Pilot Tests of a Seat Belt Gearshift Delay On the Belt Use of Commercial Fleet Drivers

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16. Abstract

This study evaluated a device that prevented drivers from shifting vehicles into gear for up to 8 seconds unless the seat belt was buckled. Participants, commercial drivers from the United States and Canada who did not consistently wear their seat belts, could avoid the delay by fastening their seat belts. Unbelted participants experienced a delay of either a constant 8 seconds or a variable delay that lasted an average of 8 seconds. United States drivers' belt use increased from 47% to 68% (a 45% increase), and Canadian drivers' use rose from 54% to 75% (a 39% increase). There was no significant difference between the fixed and variable delay schedules.

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Wearing a seat belt has been shown effective in avoiding serious injury due to traffic crashes (Tison, Solomon, Nichols, Gilbert, Siegler, & Cosgrove, 2008). Existing efforts to increase seat belt use focus primarily on public education, high-visibility police enforcement, and seat belt reminder systems. While belt use rates in the United States increased from under 60% in 1994 to 83% in 2008 (NHTSA, 2008), a substantial number of drivers still drive unbelted. This report documents a study that tested the effects of a novel engineering approach to increase belt use.

Behavioral programs that combine enforcement and education campaigns have been associated with increases in seat belt use in the United States and Canada. NHTSA's *Click It or Ticket* (CIOT) high visibility enforcement model has successfully raised levels of seat belt use to above 80% in the United States, and has been particularly successful in States with primary laws (Jonah & Grant, 1983; Williams, Reinfurt, & Wells 1996). The approach influences behavior via a punishment contingency (e.g., If I don't wear my seat belt, I may have to pay a fine). The model requires substantial efforts to fund and coordinate national and State media campaigns with multiple police departments. The resources required to execute CIOT coupled with emerging technologies have renewed interest in evaluating engineering solutions to increase seat belt use.

With the exception of the brief period in the mid-1970s during which cars were fitted with seat belt ignition interlocks, seat belt reminder systems have been the engineering solution to improve seat belt buckling. Most reminder systems focus exclusively on drivers rather than passengers. The standard reminder must combine a visual icon that lasts for up to 60 seconds and an auditory warning that lasts between 4 and 8 seconds. Auto manufacturers have introduced enhanced seat belt reminders that present warning tones or display visual icons that persist longer than standard reminders. NHTSA documented that these enhanced reminders are associated with a significant increase in seat belt use (NHTSA, 2007).

Although enhanced seat belt reminder systems are associated with increased seat belt use, low cost improvements to seat belt reminder systems may produce further increases in belt use. Furthermore, existing reminder systems do not appear to take into account variables including sequencing, timing and saliency of stimuli during trip initiation. Any of these may play a role in increasing seat belt use.

The literature provides evidence that drivers buckle at discrete points during trip initiation (Malenfant & Van Houten, 2005). These authors observed the buckling sequence and relevant latencies of 1,600 drivers in two urban areas in the United States and Canada. They reported that, 31% of drivers who fastened their seat belts did so before ignition, 42% after ignition, and 23% after placing the vehicle in gear. Only 1% buckled their seat belts more than 29 seconds after placing the car in gear. The drivers who buckled after ignition but before placing the vehicle in gear had a mean latency of 6.1 seconds and 85^{th} percentile latency of 8.0 seconds. Age and sex had little effect on gear-seat belt latency.

Malenfant and Van Houten (2005) provide evidence that the U. S. regulation FMVSS-208 and CMV99 do not require audible and visible seat belt reminders to reach maximum effectiveness. The required seat belt prompt regulation compromises the saliency of the signal by presenting the warning among other start-up stimuli, and the timing of the presentation ignores the preferred behavioral sequence of most drivers. Designers might optimize the effectiveness of the seat belt buckling prompt by isolating it from other stimuli by activating the reminder after the driver has ample opportunity to buckle up without the prompt. Malenfant and Van Houten's (2005) results indicate that the overwhelming majority of drivers who buckle (99% in their sample) would not encounter a prompt presented approximately 30 seconds after the vehicle is placed in gear. Only those drivers least likely to buckle up would experience the reminder. If a small percentage of drivers received a prompt to buckle up, it could become more socially acceptable to introduce more salient and possibly aversive systems for reluctant belt users. As more drivers consistently wear their seat belt, the percentage of drivers who would receive a more intrusive prompt would likely decline. The current study tested a seat belt reminder system designed to reflect the sequencing, timing, and saliency findings identified by Malenfant and Van Houten (2005).

A number of prompts were considered for the current study and rejected. Interrupting the air conditioning system was deemed unsafe as it might cause windshield fogging, and muting the sound system might antagonize the driver and result in unsafe behaviors such as aggressive driving. Annoying stimuli such as loud buzzers would likely encourage drivers to attempt to circumvent the system.

The reminder system timing was designed to prompt drivers before they placed the vehicles in gear to avoid the possibility of stimulus overload as they negotiated their way into traffic, a trip segment associated with high cognitive demand. It was considered safer to present the prompt at the end of the behavioral sequence of trip initiation, i.e., just prior to putting the vehicle in gear. This should allow the majority of drivers sufficient time to buckle up and avoid the prompt (Malenfant & Van Houten, 2005). It had the safety benefit of prompting unbuckled drivers before they placed their vehicle in motion.

Van Houten, Nau, and Merrigan (1981) found that people would select a more effortful behavior, using the stairs rather than an elevator, if the elevator trip duration increased. A later study, Van Houten, Malenfant, Austin, and Lebbon (2005), reported that a similar delay was effective in increasing seat belt use. The reminder system in the current study coupled the seat belt prompt (a chime) with a gearshift delay of 8 to 16 seconds that required drivers to wait for the delay to expire before putting the vehicle in gear. Only drivers who failed to buckle before they depressed the brake (in preparation for shifting) experienced the gearshift delay. The main hypothesis was that the system would be effective in increasing belt use.

In the earlier study, fixed delays of 5 to 20 seconds produced high levels of seat belt use (Van Houten et al., 2005). Feedback from the drivers in the 2005 study underscored the need to adjust the device used for the current project to reduce frustration and increase acceptability. All participants stated that 20-second fixed delays were aversive and frustrating to the point that many drivers attempted to circumvent the system.

The level of frustration was heightened when the participants were required to buckle up to move their vehicles from one parking space to another. The drivers in Van Houten et al. (2005) suggested that shorter delays and a modification to allow regularly buckled drivers to avoid the gearshift delay for short trips (e.g., moving to a different parking space) would increase acceptability to drivers. Finally, two drivers indicated that they typically buckled after placing their vehicles in motion. They suggested that researchers count trips in which drivers buckled within a few seconds after putting the vehicle into motion as buckled trips. These two buckling patterns may represent nearly 25% of all drivers, according to Malenfant and Van Houten (2005).

Based on this feedback, the system for the current project incorporated changes to the data-logging device. The 20-second seat belt gearshift delay was replaced with an 8-second delay, which could be increased to 16 seconds if seat belt use did not improve. This reminder could not be ignored because it was impossible to place the vehicle in gear during the seat belt-gearshift delay. Thus, the driver was compelled to notice the reminder chime that accompanied the delay.

To accommodate drivers who preferred not to buckle to simply move their vehicles out of the way, the current data logger did not count trips shorter than 60 seconds. Drivers would only receive the delay when belt use on trips lasting more than 60 seconds dropped below 80%. Trips during which drivers buckled within 30 seconds of shifting into gear counted toward the 80% seat belt use criterion. When drivers reached this 80% criterion, the device automatically became inactive.

METHOD

Participants

The efficiency of the seat belt gearshift system was field-tested with a fleet of 60 United States and 60 Canadian vehicles from a variety of government agencies and the private sector. Participants were drivers who made large numbers of short trips (U.S. vehicles averaged 15 trips per day). St. Petersburg, Florida, provided access to 60 of its vehicle fleet, which represented the entire U.S. vehicle sample. Drivers from this sample were adult males. The participating Canadian agencies included the New Brunswick Power Commission, the cities of Moncton, and Dieppe, Plexus Canada, Radio-Canada, and the Halifax Regional Municipality. One female and 59 male drivers comprised this Canadian sample. Data from some vehicles were lost due to technical issues. Thus, the data analyzed were obtained from 50 U. S. vehicles and 51 Canadian vehicles. Vehicles included quarter-ton and half-ton GMC, Chevrolet, or Ford trucks, and GMC or Chevrolet vans ranging from 1998 to 2005 models. Most drivers drove the same vehicles throughout the study.

Apparatus

The apparatus included a microprocessor installed under the driver's seat and connected to seven functions of the vehicles via a specially designed harness, as well as a chime and seat sensor. This microprocessor recorded data and included a programmable gearshift delay plus seat belt reminder. The delay began after the driver applied the brake to put the transmission in gear. Researchers could select the absence of a delay for baseline recording, an 8-second fixed time delay, an 8-second variable time delay, a 16-second fixed time delay, or a 16-second variable time delay.

Participants who were belted during at least 80% of their trips avoided the delay. Trips began when vehicles were in motion for more than 30 seconds. "End of trip" was defined by either of two independent criteria. The first was simultaneous absence of vehicle motion and weight on the seat sensor of more than 10 seconds. This criterion addressed an end of trip that involved leaving the vehicle with the motor running, such as making a delivery or working at a site. We adopted this definition in order to discourage drivers from avoiding the delay by leaving the motor running between trips, which would be a potentially unsafe. The programmer allowed a three second weight de-bounce to allow for the weight shifts by the driver. Second, the ignition had to be off for more than 180 seconds. This threshold was set high to ensure drivers with stalled vehicles in dangerous locations such as railroad crossings could restart and place vehicles in gear if their seat belts were unfastened. We reasoned it was unlikely that a driver would turn a vehicle off for periods less than 180 seconds before attempting a restart.

The microprocessor recorded time, date, duration of motion, presence of weight on the driver seat, ignition on or off, brake on or off, seat belt delay on or off, seat belt on or off, start of trip, end of trip, and trip history in baseline as well as experimental conditions. In addition, the microprocessor was capable of analyzing the recorded data. Illustration 1 shows the flow diagram for the procedures.

The programmer selected the gearshift delay conditions and downloaded dependent measures by connecting a laptop computer to the data logger. Onset and offset of the chimes coincided with the preset gearshift delay.

The seat belt-gearshift delay activated when unbuckled drivers depressed their brake pedals. Drivers had the option of buckling, which immediately terminated the delay, or waiting out the delay. To prevent drivers from bypassing the device, the delay and chime activated if drivers buckled before sitting down. Figure 14 in Appendix A presents a flow chart to show how the gearshift delay operated.

Measures

The data logger monitored the following events: vehicle ignition, person seated in driver's seat, seat belt closure, brake use to unlock gearshift, motion, start and end of trip and implementation of the gearshift delay. Each of these events was recorded with a date and time stamp. The data logger also calculated the percentage of seat-belted trips and the times when the seat belt was unbuckled for more then 15 seconds after the vehicle began moving. The dependent variables in this study were percentage of belted trips; percentage of trips the driver's seat belt was removed; percentage of trips with no delay; mean number of trips; and mean trip duration. The independent variables were delay type (fixed or variable) and delay interval (8 or 16 seconds).

Experimental Design

A reversal design was used for the study. After obtaining baseline data from all vehicle fleets, half the vehicles were randomly assigned to receive a fixed (8-second) or variable (8-second average, 4- to 19-second range) seat belt-gearshift delay. If the response to the 8-second delays did not produce marked improvements in belt use, the interval was increased to a 16-second delay for U. S. vehicles. The researchers informed drivers of the interventions prior to activating the seat belt-gearshift delay in their vehicles and provided drivers printed summaries describing the baseline phase and later the intervention phase. Appendix A contains the summaries.

The researchers assured participating agencies and drivers that individual seat belt use data would be kept anonymous, confidential, and would not be divulged to their supervisors or anyone else. Each employer fully agreed and supported this commitment.

Baseline 1 Phase. Prior to installing recording data, meetings were held with the drivers, their union representatives, and their supervisors to explain the baseline data collection phase of the study. Drivers were informed that a data logger had been placed in their vehicles as part of a study for the NHTSA and Transport Canada. After the data loggers were installed and baseline began, the loggers recorded the dependent measures, but drivers did not experience the seat belt-gearshift delay.

For the U. S. sample, the initial baseline period ranged from 4 to 52 days, with a mean baseline period of 24.61(SD = 7.97) days. For the Canadian sample, the range was 3 to 66 days, with a mean and standard deviation of 18.41(11.14) days.

Intervention Phase. During this phase, the delay occurred whenever the driver did not fasten the seat belt and tried to place the transmission into gear. The driver could escape the delay at any time by buckling the seat belt. Vehicles were randomly assigned to the variable or fixed-time 8-second delay condition. A 16-second delay was introduced for a portion of U. S. drivers who did not show marked improvements or had belt use stabilized below 80%. For the U. S. sample, the intervention phase lasted 12 to 103 days, with an average intervention period of 37.32 (SD = 20.33) days. For the Canadian sample, the intervention phase lasted 10 to 89 days (M=41.92, SD=19.79).

Return to baseline. The seat belt delay with its associated reminder was inactive during the return to baseline while data continued to be logged. For the U. S. sample, second baseline period ranged from 4 to 43 days, with an average duration of 27.11(SD = 8.04) days. For the Canadian sample, this period lasted 6 to 42 days (M=24.62, SD=9.01).

RESULTS

The U. S. sample analysis included 26 vehicles with the fixed-time delay and 24 vehicles with the variable-time delay. Data from 10 vehicles from this sample were excluded from analysis. Drivers of seven vehicles discovered that they could escape the delay by briefly depressing the seat belt release button, and used this strategy throughout the study. One driver reported that he avoided the system by leaving the vehicle in neutral with the engine running and the emergency brake on; another repeatedly disconnected the device. Data from a tenth vehicle was omitted because of hardware failure after installation.

The Canadian sample included 51 vehicles, 26 vehicles in the fixed time delay condition and 25 with the variable time delay condition. Ten of the Canadian vehicles did not provide useful data. Equipment in five vehicles malfunctioned during the study. Drivers of three other vehicles failed to bring their vehicles in for downloads and to switch on the device. Data from two vehicles were omitted because baseline data were not collected.

In addition to the mean number of belted trips, the data loggers recorded mean trip length, and mean trips per day. Table 1 presents the means and standard deviations for these variables as a function of treatment period and country. For both countries, some data points for the variables were not recorded across the study period. See Appendix A for tables that provide the mean percentage of trips that data loggers indicated that drivers wore their seat belts or removed their seat belts. These results are broken out by treatment period (baseline 1, intervention, baseline 2), country, and delay type (fixed versus variable).

Table 1. *Belted Trips, Trip Duration, and Trips per Day, by Country and Treatment Period*

		Baseline 1	Intervention	Baseline 2
United States				
% Belted Trips[1]				
	Fixed	41.65 (28.21)	69.85 (27.11)	61.60 (33.91)
	Variable	54.37 (27.94)	64.83 (29.86)	51.91 (31.42)
Trip Duration[2]				
	Fixed	8.35 (4.61)	9.07 (3.90)	9.02 (4.29)
	Variable	7.54 (2.86)	8.59 (4.16)	8.89 (3.12)
Trips per Day				
	Fixed	14.18 (6.79)	15.13 (8.63)	14.68 (10.01)
	Variable	15.20 (7.44)	16.74 (9.13)	16.93 (10.92)
Canada				
% Belted Trips				
	Fixed	51.92 (33.75)	72.35 (23.38)	61.03 (31.37)
	Variable	55.88 (26.98)	76.56 (17.40)	67.37 (22.63)
Trip Duration				
	Fixed	9.74 (6.24)	10.05 (4.27)	10.40 (5.35)
	Variable	9.45 (4.06)	10.21 (4.33)	9.87 (3.80)
Trips per Day				
	Fixed	12.59 (9.78)	14.26 (9.35)	18.04 (12.70)
	Variable	11.04 (5.59)	11.56 (5.82)	13.26 (6.89)

[1] Mean percentage of trips wearing seat belt; [2] Trip duration in minutes

Seat belt Use. A 2 (Country) by 2 (Gearshift Delay Type) by 3 (Treatment Period) mixed ANOVA tested for differences in seat belt usage. The main effect for country was significant: $F(1,268) = 4.09$, $p<.05$. Across treatment period and gearshift delay condition, Canadian participants drove a significantly higher percentage of belted trips (M=64.74%) than their U. S.'

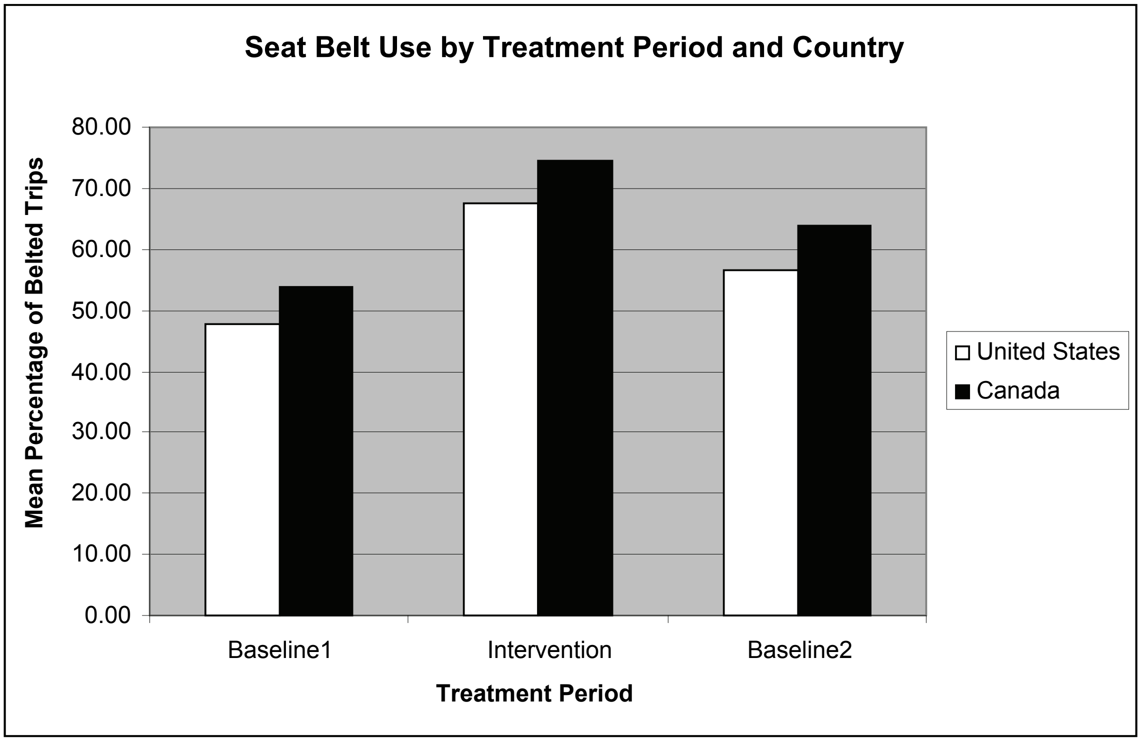
counterparts (M=57.32%). A similar 2x2x3 ANOVA tested for differences in trip duration. The main effect for country was significant: $F(1, 229)=25.58$, $p<.001$. The Canadian sample drove longer trips (M=11.37 minutes) than the U. S. sample (M=8.57 minutes). As a result of these differences between countries, separate 2 (Gearshift Delay Type) by 3 (Treatment Period) ANOVAs assessed each sample for the effect of the gearshift delay on the mean percentage of buckled trips.

A portion of the U. S. sample received a 16-second gearshift delay intervention after exposure to the 8-second delay. Twelve of 26 participants assigned to the fixed gearshift delay received the 16-second delay, whereas 14 of 24 participants in the variable gearshift delay received this longer intervention. Difference scores were generated by subtracting the mean percentage of seat belt use during the intervention period from mean percentage of use during baseline. More specifically, for individuals who received the 16-second delay, mean usage rate during this period was subtracted from the initial baseline period. Likewise, for individuals who received only the 8-second delay, mean percentage of seat belt use was subtracted from baseline 1. We then conducted two t-tests, one for participants in the fixed delay and one for participants in the variable delay, to determine if the there was a difference between the 8- and 16-second delays. Neither the t-test for the fixed delay condition nor that for the variable delay conditions were significant: $t(24) = 1.62$, *n.s.*; $t(22) = .41$, *n.s.*, respectively. Mean percentage of belt use did not reliably vary between individuals who received the 8-second delay or the 16-second delay.

For the primary 2 by 3 ANOVA, mean seat belt use for the intervention period was defined as the usage rate during exposure to the 8-second gearshift delay. As expected, the analysis for the U. S. sample found a main effect for treatment period: $F(2, 135) = 5.33$, $p<.01$. A Tukey HSD post hoc test revealed that the mean percentage of seat belt use was significantly higher during the intervention period when drivers drove with the delay (M=67.44) than during the first baseline period (M=47.76). The main effect for gearshift delay type was not significant: $F(1,135) = .02$, *n.s.* The interaction between gearshift delay and treatment period was also not significant: $F(2,135) = 1.88$, *n.s*.

The pattern of results for the Canadian sample was similar to the U. S. sample. As expected, the main effect for treatment period was significant: $F(2,133) = 7.35$, $p<.01$. A Tukey HSD post hoc test indicated that the Canadian drivers wore their seat belts more frequently during the intervention period (M=74.41) than the initial baseline phase. As with the American sample, the effects for gearshift delay type and the gearshift delay type by treatment period interaction were not significant: $F(1,135) = .02$, *n.s.* and $F(2,135) = 1.88$, *n.s.,* respectively. Figure 1 depicts the mean percentage of seat belt use as a function of treatment period for the U. S. and Canadian groups. Tables 2a and 2b follow Figure 1, and present the results of the ANOVAs for the U. S. and Canadian groups' mean seat belt use.

Figure 1. Seat Belt Use by Treatment Period and Country.



Note. For the United States and Canada, seat belt use increased significantly from Baseline 1 to Intervention. For both countries, there were no significant differences between Baseline 2 and the other treatment periods.

Table 2a

Analysis of Variance for Percentage of Seat Belt Use - United States Sample

Source	*df*	F	*p*
Delay Type[1] (D)	1	.02	.90
Treatment Period[2] (T)	2	5.33	.01*
D x T	2	1.88	.16
Error	135		

1 Delay Type was either an 8-second fixed gearshift delay or a variable time gearshift delay that averaged 8 seconds.

2 There were 3 treatment periods: Baseline 1, Intervention, and Baseline 2

Table 2b

Analysis of Variance for Percentage of Seat Belt Use - Canadian Sample

Source	*df*	F	*p*
Delay Type[1] (D)	1	1.16	.28
Treatment Period[2] (T)	2	7.35	.001**
D x T	2	.03	.97
Error	133		

1 Delay Type was either an 8-second fixed gearshift delay or a variable time gearshift delay that averaged 8 seconds.

2 There were 3 treatment periods: Baseline 1, Intervention, and Baseline 2

The data logger recorded few instances of drivers removing their seat belts during trips. During the Baseline 1 and Intervention periods, seat belt removal averaged less than 1% for the U. S. group.

Canadian drivers removed their belts more often. During the initial baseline period seat belt removal averaged 2% of trips in the fixed-delay group and 4.2% in the variable delay group. During the intervention period seat belt removal averaged 2.5% in the fixed-delay group and 1.7% in the variable delay group. Seat belt removal occurred during 2% of trips for vehicle in the fixed delay group and 1.6% of trips in the variable delay group during the return to baseline. The mean percentage of seat belt removal in Canada's variable delay condition was largely influenced by drivers of three vehicles (vehicles 11, 12 and 14). These three drivers removed their seat belts on almost a quarter of trips during the initial baseline condition.

The percentage of belted trips without a seat belt provides evidence that drivers tended to avoid the delay by wearing the seat belt. Among the U. S. sample, the percentage of belted trips without a delay averaged 72.0% in the fixed 8-second delay condition and 80.6% for drivers in the variable delay condition. Although the percentage of belted trips without a delay was higher in the variable delay condition, seat belt use was also somewhat lower in the variable delay group. Among the Canadian sample, drivers in the fixed delay condition averaged 70.4% trips without presentation of the delay, and participants in the variable delay condition averaged 71.6% trips without the delay.

Individual Results. There was considerable variation among the overall sample with regard to the effect of the intervention and its maintenance after removal. For many individuals the treatment was effective only during the intervention period. In contrast, some drivers increased the frequency with which they drove buckled and maintained the increase during the second baseline period. The sample also included some drivers who were quite reluctant to wear seat belts. Figures 1 to 13 in Appendix A depict the individual results of several U. S. and Canadian drivers.

Focus Group Results. The study ended with a focus group to get feedback about the gearshift delay systems. Topics of interest included perceived system effectiveness, ability to bypass, usefulness for teenage drivers, annoyance, and acceptance. Most drivers (56%) indicated that the system increased their belt use, although some drivers (9%) reported that the system decreased or did not alter their seat belt use. The breakdown was essentially the same for those in the fixed and variable delay conditions. Four drivers with no evidence of bypassing the system said they could bypass the delay by methods that were found to be ineffective during pilot testing. Reported approaches included buckling the seat belt behind the driver and leaving the belt buckled. One driver said that he could sometimes bypass the system by pressing the brake and shifting into neutral at the same time. This method was discovered and corrected before the system was installed into the fleet. This driver also showed a large increase in seat belt use, and we were not able to get the method to work for us. The one reported bypass method that did appear to work was used by one driver who left the engine in neutral with the emergency brake on. This method bypassed the delay because the vehicle was not returned to park.

All but one driver felt the device would be something that parents would want for teenage drivers. However, most drivers indicated the system was annoying because it required them to wear their seat belts when moving the vehicles on-site, or on very short trips. These drivers may not have been able to place the vehicle in the inactive mode because their seat belt use did not meet the 80% criterion for deactivating the delay. Several drivers who mentioned this problem thought it would be useful to have a device that only required seat belt use over a certain speed. Generally drivers felt the system was acceptable for long trips. One driver felt a voice prompt would be better than the chime and another thought a bright flashing light to accompany the delay would be effective. Some drivers had no problem with the system and others said they got used to the system over time. One driver said it increased seat belt use in his personal vehicle.

DISCUSSION

The results of this study support the effectiveness of a short 8-second seat belt gearshift delay with the U. S. drivers. The 8-second delay produced a significant increase in seat belt use for drivers during the intervention phase. The analyses indicate some differences between the U. S. and Canadian samples. However, the overall increase in mean seat belt use for the Canadian drivers and U. S. drivers was nearly identical; in both samples seat belt use was approximately 20 percentage points higher in the intervention period than the initial baseline period. Although the overall intervention was effective, there was no statistical interaction between gearshift delay type (fixed or variable) and treatment period; the fixed and variable delay schedules were equally effective. Finally, data indicates that drivers who buckled their seat belts during a final reminder associated with the short gearshift delay were no more likely to remove them than those who buckled during the initial baseline.

Belt use appeared to decline after the intervention, but the drop was not statistically significant. It should be noted that trends indicate some lasting change for certain treatment groups. Take for example the fixed time delay group of the U. S. sample. During the initial baseline period only 19% of these drivers buckled during 80% or more trips. After treatment 54% of drivers in this condition had belt use levels above 80% and 35% had seat belt levels above 90%.

A portion of the U. S. sample received a 16-second gearshift delay. This longer delay was introduced as a more intensive intervention for the purpose of achieving a further spike in seat belt use. This longer delay was applied to individuals who showed little change after initial exposure to the 8-second intervention. Geller, Berry, Ludwig, Evans, Gilmore, and Clarke (1990) recommend such incrementally intensive interventions to change the behavior of reluctant individuals. However, individual results indicate that some drivers exposed to the 16-second delay had relatively high belt use during the baseline and intervention phases. These individuals showed a ceiling effect. In other words, some of the individuals who experienced the longer delay may not have belonged to the reluctant group of seat belt non-users. Using a criterion of low belt use rather than low response to initial treatment may have led to different results associated with the 16-second delay. Alternatively, the lack of differences between the 8- and 16-second interventions may simply indicate that the longer delay was not sufficiently intense.

The results also indicated that although many drivers avoided the delay by buckling before applying pressure to the brake pedal, they continued to display a proportion of escape responses after the delay was applied. Because drivers needed to engage in at least 80% seat belt use to avoid the delay for trips shorter than 30 seconds or occasions when they fastened their seat belts within 30 seconds of motion, a substantial proportion of drivers rarely had the device in the inactive monitoring mode. This suggests that a longer definition of brief trips may have been more effective.

The individual subject data indicated that the range of effects varied across drivers and across the treatment periods. As was seen from Figures 2, 3, and 4, drivers' seat belt usage ranged from no response during treatment, to dramatic increases during the treatment period only, to maintenance of the change after the intervention's removal.

The focus groups indicated that drivers tended to underestimate whether the system increased their seat belt use. Many drivers reported that the system was annoying because it required them to wear their seat belt during short trips. These drivers may not have been able to achieve the 80% belt use criterion that allowed the driver to drive unbelted on trips shorter than

30 seconds. Some drivers stated that they would prefer a delay that only occurred if the driver exceeded a criterion speed. All but one driver felt the device would be useful to increase the seat belt use of teenage drivers.

Teen drivers may be an appealing target population for this technology, as this population buckles less frequently and crashes more often than older drivers. Given this magnitude of increased crash risk among teens, parents may view such a system as an attractive means of ensuring their children are buckled. Moreover, some states' graduated drivers licensing laws have consequences for teen drivers who drive unbuckled during the initial licensure phases. However, it is difficult to enforce these seat belt requirements because the age of the driver is often unclear. Technology such as the gearshift delay would reduce the burden of enforcing a behavior that is problematic to capture.

A second line of future research could investigate various iterations of this technology. A complete gearshift interlock would prevent unbelted drivers from shifting the vehicle into gear. To the extent that drivers do not bypass such a system, seat belt use would be 100%. The seat belt-ignition interlocks introduced and quickly abandoned due to public uproar in the 1970s suggests that a system that forces a behavior has great potential for disuse (see Parasuraman & Riley, 1997.) This example of clumsy automation may not apply to the current situation, as the seat belt usage rate is much higher than it was during the 1970s. Further, the advancement of programming logic would allow gearshift interlocks that might receive higher acceptance than ignition interlocks. For example, a gearshift interlock that requires belting prior to placing the vehicle into drive would allow drivers to warm up vehicles before an icy morning commute and should receive higher acceptance ratings than an interlock that requires buckling to start a vehicle.

In sum, this field study showed that a gearshift delay resulted in a significant 20-percentage-point increase among two samples of commercial fleet drivers. Some drivers consistently bypassed the system, but many of these problems can be addressed in future work by refining the systems. Focus group results suggest that future research should assess the effects of this system on teenage drivers. Finally, research should continue to focus on the balance between driver acceptance and behavior change.

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Table 1A. The mean percentage of U. S. vehicle trips when seat belts were worn.

Veh No	BL	FT 8	FT 16	FT 8	BL 2
1	72	90	89		
2	34	79			2
3	50	86	83	80	
4	40	5	10		100
5	82	44			
6	13	4			
7	21	84			60
8	55	90			93
9	15	92			94
10	4	52	31		8
11	86	97			87
12	87	93			61
13	53	80			63
14	38	51	75		12
15	41	88			86
16	2	46	43		32
17	27	49	69		
18	83	88	87		84
19	94	90	98		99
20	11	57			81
21	50	76			26
22	11	93			
23	27	90			100
24	45	63	71		51
25	32	95	97		76
26	10	33	42		17
MEAN	**42**	**69.8**			**61.6**

Veh No	BL	VT 8	VT16	BL 2
1	12	83	81	
2	86	83		67
3	91	19	29	
4	87	90	94	94
5	82	86		71
6	69	75	77	73
7	69	83		77
8	48	71	83	62
9	93	99		98
10	64	43	39	72
11	29	66	61	32
12	0	1	3	3
13	32	74		24
14	8	6	0	21
15	84	92		21
16	31	38	41	
17	33	39	58	17
18	44	42	56	37
19	80	95		74
20	56	72		9
21	69	90	83	89
22	26	28		21
23	53	88		94
24	59	93	85	34
MEAN	**54.4**	**65**		**52**

BL = Baseline 1; FT 8 = Fixed 8-second delay; FT 16 = Fixed 16-second delay; BL 2 = Baseline 2; VT 8 = Variable 8-second delay; VT 16 = Variable 16-second delay

Table 1B. Mean percentage of Canadian vehicle trips when seat belts were worn.

Veh No	BL	FT 8	BL2
1	39	81	27
2	83	93	95
3	17	76	56
4	63	88	92
5	88	70	6
6	97	83	69
7	4	13	9
8	93	98	93
9	39	73	34
10	46	67	56
11	82	86	81
12	27	84	89
13	10	74	19
14	93	93	99
15	61	78	69
16	63	41	
17	55	89	88
18	82	72	67
19	5.2	59	
20	4	14	2.7
21	86	82	95
22	5	83	
23		26	48
24		82	76
25		90	83
26		86	50
MEAN	**51.9**	**72.3**	**61**

Veh No	BL	VT 8	BL2
1	40	54	28
2	71	85	81
3	13	17	43
4	66	79	75
5	59	78	26
6	74	87	82
7	82	94	83
8	67	76	45
9	82	97	87
10	54	72	72
11	62	78	67
12	21	74	49
13	67	95	95
14	69	72	69
15	35	81	
16	67	82	84
17	85	97	100
18	64	87	74
19	50	87	84
20	97	79	
21	89	85	
22	13	53	
23	3	72	
24	11	53	
25		80	36
MEAN	**55.9**	**76.6**	**67.4**

BL=Baseline 1; FT 8 = Fixed 8-second delay; BL 2 = Baseline 2; VT 8 = Variable 8-second delay

Table 2A. The mean percentage of U. S. vehicle trips when seat belts were removed.

Veh No	BL	FT 8	FT 16	FT 8	BL 2
1	0.7	0.7	0.6		
2	2.2	2.5			0
3	7.1	1.9	2.3	3.4	
4	0	0	0.1		0
5	0	1			
6	0	0			
7	0	2.9			3.6
8	0	0			0
9	0	0			0
10	0	0.3	0		0
11	2.2	0.5			0
12	0	0			0
13	2.2	5.8			3.2
14	0.5	0.3	0.6		0
15	0	0			0.3
16	0	1.6	2		0
17	0	0	0.3		
18	0.7	0.7	0		0.6
19	0	0	0		0
20	1.7	0			0
21	0	0.5			0
22	0	0			
23	0	1.5			0
24	0.4	1.5	0.3		0.8
25	2.4	0	0		0
26	0	0	1.2		3.3
MEAN	**0.8**	**0.8**			

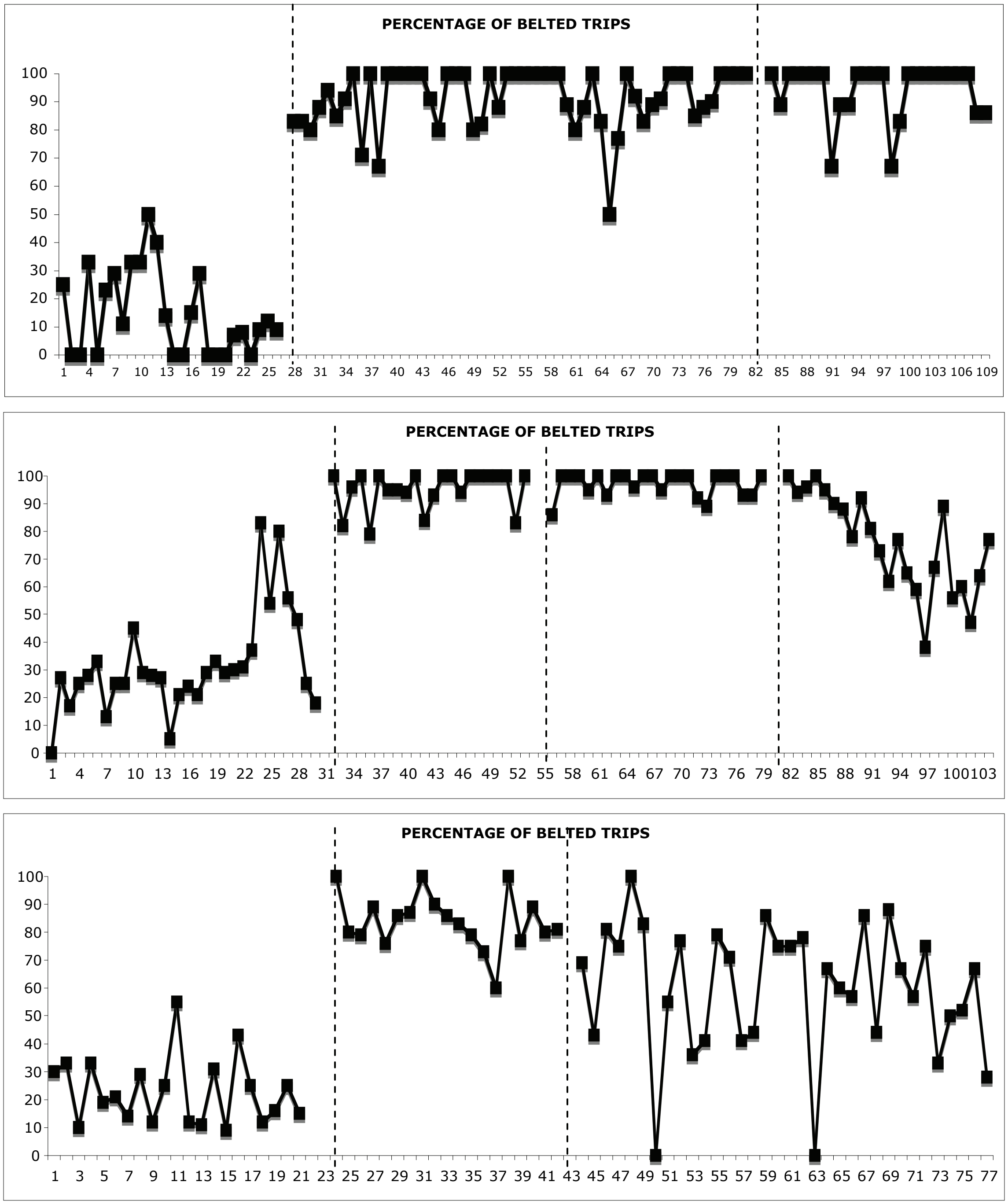
Veh No	BL	VT 8	VT16	BL 2
1	0	0.3	0	
2	0.5	0.5		1
3	0.4	0	0	
4	0.3	0.4	0.7	0.4
5	0.4	7.2		4.1
6	5.3	0.5	1	1.6
7	0	0.3		1
8	0.7	0	0	0.4
9	2.5	0.6		1.1
10	0	1.6	1.1	0.3
11	1.9	0.1	0.7	0.8
12	0	0	0	0
13	7.3	6.4		6.5
14	0	0	0	2
15	1.3	1.3		3.7
16	0.3	0	0	
17	0	0.2	0.15	0
18	1.3	0	2.1	0
19	0	0		3.9
20	0	0		0
21	0.4	0	0	0
22	0	0		0
23	0	0		0
24	0	0	2.6	0.6
MEAN	**0.9**	**0.8**		

Table 2B. The mean percentage of Canadian vehicle trips seat belts were removed.

Veh No	BL	FT 8	BL2
1	0	0.9	2
2	15.4	5.8	1.4
3	0	3.1	14.1
4	4.3	14.2	3.3
5	0.7	0.3	4.8
6	1.1	0.7	0.4
7	0	0.5	0
8	0	0.4	0
9	0	1.5	1.4
10	3	2.3	2.6
11	1.1	3	1.8
12	1.3	0.7	0.9
13	0	2.1	5
14	1.5	1.2	0
15	0	17.3	2.2
16	0	0.47	
17	9.3	1.4	1.7
18	0	1.4	1.2
19	0	3.3	
20	6.3	3	0
21	0	0.3	0
22	0	0.6	
23		0	2.8
24		0	0.3
25		0.6	0.9
26		0	0
MEAN	**2**	**2.5**	**2**

Veh No	BL	VT 8	BL2
1	1.2	1.4	0.2
2	3.2	2.3	3.6
3	0	0.2	1.2
4	0	0	0
5	9	3.8	2.3
6	0	1.1	1.3
7	1.1	0.4	2.7
8	1.8	3.3	2
9	0	0	1.5
10	5.3	5.4	2.9
11	24.9	1.1	0.2
12	24.1	3.8	3.8
13	0.3	0	0
14	16.4	0	0
15	0.7	3.6	
16	8	7.1	6.3
17	0	0	0
18	1.6	0.8	0.7
19	2.4	4	1.6
20	0	1.3	
21	0.5	0.7	
22	0	0.2	
23	0	0.5	
24	0	0.2	
25		0	0
MEAN	**4.2**	**1.7**	**1.6**

Figure 1. Three typical graphs of U. S. drivers who were typical of those showing a large increase in use in the fixed delay condition.



The dashed vertical lines delineate Baseline 1, intervention, and Baseline 2 periods. The second vertical line in the center figure delineates a driver who received an 8-second delay followed by a 16-second delay.

Figure 2. The results for three U. S. drivers who were typical of those showing a moderate effect in the fixed delay condition.

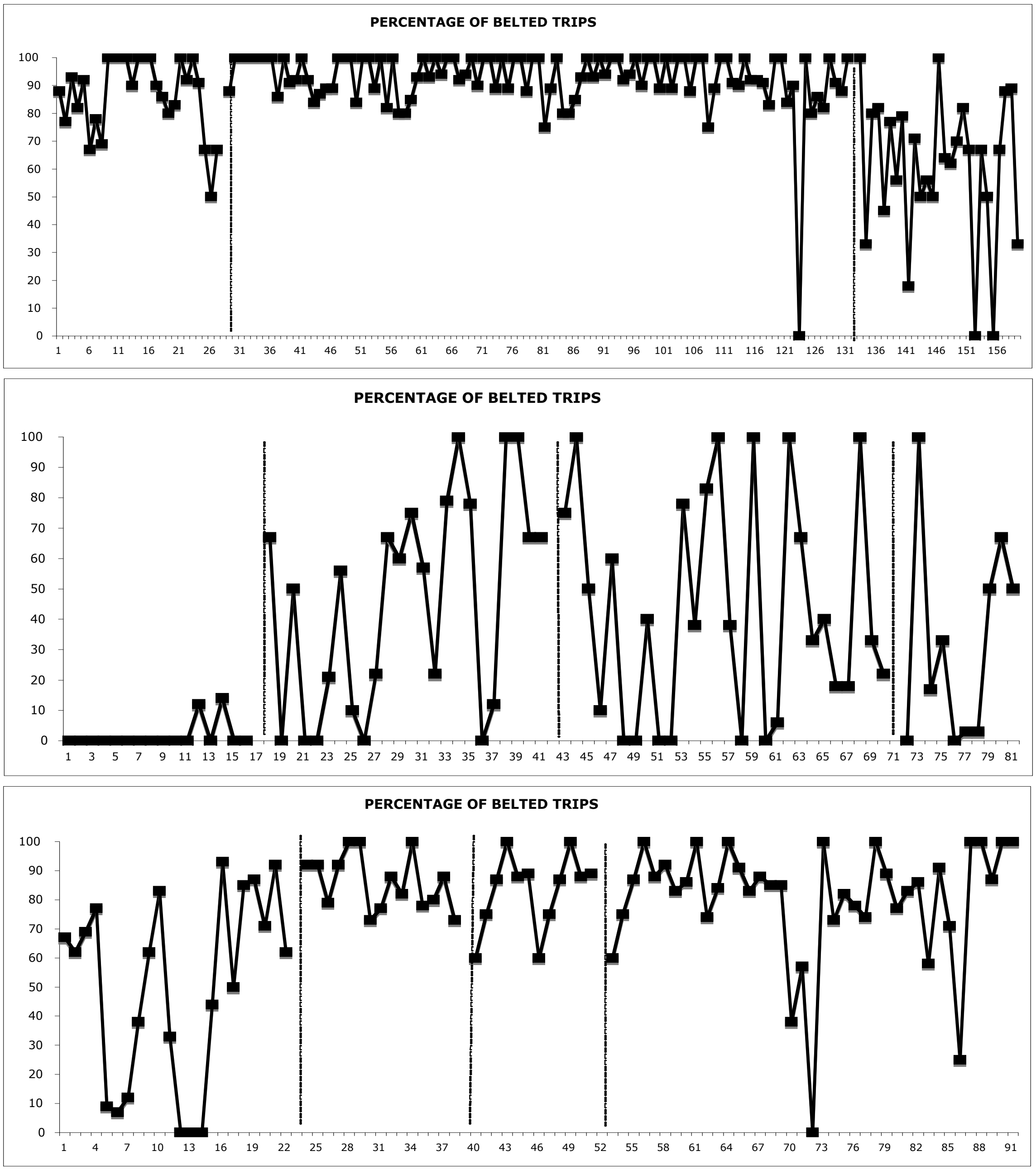
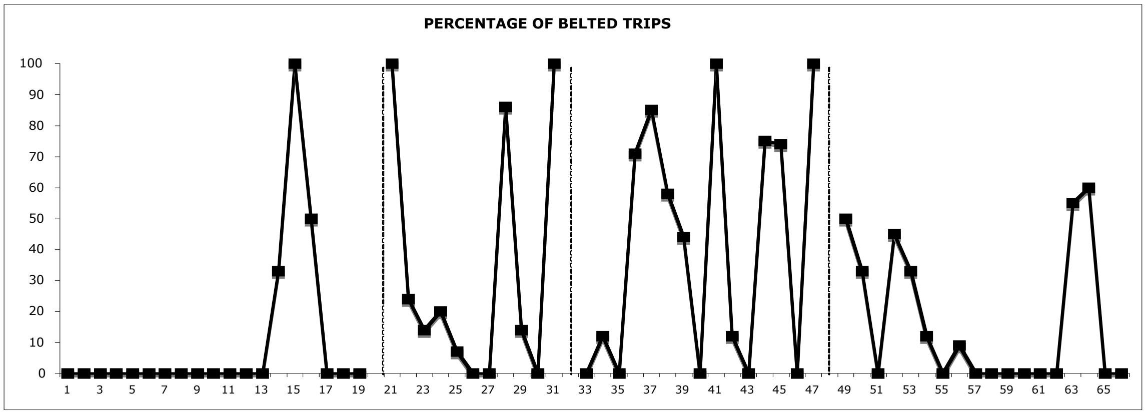
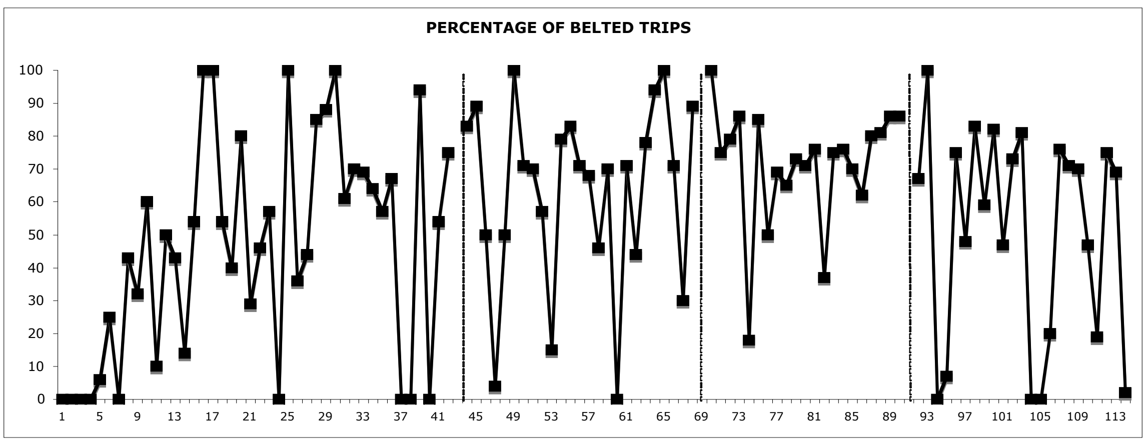


Figure 3. Results for three U. S. drivers who were typical of those showing little or no change in seat belt use during the fixed delay condition.





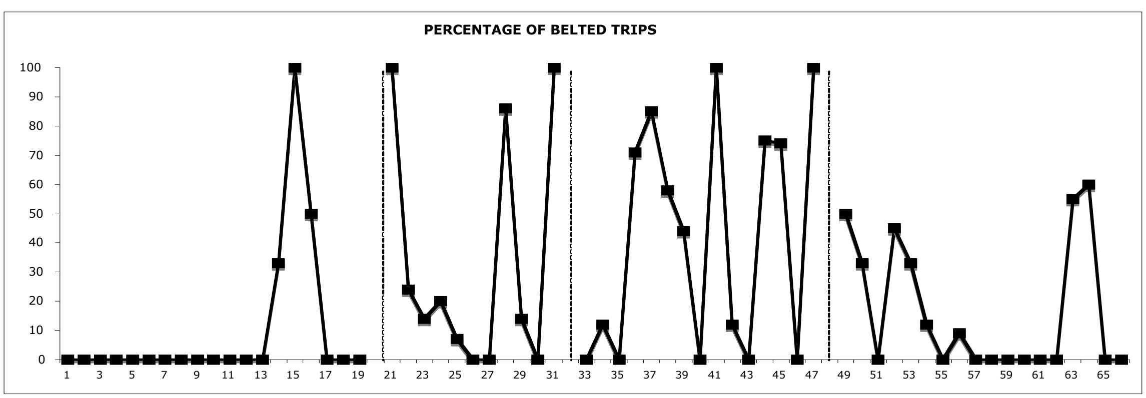


Figure 4. U. S. drivers who showed declining seat belt use under the 8-second fixed delay. Drivers in the top 2 frames were then changed to the 16-second delay. In both cases there was some improvement in the fixed 16-second delay condition.

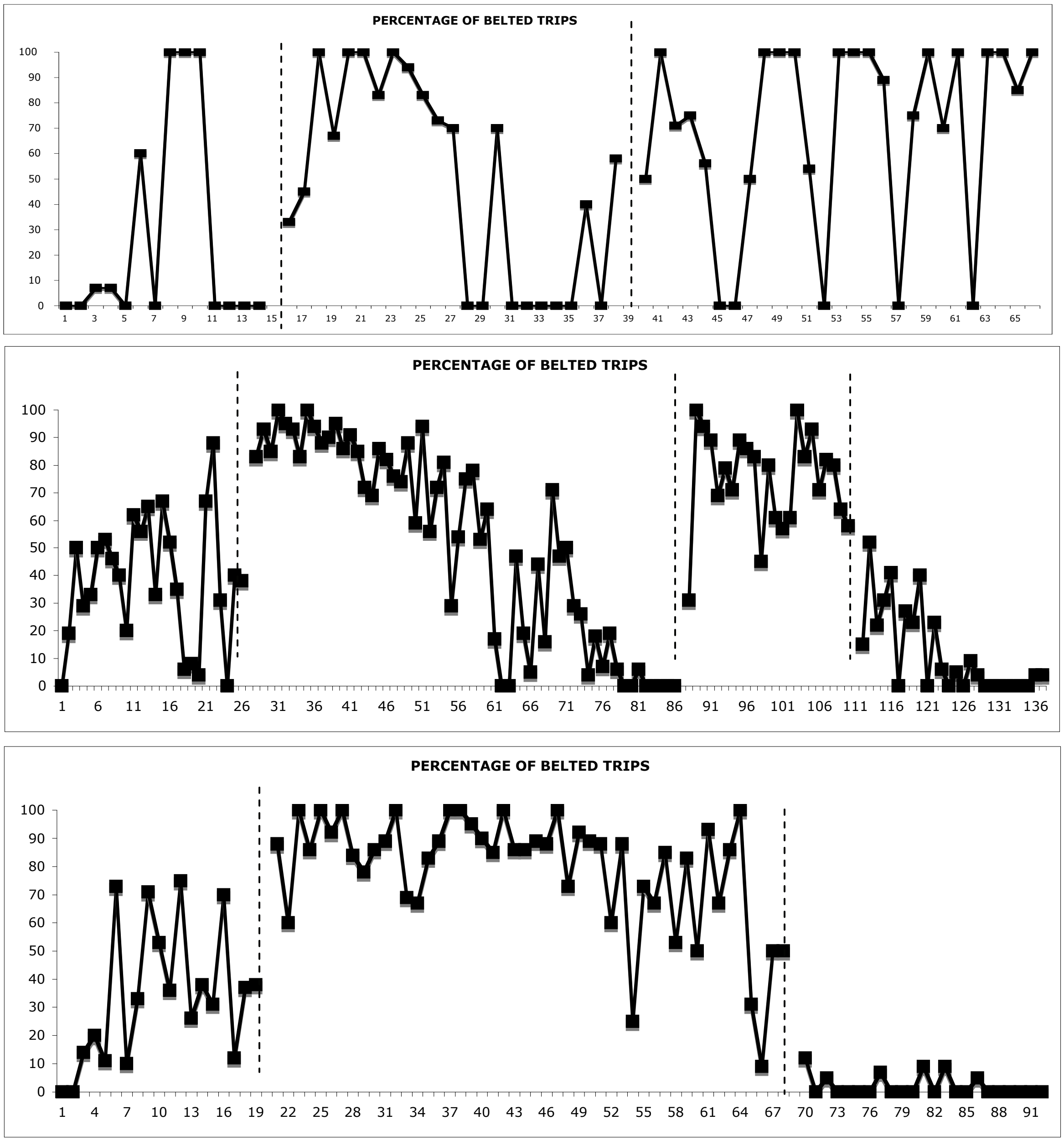


Figure 5. This figure shows the graphs for three U. S. drivers in the variable time delay condition that showed large increases in seat belt use.

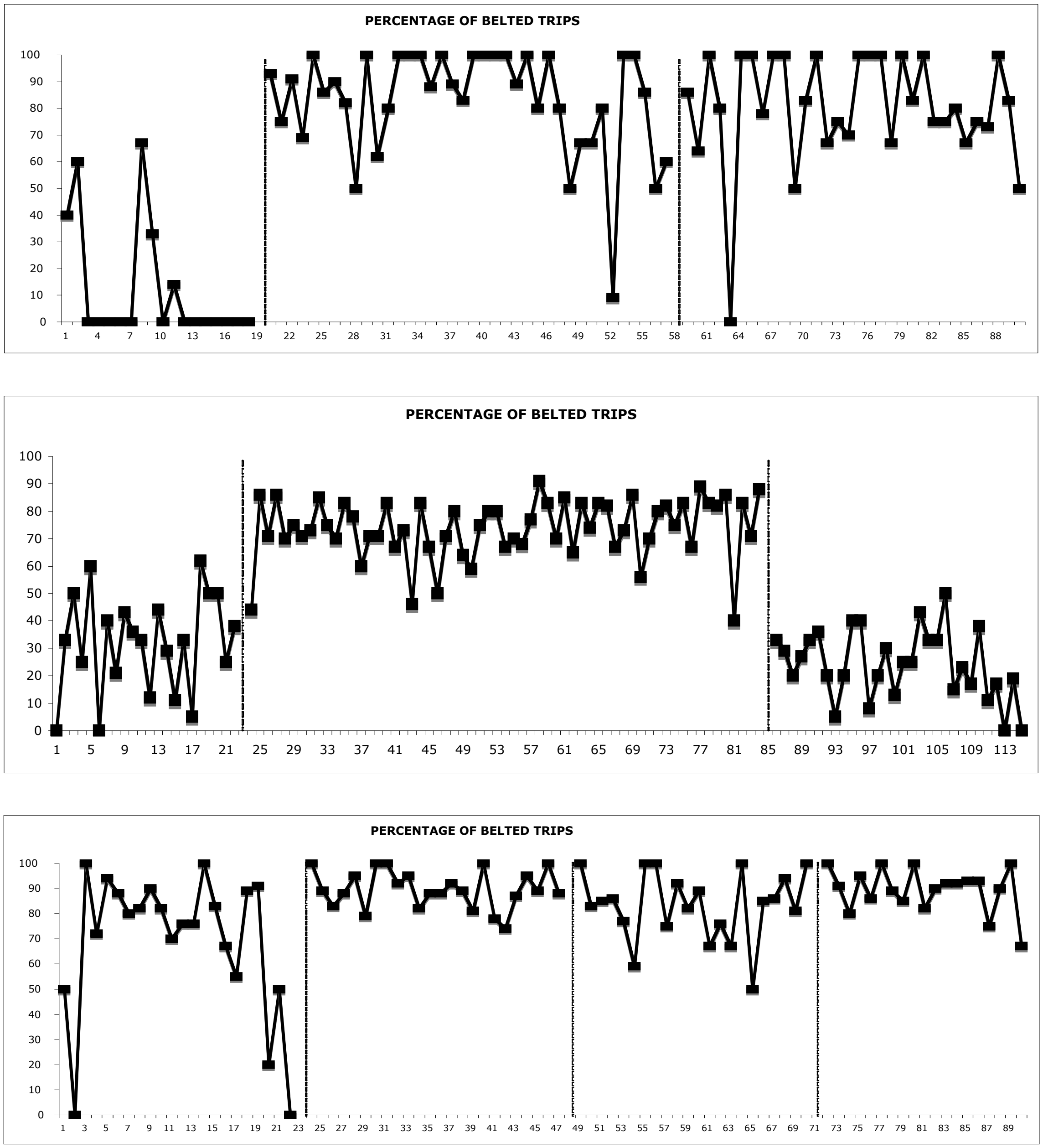
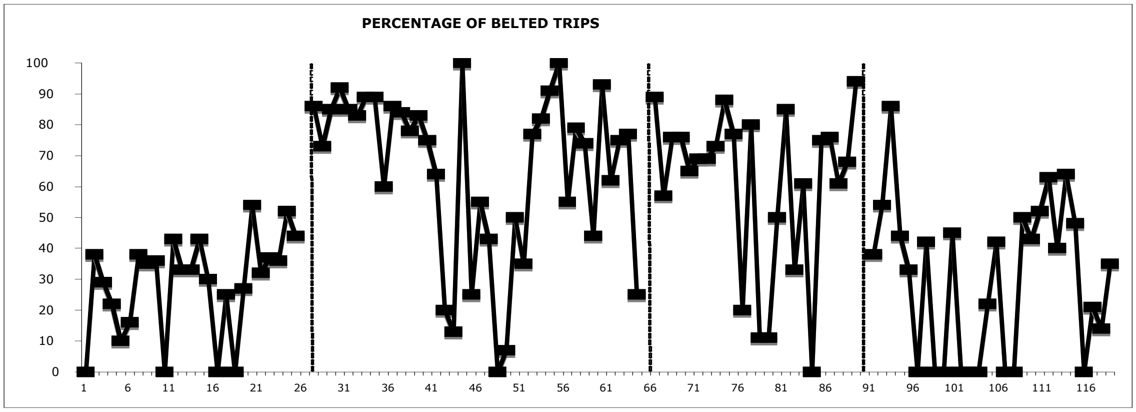
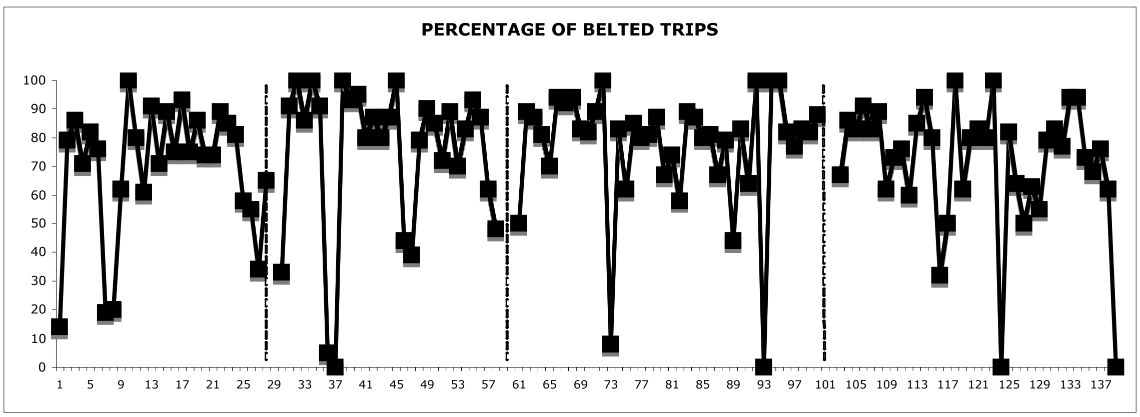


Figure 6. This Figure shows three U. S. drivers from the variable delay condition that showed a moderate increase in seat belt use.





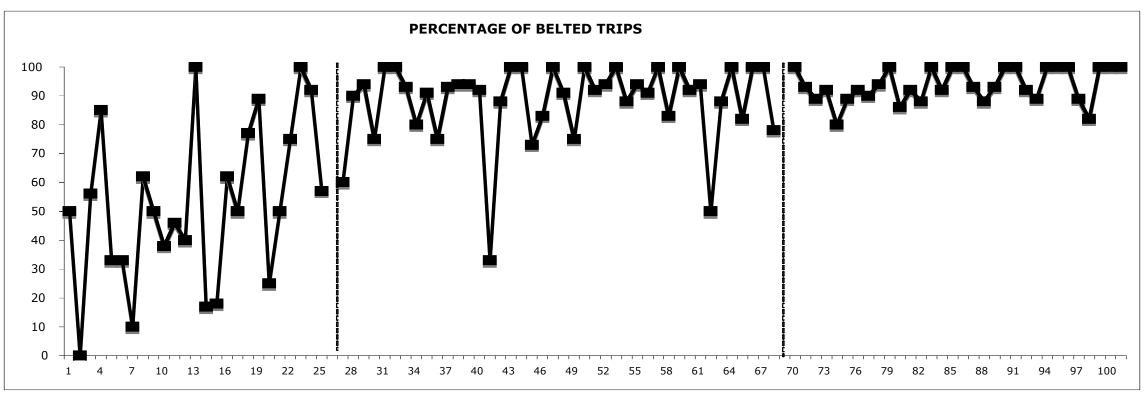


Figure 7. Results from three U. S. drivers who showed little or no effect in the variable delay condition.

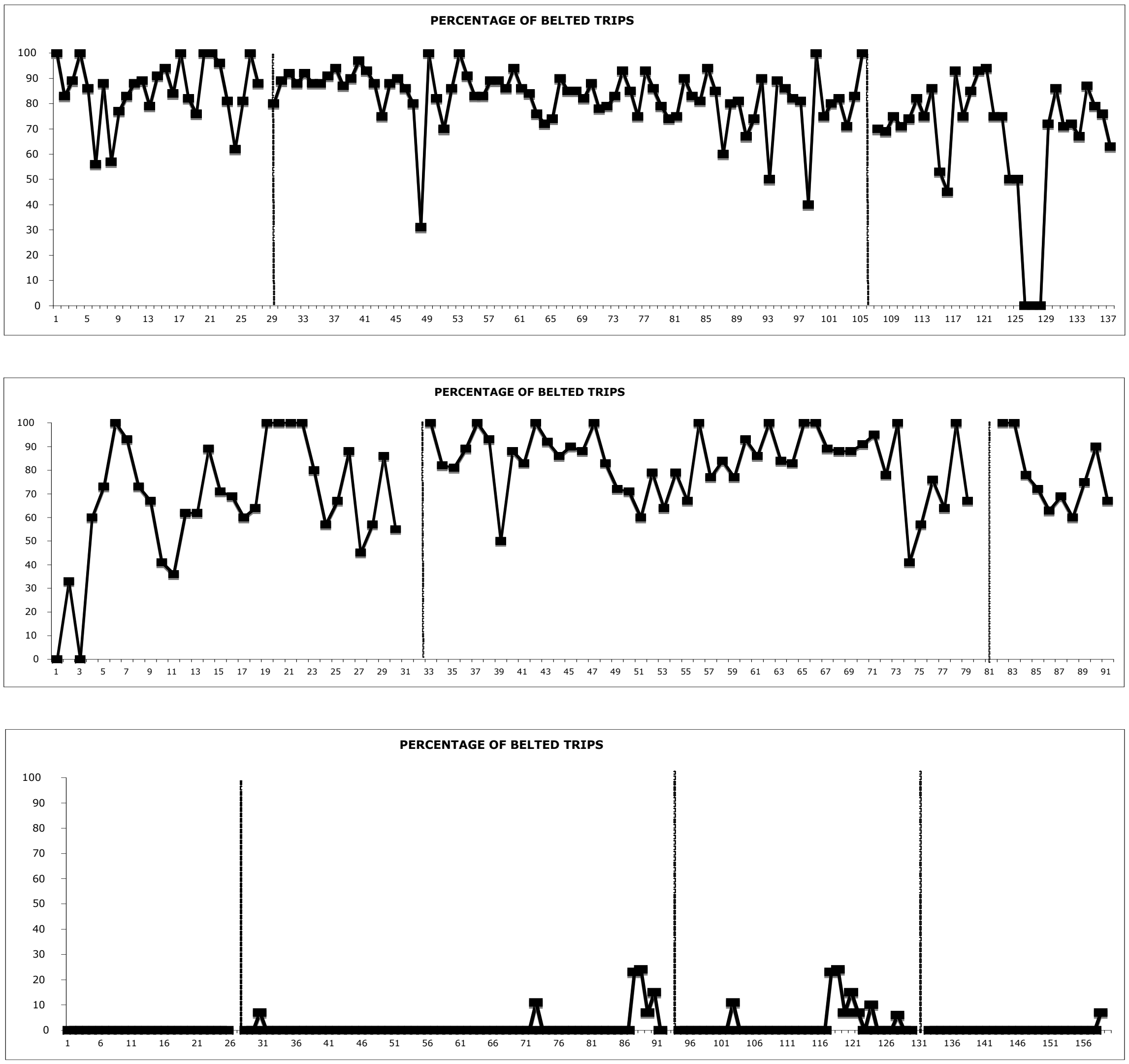


Figure 8. Three typical graphs of Canadian drivers in the fixed delay condition that showed a large increase in seat belt use.

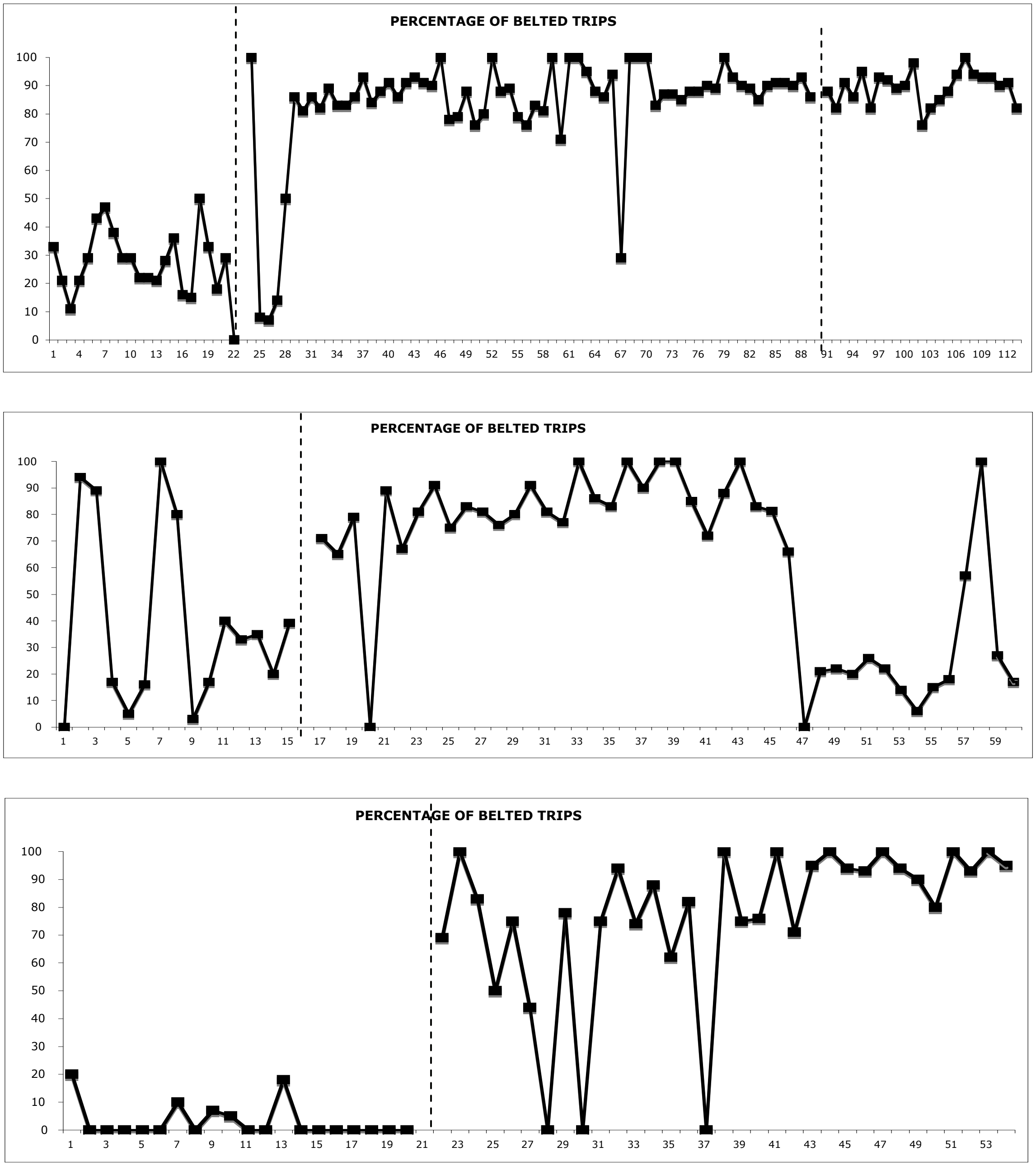


Figure 9. Data from three Canadian vehicles in the fixed delay condition that showed small or inconsistent increases in seat belt use.

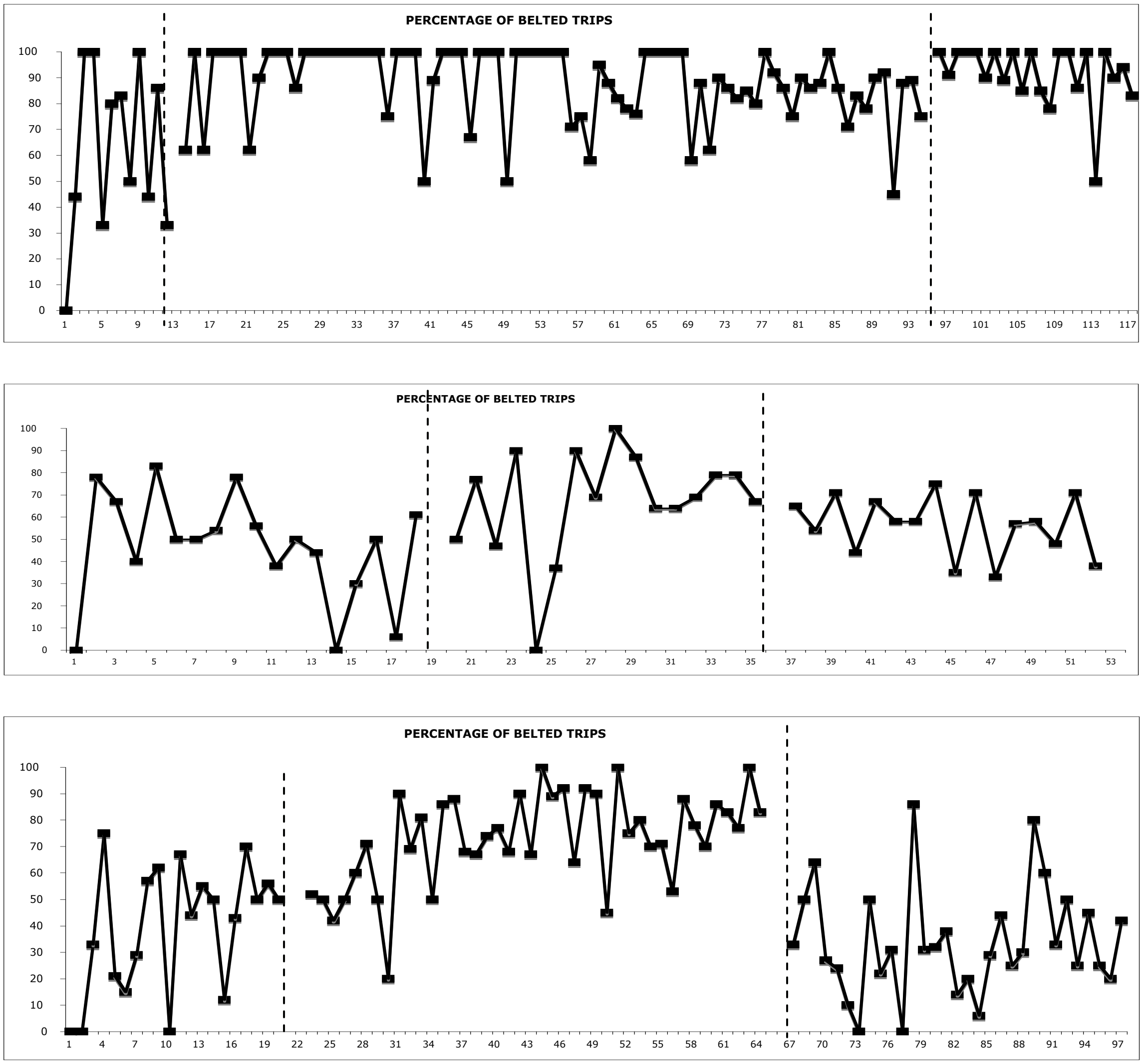
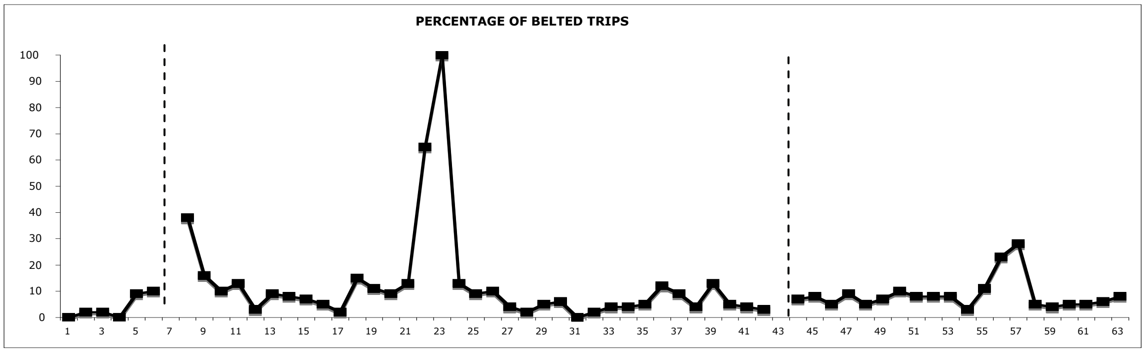
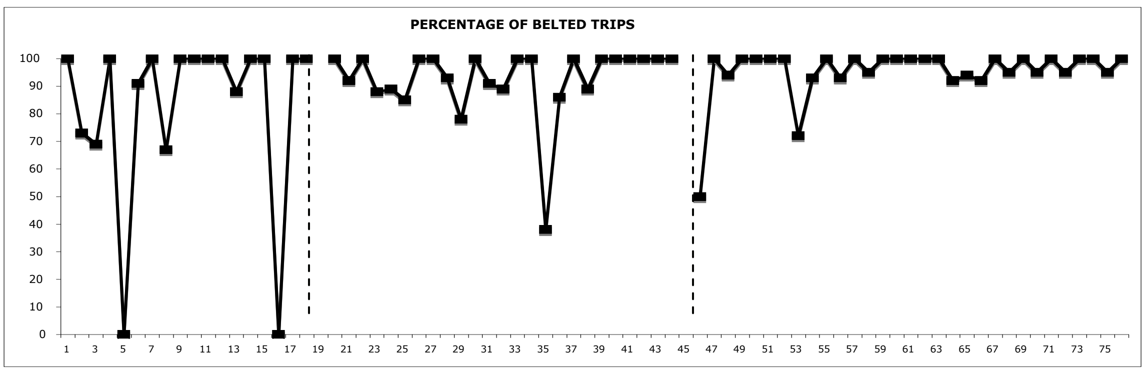


Figure 10. Data from three Canadian vehicles in the fixed time delay condition that showed little or no effect.





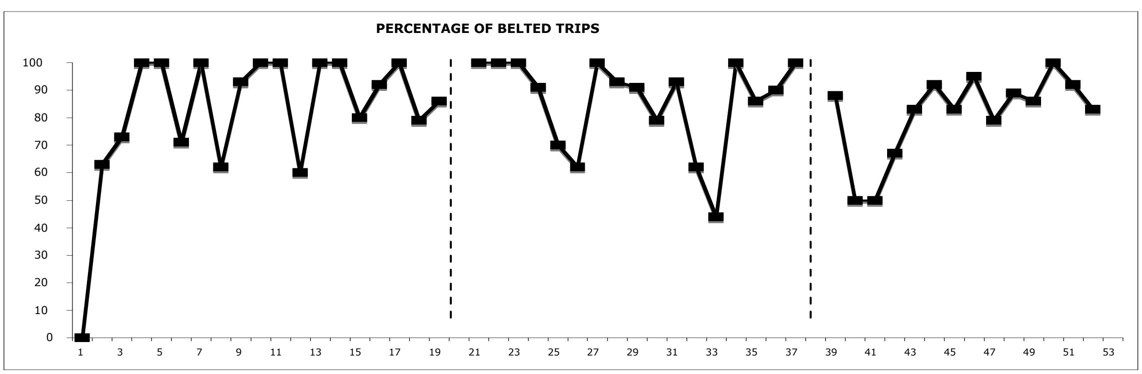


Figure 11. Data from three Canadian vehicles in the variable delay condition whose drivers showed a large increase in seat belt use.

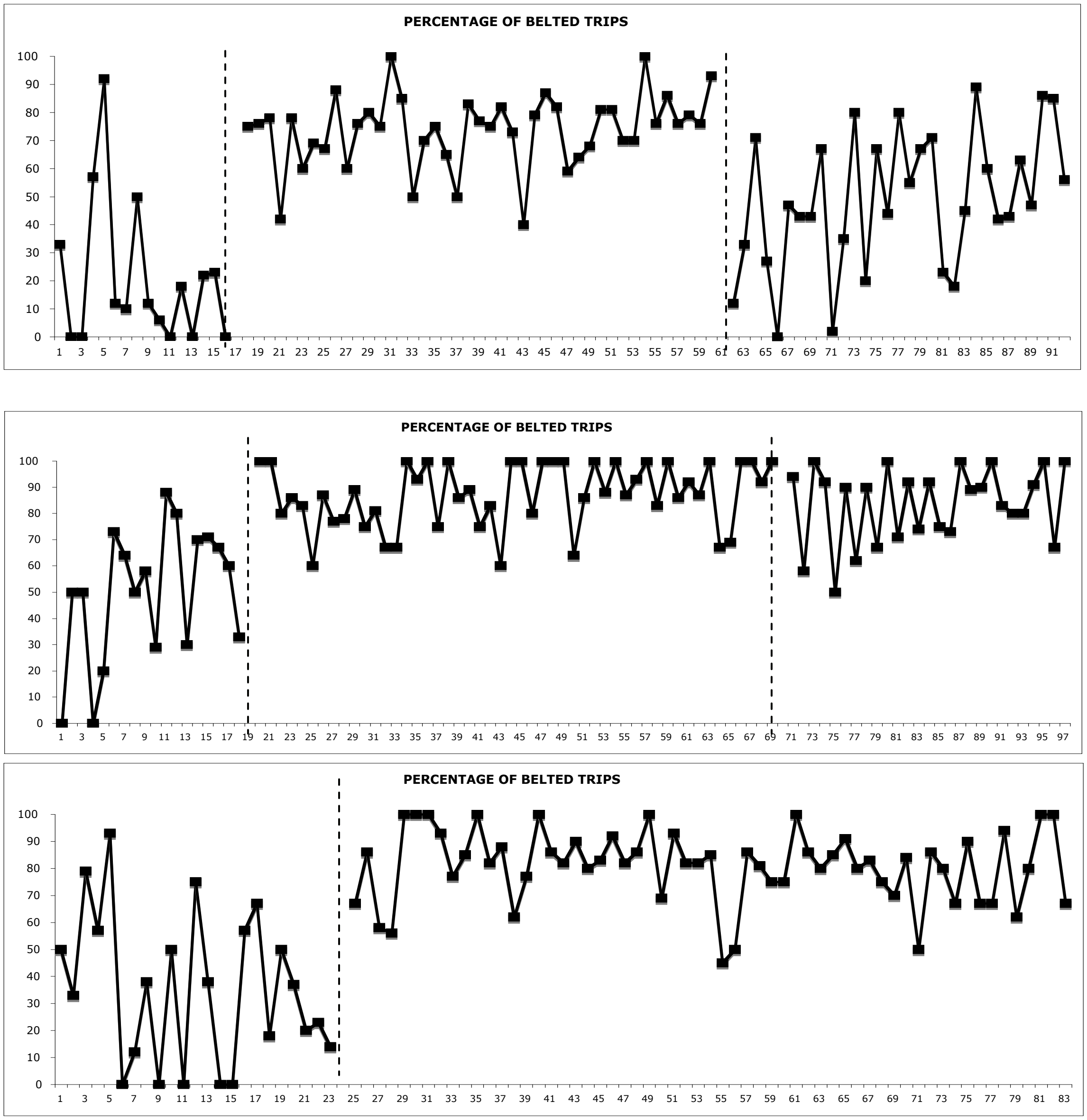
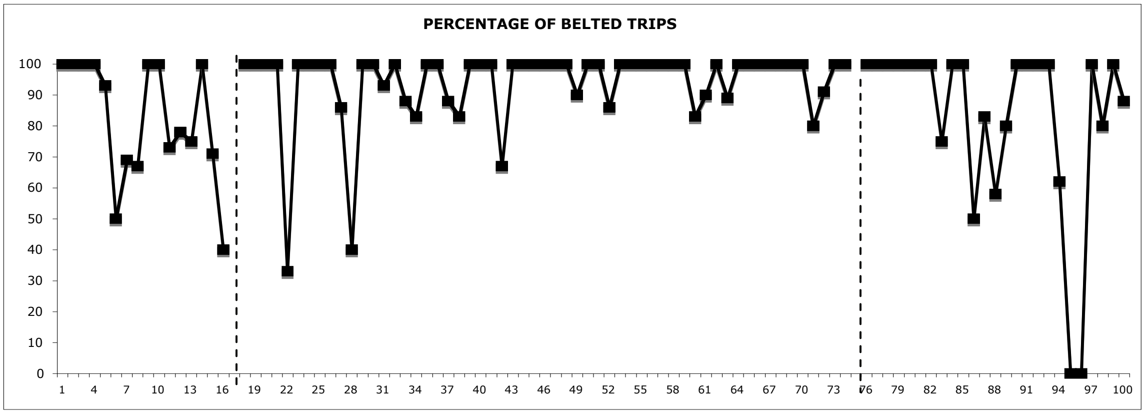
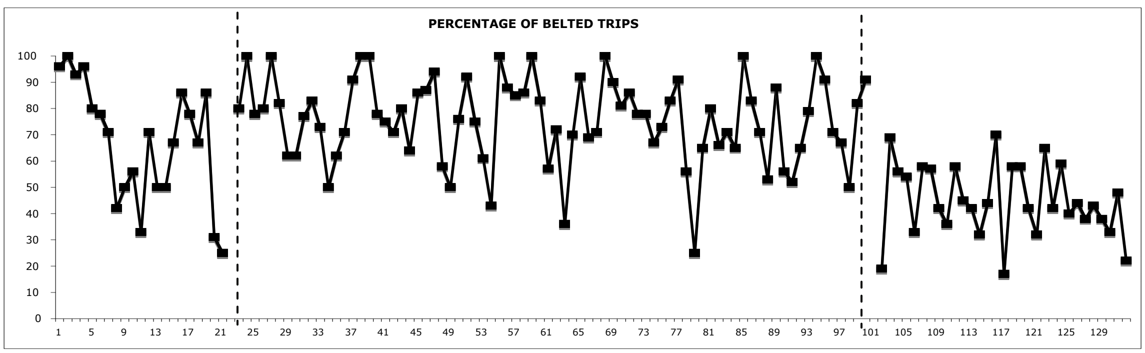


Figure 12. Data from three Canadian vehicles in the variable delay condition whose drivers showed a small or inconsistent increase in seat belt use.





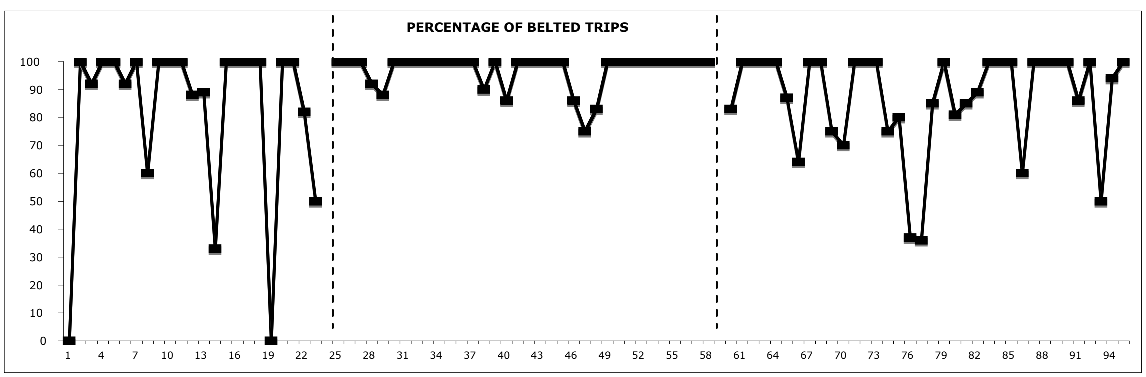
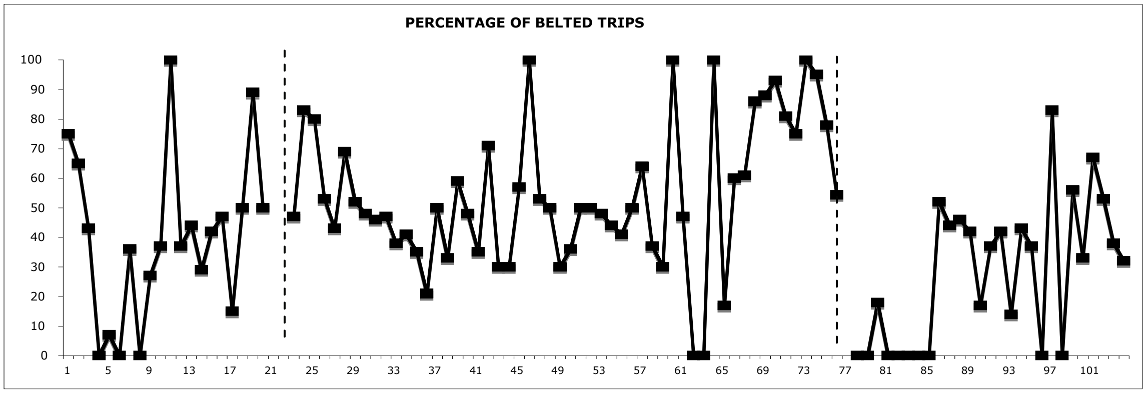
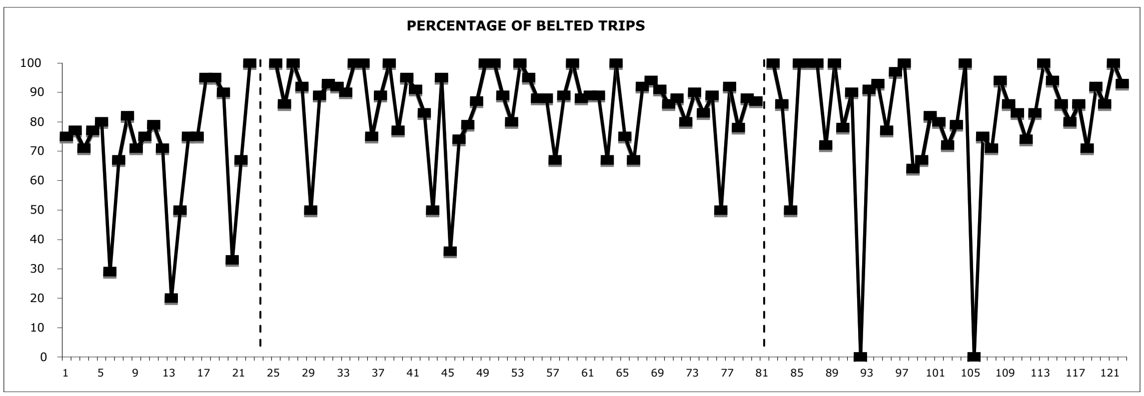


Figure 13. Data from three Canadian vehicles in the variable delay condition whose drivers showed little or no change in seat belt use.





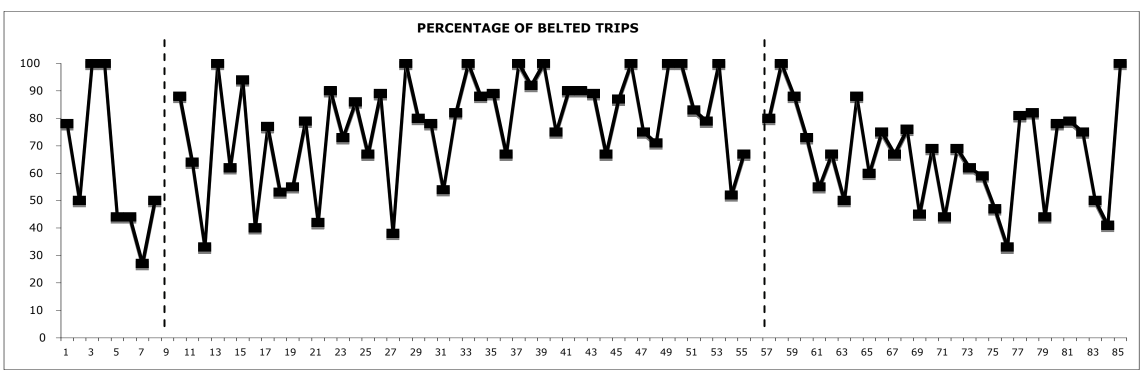
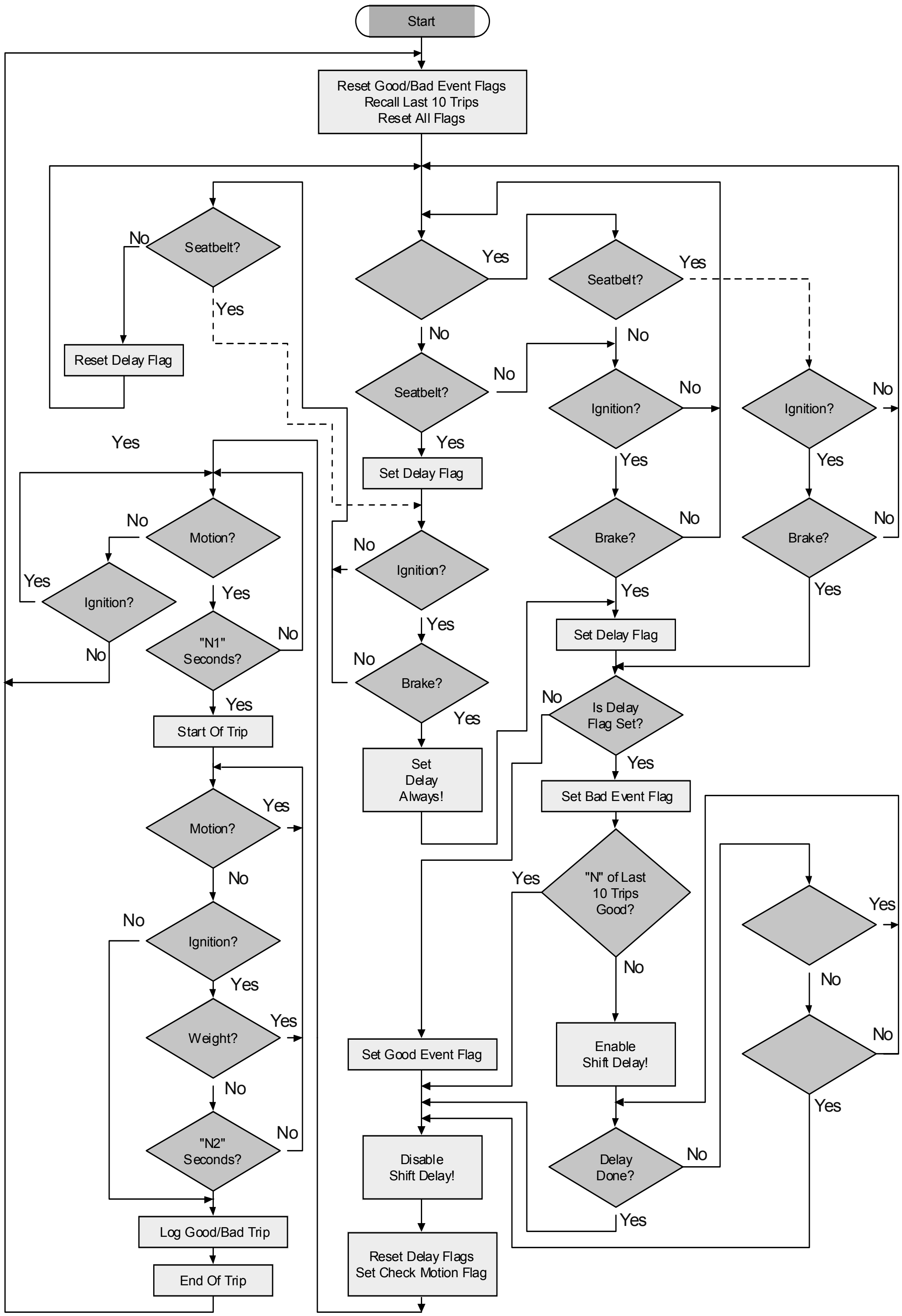


Figure 14. System Flow chart.



Appendix B
Instructions to drivers, data-logger acknowledgement sheet, & fleet manager consent form

MEMORANDUM

From: Dr. Ron Van Houten

To: Drivers with seat belt/transmission delay systems installed

The National Highway Traffic Safety Administration, a Department of the Federal Government involved in regulating vehicle safety, is conducting research on new ways to increase seat belt use. The City of St. Petersburg has agreed to take part in this study designed to evaluate a new method of increasing seat belt use. Your participation in this study is confidential and your name or information on your seat belt use will not be divulged to your supervisors.

A device has been installed in your vehicle that is designed to help you remember to buckle your seat belt every time you drive your vehicle. The way the system works is to give you more time to buckle your seat belt before driving. If you do not buckle your seat belt, there will be a short delay for a few seconds before you can put the vehicle in gear. Also, if you buckle the seat belt before sitting down, there will still be a delay in allowing you to put the vehicle in gear. This means you cannot get around the system by sitting on a buckled seat belt.

The delay is always associated with a reminder chime. In some cases you will need to wait a fixed number of seconds before the delay times out and in other cases the chime will come on for a variable period of time. When the chime terminates the waiting period is over and you can place your vehicle in gear. If you buckle your seat belt while the chime is on, it will turn off the chime and you can put your car in gear immediately.

Previous groups of government workers suggested that they felt it was unfair to have to buckle to just move the vehicle. In this version of the device, the delay will not be introduced unless you fail to wear your belt consistently. If your trip is less than 30 seconds long it will not be counted in calculating seat belt use. If you put your belt on within 30 seconds of starting a longer trip it will not be counted against you. However if your seat belt use on trips over 30 seconds falls below 90 percent the device will be activated. Once activated you will get the reminder each time you try to place the vehicle in gear when you are not wearing your seat belt.

This system will be evaluated for a few months. At the end of that time, the researchers running the project will want to know your feelings about the seatbelt system and will get input from you about the project. The intent is to develop a system that helps people buckle up more consistently.

So, remember, if you get in your vehicle and you hear the chime, and you are not wearing your seatbelt, and your vehicle will not allow you to put the car in gear right away, **the vehicle is not broken**. You can either put on your seatbelt and immediately put the vehicle in gear, or wait for the chime to stop at which time the vehicle will go into gear.

Feel free to contact me at [redacted] if you have any questions or concerns about this.

Data logger installation acknowledgement sheet.

Acknowledgment of Data Logger Installment
Participant Driver Form

A data logger has been put in your work vehicle as part of an international study funded by the National Highway Traffic Safety Administration (NHTSA) in Washington. This device will log information on a number of driving related measures. Data loggers have also been placed in 120 vehicles at a number of other sites in Canada and the United States,

The data collected are completely anonymous and the researchers that analyze the data will not share individual results with employers or anyone else for that matter. Please be assured that we are not concerned with individual driving behaviors. We are primarily interested in the performance of the data-logging device and with the group results. Please continue to operate your vehicle in the usual manner. In a few weeks we will provide you with additional information on this study. In the meantime we thank you for your participation. Your inclusion in this study is very important and we greatly appreciate your support.

Signed ___________________________ Date_______________

Name of driver_______________________

Signed_____________________________Date________________

Dr. Ron Van Houten
Co-research director,
Center for Education and Research in Safety

Site Manager Consent Form

MEMORANDUM OF AGREEMENT
BETWEEN
THE CITY OF ST. PETERSBURG FLEET SERVICES
AND
THE CENTER FOR EDUCATION AND RESEARCH IN SAFETY

The city of St. Petersburg Fleet Services has given its permission to participate in a study conducted by the Center for Education and Research in Safety (CERS) the National Highway Traffic Safety Administration (Washington) to evaluate a device to prompt drivers to wear their seat belt. St. Petersburg Fleet Services will provide 60 vehicles for the study for the duration of the study beginning on January 12th for a period of several months.

CERS agrees to pay for the installation and de-installation costs of the data loggers. The City of St. Petersburg is not expected nor will it be required to incur any of the costs of this research project. CERS will be responsible for the collection and analysis of all the data and will download data from the 60 vehicles at times that are convenient for Fleet Services.

Both parties agree that the research project will not adversely impact the well being of the employees who participate in the study. All data and outcomes from the vehicles collected by CERS will be kept confidential so that no individual will be identified. Data collected on driver behavior by CERS will be kept anonymous and displayed in such a manner that pooled results and individual driver results will not be released nor compared with the other government agencies that participate in this study. The primary purpose of the study is to evaluate how drivers react to the various prompts to buckle their seat belt.

It is further understood that St. Petersburg Fleet Services may terminate its participation if unforeseen problems arise that cannot be dealt with to St. Petersburg Fleet Service's satisfaction.

At the end of the study, CERS will organize a Closing Get Together to thank the participants and to receive their feedback. CERS will also acknowledge the city of St. Petersburg's participation as well as the drivers that participated in the study through the media and the publication of the research.

______________________Date______	____________________________________
Dr. Ron Van Houten	Mr. Joseph Krizen
Co-research director CERS	Director, Fleet Services HRM

DOT HS 811 230
December 2009

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA
www.nhtsa.gov