilot®*, *SleepWatch®*, *PVT*, *SafeTRAC®*). Drivers ranked the systems relative to each other on how well each matched the driver's own sense of alertness (question 70) and drowsiness (question 71). *SafeTRAC®* received the highest average ranks in both the Canada study phase (alertness = 1.90, drowsiness = 2.00) and U.S. study phase (alertness = 2.10, drowsiness = 1.91). The *PVT* averaged the second highest rank in the Canada study phase (alertness = 2.04, drowsiness = 2.22), and the third rank in the U.S. study phase (alertness = 2.70, drowsiness = 2.36). These ranks were comparable to those for the *SleepWatch®* in both the Canada (alertness = 2.38, drowsiness = 2.23) and U.S. phases (alertness = 2.10, drowsiness = 2.54). The *Copilot®* PERCLOS monitor received the lowest rank in both the Canada (alertness = 3.05, drowsiness = 2.84) and U.S. study phases (alertness = 3.00, drowsiness = 3.18). Drivers were not asked to rank the *Howard Power Center Steering®* system because it did not purport to measure alertness or drowsiness.

The results in Tables 77, 78, and 79 provide additional insight into how drivers perceived the technologies, since they include ratings on a 10-point scale (10 is the highest, 0 is the lowest) for all four FMT technologies (*Copilot®*, *SleepWatch®*, *PVT*, *SafeTRAC®*, and *HPCS®*). Drivers were not asked to rate the *PVT* because it was not conceptualized in the study design as an FMT technology, although the drivers thought of it that way and rated it highly when asked to (see Tables 69, 75, and 76). Tables 77-79 reveal that the *Howard Power Center Steering®* system scored the highest rating from drivers in both study

phases, with no statistical significance between them (Canada mean = 7.60; U.S. mean = 8.33). *SafeTRAC*® ratings were also not significantly different between study phases (Canada mean = 7.60; U.S. mean = 7.46), and they were not significantly different from ratings for *HPCS*®. Drivers' ratings of *SleepWatch*® were also not significantly different between study phases, but they were below those for *HPCS*® ( $p = 0.088$ ) and *SafeTRAC*® ( $p = 0.76$ ) in the Canada study phase, and below *HPCS*® ( $p = 0.076$ ) in the U.S. study phase. The *Copilot*® PERCLOS monitor was the lowest rated FMT technology in both study phases. It was also the only technology in which driver ratings differed significantly between countries. In the Canada study phase *Copilot*® had an average rating of 5.79, but its rating in the U.S. study phase was 2.96 ( $p = 0.001$ ). This a troublesome difference, since the U.S. study phase involved primarily night driving, when one would expect the *Copilot*® PERCLOS monitor to be optimally effective (i.e., not affected by ambient light). Drivers' dissatisfactions with *Copilot*® can be found in Appendices F-1 and F-2.

When subjects were combined across the two study phases (Table 79), there was no statistically significant difference in drivers' ratings of *HPCS*® and *SafeTRAC*®, both of which were rated significantly higher than *SleepWatch*® ( $p < 0.03$ ), and significantly higher than *Copilot*® ( $p < 0.0005$ ). *SleepWatch*® was also rated significantly higher than *Copilot*® ( $p = 0.002$ ). If one considers that ratings greater than or equal to 5.5 (on the 10-point rating scale used by drivers) indicate a driver's positive attitude toward a given technological approach to fatigue management, then the *Howard Power Center Steering*® system was positively endorsed by 83% of drivers, followed by *SafeTRAC*® at 76%, *SleepWatch*® at 59% and *Copilot*® at 39% (Table 79). ***In conclusion, drivers rather consistently reported that the Howard Power Center Steering® system and SafeTRAC® offered FMT benefits relative to SleepWatch® and Copilot®, although all FMT technologies were seen to have some promise. It is noteworthy that HPSC and SafeTRAC are also vehicle performance-based technologies, while SleepWatch and Copilot are operator-based technologies. It may be that truck drivers prefer fatigue management be carried out by way of vehicle monitoring more so than driver monitoring.*** On the other hand, *HPSC* and *SafeTRAC* were also more commercially-ready technologies when used in the study, which may have contributed to drivers rating them higher.

***For the most part, volunteer drivers in both the Canada Study Phase and U.S. Study Phase were supportive of the idea of continuing to explore ways to perfect technological devices to monitor alertness and drowsy driving, and to help them manage their fatigue levels.*** That is encouraging, since prior to the study some researchers predicted that drivers would not be supportive of fatigue management technologies—although it must be considered that drivers who would volunteer for such a study are also likely among those who might view fatigue management technologies favorably anyway.

In post-experimental debriefings, the drivers pointed out that most of technologies used in the study did not appear to be ready for routine use. These drivers contributed numerous suggestions for making improvements to the FMT devices; most of these suggestions involved improved human engineering. Many of the drivers suggested that if such FMT devices and technologies were improved, those mounted in truck cabs would have to be integrated into the dashboards or truck instrument panels to avoid being in the way. It appears that at least some professional truck drivers would use fatigue management technologies if/when they were perfected for easy integration into the truck console.