Human Factors Assessment of Distraction, Workload, and Traffic Safety In Relation to Bus Operator Workload During Manual Stop Announcements

Smahel, T. CCPE, Human Factors North Inc.
Smiley, A., PhD, CCPE, Human Factors North Inc.

Paper prepared for presentation
at the Human Factors Session
of the 2014 Conference of the
Transportation Association of Canada
Montreal, Quebec

ABSTRACT

In 2007 the Human Rights Tribunal of Ontario decided that all transit operators should manually call out stops in order to address the problem of accessibility for persons with visual impairments. In response to this requirement a study was carried out to determine the effect on traffic safety of having bus operators make manual stop announcements. Specifically the study was designed to determine whether the manual announcement of stops increased bus operators' distraction levels to a significant degree, with a resulting adverse impact on operator health and safety and general public safety. An on-road experiment was carried out to compare the current situation in which no stops are announced with two conditions: the manual announcement of only major stops and the manual announcement of all stops.

Data were collected on two busy routes with twelve on-duty operators, including six novice and six experienced transit operators. Two miniature cameras and a microphone were installed on the bus; one camera was aimed towards the bus operator and the other was oriented toward the road scene ahead. Five measures were selected to assess safety in relation to making manual bus stop announcements: stop announcement accuracy, glances to the list of stop names, glances to mirrors, subjective ratings of operator workload, and subjective ratings of perceived safety. The number and length of off-forward view glances were used to estimate changes in crash risk.

On average, bus operators were able to announce all stops with an accuracy of 79.3%. With respect to the announcement of all stops as compared to no stops, bus operators spent time glancing at the stop name sheet while the bus was in motion (1.24 glances per minute). Some of these glances lasted over two seconds in duration (15.3 long glances per hour). While announcing all stops, bus operators spent less time looking at their mirrors when departing from a bus stop (4.01 vs. 5.06 seconds). Bus operators reported a higher workload when announcing all stops (18.1 vs. 8.8 on a 21-point scale) as compared to announcing no stops.

Despite receiving training prior to their test session, and being specifically instructed not to look at the stop announcement sheet while in motion, all operators made glances to the stop name sheet while the bus was in motion. Based on experimental data showing that a two second glance away from the road doubles crash risk, if all operators on all routes were required to announce all stops, in the worst case there could be an increase of 2.8 to 5.6 crashes per year.

INTRODUCTION

This purpose of this study was to examine the effect of mandatory stop announcements on bus operator performance. Specifically, the study was designed to determine whether the manual announcement of all stops increased bus operators' distraction levels to a significant degree, with a resulting adverse impact on operator health and safety and general public safety. Although data were collected related to the announcement of "major stops" in addition to "all stops", this option was not considered to be acceptable to the Human Rights Commission. Therefore, the results from only two trip conditions are reported: announcing no stops vs. announcing all stops. Results are reported for these conditions for four safety related measures:

- Proportion of stops that the operator was unable to call out due to other work demands
- Number and duration of glances made to the stop call sheet, both when the bus was stopped and when it was in motion
- Number and duration of glances made to mirrors when leaving a bus stop
- Bus operator self assessment of task workload and perceived safety

According to the weekday worksheet provided by Grand River Transit, over the course of a 9.5 hour shift, including 8.5 hours of driving, a bus operator passes over 550 bus stops (more than one bus stop per minute).

METHOD

Prior to the start of the on-road study, Human Factors North Inc. (HFN) redesigned the stop name sheet. The original stop name sheet designed by Grand River Transit was too large for easy use while driving, had a font size that was too small to read at a distance, and individual stop names that were difficult to identify from the long list of stops.

The study period spanned two weeks from September 24 to October 12, 2009. Data were collected on two routes, Route 7 and Route 12. Route 7 was selected because it was the busiest route travelling through the downtown areas of Kitchener and Waterloo. Route 12 was selected because it was one of the longest routes and featured many turns and closely spaced bus stops.

Design of the Stop Name Sheet

In preparation for the on-road study, the stop name sheet, which lists all of the stops in addition to scheduled stop times, was redesigned in order to optimize the ease with which the stop announcement task can be carried out. The original design used a very small font size (9 pt) and organized names in a long list. A key concern was that the stop name list must be organized in a user-friendly format for operators who need to locate the relevant information (i.e., the next three stop names) in a quick glance. The list had to be sufficiently legible to be comfortably read in a quick glance under low levels of light. Finally, the stop name list had to be stored in a location that is readily accessible for the bus operator who, especially at first, will need to look at it frequently.

The revised stop name sheet organizes information into three columns (see Figure 1). The first column shows the name of the street that is being travelled, the second column lists the cross street, and the third column shows the stop time. The font used is 14 pt Arial in upper and lower case. Major stops (as defined by GRT) are shown in bold black font. Non-major stops are in dark grey. Stop names are shown in groups of three. The rationale for grouping stop names is that displays of all types are more easily read if the information is organized in small “chunks”, thus reducing the number of areas that have to be looked at to locate a name.

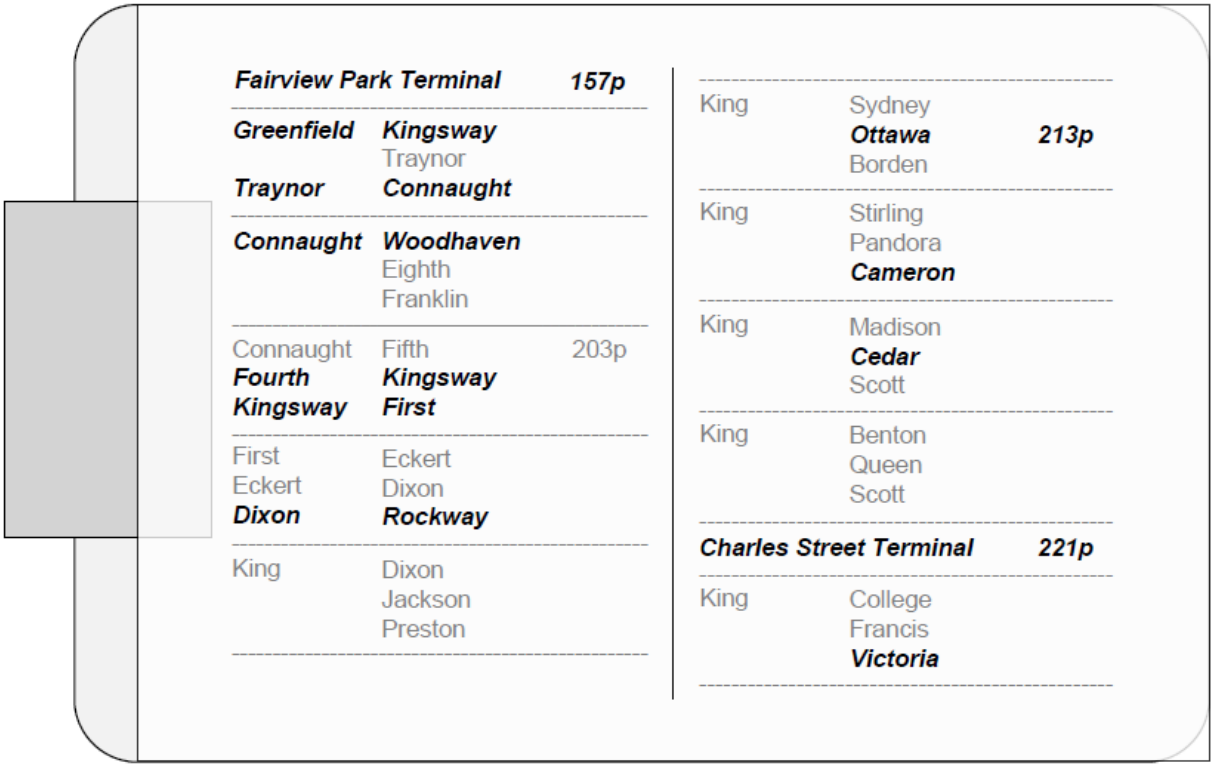

Figure 1: Template for Revised Stop Name Sheet

Equipment

One NOVA bus was used for all test trials (#2710). The bus was outfitted with a manual stop announcement system, which consists of a foot-activated switch and an omni-directional microphone. In order to create an announcement, operators must press and hold down the foot pedal switch, say the name of the stop, and then release the foot pedal switch. The announcement system repeats the recorded message (once) to the middle and back of the bus. To cancel the recording an operator must immediately press down on the foot pedal switch a second time.

A miniature video camera was installed at the front of the Grand River Transit bus and aimed towards the bus operator (see Figure 2). The purpose of this camera was to measure the number and duration of bus operator glances towards the stop call sheet and mirrors both while the bus was stopped, and while the bus was in motion. A second miniature camera was installed at the front of the bus oriented forward towards the road scene ahead. Video footage from both cameras and an audio feed from a hidden microphone were recorded onto a portable digital video recorder. Computer software was used to analyze the video recordings in slow motion (from one-third speed to one-half speed) and glance durations were measured to an accuracy of one-tenth of one second.

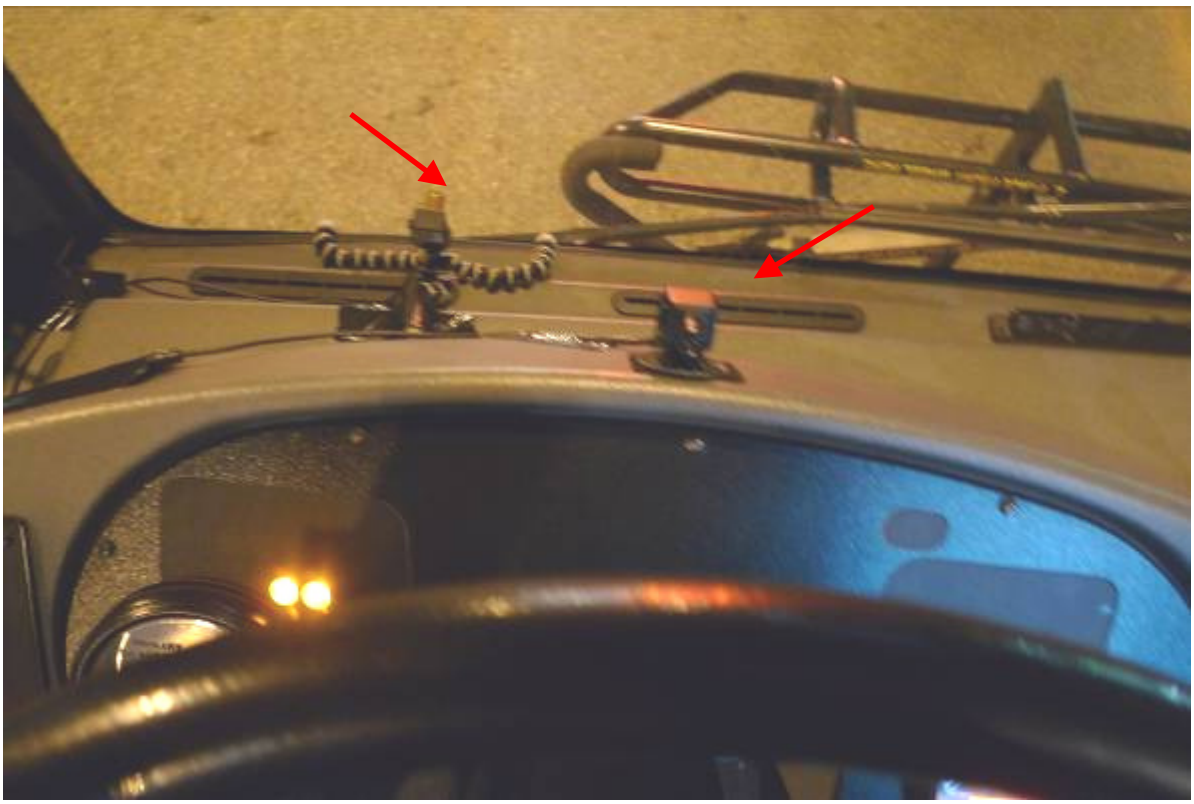

Figure 2: Locations of video cameras

Measures

Five measures related to accurate and safe performance were selected. These were as follows:

1. Stops not called
2. Glances to stop name sheet
3. Glances to mirrors
4. Operator workload
5. Operator perceived safety

Each of these is described below.

STOPS NOT CALLED

While driving, transit bus operators are required to attend to a variety of non-driving tasks, such as monitoring passengers within the bus, responding to stop requests, receiving communications from dispatch, and answering passenger questions. An increase in task workload will result in delays in addressing these non-driving tasks. If the bus operators' task workload is too high they may forget the name of the upcoming stop or forget to call out the stop until they arrive. The number of stops not called was analyzed to determine how well the stop calling task was performed.

GLANCES TO STOP NAME SHEET

The length of glances at the stop sheet was an important measure because the length of glances away from the forward view while in motion has been correlated with changes in crash risk. A naturalistic study of 100 drivers that videotaped drivers for a year captured about 85 crashes (most minor and not reportable). Looking away from the forward scene for more than two seconds in a single glance was found to double the risk of a crash (1).

GLANCES TO MIRRORS

The miniature video camera used to measure glances to the stop name sheet was also used to measure bus operator glances to internal and external mirrors at the front of the bus. The number of glances made to mirrors while driving on the route during full stop calling was compared to those made while driving when not calling out all stops, to determine if the increased workload during stop calling decreased driver attention to mirror checks.

OPERATOR WORKLOAD

Measuring operator workload during task performance is challenging. Techniques involving objective measurements, such as using electroencephalograms (EEGs), are appropriate for laboratory studies in a controlled environment, but they are not practical for use on a transit bus in service. The NASA Task Load Index (NASA-TLX) is a very commonly used technique for measuring subjective mental workload. In the last 20 years NASA-TLX has been used or reviewed in over 500 scientific studies (2). It has been used to measure workload associated with mobile phone use while driving (3)(4) , assess visual distraction from in-vehicle technologies (5), measure pilot workload in the commercial aviation industry (6) and assess nuclear power plant control room design (7).

Bus operator mental workload was assessed using NASA-TLX. Bus operators were asked to estimate their mental workload on a series of 21-point scales (from “very high” to “very low”), including mental demand, time pressure, effort, and frustration level. NASA-TLX requires very little time from the operator, approximately one minute in total for each assessment. Operator workload during full stop announcements was compared to that experienced while driving when not announcing any stops.

OPERATOR PERCEIVED SAFETY

Using the same 21-point scale (from “very high” to “very low”) as the NASA-TLX, bus operators were asked to estimate how safely they were able to carry out their driving task at the end of each trip condition. Perceived safety during full stop announcements was compared to that experienced while driving when not announcing any stops.

Participants

On Route 7, twelve (12) Grand River Transit bus operators, six novice (i.e., less than 2 years of experience) and six experienced (i.e., more than 3 years of experience), were observed during three outbound and inbound trips from the Charles Street terminal. Half of each of the novice and experienced operator groups drove during daytime hours (2:30 p.m. to 5:15 p.m.) and half during nighttime hours (8:30 p.m. to 11:15 p.m.).

On Route 12, three novice Grand River Transit bus operators were observed for one outbound and inbound trip from the Charles Street terminal. All three operators drove during daytime hours (2:30 p.m. to 5:15 p.m.).

Experimental Design

On Route 7, data were collected on three round trips for each of twelve operators from the Charles Street transit terminal. On each trip, bus operators were asked either to, (a) announce All Stops, (b) Announce Only Major Stops, or (c) not announce any stops. In order to reduce the influence of the order in which the conditions are done, the order of the conditions was counterbalanced. The three operators in each sub-group (e.g., nighttime experienced) were assigned to one of three orders.

At the request of the Joint Health and Safety Committee, a smaller set of data were collected on Route 12. Compared to Route 7 this route is longer and has more turns. On Route 12 data were collected for three novice Grand River Transit bus operators, for two trips, each lasting 90 minutes. On the first trip, all three operators were asked to announce Only Major Stops. On the second trip, all three operators were asked to announce All Stops. No observations were made of these operators announcing No Stops.

Procedure

All 15 bus operators participating in this study received stop name calling training from Grand River Transit. All operators attended a two-hour training session during which the study background, testing process, and procedure for announcing stops were presented. At the end of the presentation all bus operators had an opportunity to practice using the announcement system aboard a stationary bus.

At the start of each test session operators were reminded that their primary task was the safe operation of the bus and they should not look at the stop lists while the bus was in motion or announce stops should they feel it was not safe to do so.

During the data collection period a researcher accompanied the bus operator to set up video recording equipment, inform drivers on which trips they were to call out all stops, make observations of stop call names missed, and collect responses to the NASA-TLX questions. The researcher making the observations of the bus operator during the on-road study also noted any unusual incidents (e.g., difficulty accessing the stop call sheet) that occured during the course of the trip. During each trial a GRT management representative and a worker member from the Joint Health and Safety Committee were also on the bus to monitor testing.

At the end of each trip condition (e.g., announcing All Stops) operators were asked to rate their workload using the NASA-TLX on a series of five 21-point scales. Bus operators were encouraged to provide additional feedback on safety concerns at the end of their trip regarding their experience calling out stops and the ease of using the bus stop list. All information was kept anonymous.

Analysis

Three statistical tests were used in the analysis of the results. A chi-square test was used to determine if there was a difference in the frequency of an event occurring between two samples (e.g., comparing how frequently bus operators made a correct stop announcement between the two stop announcement tasks). A T-test was used to compare whether there was a difference in the average measurement between two samples (e.g. comparing the average duration of stop sheet glances between the two stop announcement tasks). An analysis of variance (ANOVA) was used to compare whether there was a difference in the average measurement between groups or conditions (e.g. comparing the average mirror glance duration for two trip conditions, and between novice and experienced operators).

RESULTS

Accuracy of Stop Announcements

Each stop announcement had to satisfy two criteria in order to be scored correct: (1) the announcement was made between the previous and current stops, and (2) the operator called only the crossing street or both the crossing street and the street the bus was on. For example, if the bus was travelling on King Street and the next stop was at Gaukel Street, an announcement of either “Gaukel” or “King and Gaukel” was scored correct. If the next stop was on the crossing street (i.e., bus turned onto crossing street) bus operators would have to say both street names to be scored correct. As the focus of this study was on measuring the work demands associated with announcing stops while driving, the audible clarity of the announcement did not impact the scoring.

A chi-square test was used to compare stop announcement accuracy between novice and experienced operators. There was no significant difference between the two experience groups (80.8% vs. 77.7 %, ns).

Glances to Stop Name Sheet

A chi-square test was used to compare the proportion of stop sheet glances made while the bus was in motion. Overall, operators made more glances to the stop name sheet when the bus was stopped as compared to when the bus was in motion (58.4% vs. 41.6%, $p < .03$). There was no significant effect of driver experience (38.3%, 45.3%, ns).

The average recorded time in motion for each trip was 31.4 minutes (SD = 3.7). Since individual trips varied in length due to various reasons (e.g., traffic volume, number of stops requested, interruptions in video recording), comparisons were made of the number of stop sheet glances per minute while on route (i.e., stopped and in motion). A Paired T-Test was used to compare the effect of operator experience on the number of stop sheet glances per minute. There was no effect of driver experience in the number of stop name sheet glances while announcing all stops (1.24 vs. 1.24, ns).

A Paired T-Test was used to compare novice and experienced drivers with respect to the overall number of stop name sheet glances that lasted 2.0 seconds or longer per hour. Due to the small sample size the effect of driver experience on long glances per hour was not significant (11.0 vs. 19.6, ns).

Glances to Mirrors

A comparison was made to determine if there was an effect of driver experience on the amount of total mirror glance time per stop. Overall, there was no effect of driver experience on total mirror glance time per stop ($F(1,260) = 0.12$, $p = 0.73$). There was, however, a significant effect of trip condition on the total time that bus operators spent looking at their mirrors for each stop ($F(1,260) = 13.77$, $p < .001$). Operators spent significantly more time looking at their mirrors during the No Stops trip condition as compared to the All Stops (5.06 vs. 4.01 seconds) trip condition.

A comparison was made to determine if there was an effect of driver experience on the average mirror glance duration. Overall, there was no effect of driver experience ($F(1,1484) = .41$, $p = 0.41$) or trip condition ($F(1,1484) = .08$, $p = 0.77$) on average mirror glance duration. The average mirror glance duration for novice and experienced bus operators was 1.10 seconds.

Bus Operator Workload

Bus operator workload was assessed using the NASA Task Load Index (NASA-TLX). At the end of trip condition (i.e., No Stops, Only Major Stops, All Stops) bus operators were asked to rate four aspects of the workload associated with that trip, on a 21-point scale (1 = very low, 21 = very high). The questions asked were:

1. How mentally demanding was the task?
2. How hurried or rushed was the pace of the task?
3. How hard did you have to work to accomplish your level of performance?
4. How discouraged, stressed and annoyed were you?

The total bus operator workload for each trip condition was the average score in response to the above four question (i.e., each question was weighted equally).

A Paired T-Test was used to compare bus operator workload between trip conditions. The results are shown in Table 1. Overall, there was a significant effect of trip condition on bus operator workload ($p < .0001$). On average, operators reported experiencing significantly higher workload when announcing All Stops compared to announcing No Stops ($p < .001$). There was no effect of experience on operator workload.

Table 1: Bus Operator Workload, by Operator Experience

	No Stops (n=12)		**All Stops (n=12)**	
	Novice	**Experienced**	**Novice**	**Experienced**
Mental Demand	8.7	8.5	19.7	17.7
Time Pressure	11.2	10.5	18.5	16.5
Effort	8.3	8.8	19.5	17.8
Frustration	5.3	9.0	19.0	16.5
TOTAL	8.4	9.2	19.2	17.1

**** 1 = very low, 21 = very high***

Operator Perceived Safety

Using the same scale as the NASA-TLX bus operators were asked to rate, on a 21-point scale, “How safely were you able to complete your driving task?” following each trip

condition. Overall there was no significant effect of trip condition [$F(1,20) = 2.59$, $p = .12$] or operator experience [$F(1,20) = 0.33$, $p = .57$] on perceived safety. It is important to note that during the analysis of the data it became apparent that some operators were confused by the reversal of the scales compared to the previous operator workload questions (e.g., lower numbers were "good" for the operator workload questions but "bad" for safety).

Crash Risk Due to Long Stop Sheet Glances

On Route 7, during the All Stops trip condition, bus operators spent 1.08% of their total time in motion glancing at the stop name sheet for two seconds or longer. It is assumed that, on average, all operators will spend this proportion of time taking long glances to the stop name sheet. As discussed earlier, these long glances are associated with a doubling of crash risk. If all bus operators are required to announce all stops on Route 7, an increase of approximately 0.38 crashes over a one year period on Route 7 can be expected.

On Route 12, during the All Stops trip condition, bus operators spent 2.56% of their total time in motion glancing at the stop name sheet for two seconds or longer. Based on the same assumptions made above for Route 7, if all operators are required to announce all stops on Route 12, an annual increase of approximately 0.44 crashes on Route 12 can be expected.

Based on the available data for Route 7 and 12 it is assumed that bus operators on other routes would take long glances to the stop name sheet while driving, with a likely frequency in the range of 1.08% to 2.56%. Based on this range of high risk glances away from the road the corresponding expected increase in bus crashes is 2.00 to 4.75 annually. These ranges represent the worst case scenario as 1) Route 7 is a very demanding route through the busiest areas of Kitchener and Waterloo, and has an above average crash rate (25.8 crashes/million km in 2009 vs. 19.2 crashes/million km system wide), and 2) Route 12 is one of the longest routes with testing only carried out with novice operators.

Overall, based on the average expected increase for Route 7 and Route 12, the system wide worst case for the manual announcement of all stops could result in an increase of 2.82 to 5.57 annual crashes.

DISCUSSION

Impact of Announcing All Stops vs. No Stops

In comparison to the current situation of not having to announce stops, bus operators spent time looking at the stop name sheet, including long glances lasting two seconds or more, while the bus was in motion. While carrying out the All Stops announcement task, bus operators spent 25% less time looking at their mirrors when departing from a bus stop (4.01 vs. 5.06 seconds). This suggests that in the process of reviewing and memorizing upcoming stop names bus operators spent less time looking at their mirrors. Bus operators reported higher workload when announcing All Stops, but there was no difference in perceived safety.

Crash Risk Associated with Manual Stop Announcements

A study of naturalistic driving has shown that glances away from the road while driving of 2 seconds or longer are associated with a doubling of crash risk (1). Based on bus operator behaviour on Route 7 and Route 12 with nine novice and six experienced operators, long glances to the stop name sheet while announcing All Stops system wide could result in an increase of 2.8 to 5.6 crashes annually.

Impact of Driver Experience

Novice operators had less than two years of GRT bus driving experience and experienced operators had more than three years of GRT bus driving experience. There was no effect of driver experience on (1) stop announcement accuracy, (2) frequency of stop name sheet glances or (3) long stop name sheet glances made while the bus was in motion, (4) mirror glance time per stop, (5) average mirror glance duration, (6) operator workload, or (7) operator perception of safety.

Impact of Time of Day

Half of the trials were carried out during the afternoon rush hour and the other half were carried out during the early evening, after dark. Bus operators spent less time looking at their mirrors when leaving a bus stop during evening trials as compared to afternoon trials (4.19 vs. 4.83 seconds). There was no effect of time of day on average mirror glance duration or stop announcement accuracy.

Comparison between Route 7 and Route 12

Six novice operators spent an average of 31 minutes driving on Route 7 and were required to announce 52 stops. Three novice operators spent on average of 53 minutes driving on Route 12 and were required to announce 86 stops. There was no difference in stop announcement accuracy between the two routes, for either announcement task. Novice operators on Route 12 took more long glances to the stop name sheet while the bus was in motion, as compared to novice operators on Route 7. There was no effect of bus route on the average mirror glance duration.

Effectiveness of Stop Announcement System

During the data collection period general observations were made of the audibility of the stop announcement system. Announcements were occasionally muffled and interfered with by other audio sources within the bus, including bus rattling, GRT radio chatter, and passenger conversations. As a result, operators sometimes had to cancel the recording of their announcement and repeat the process. At other times the operator continued with the announcement but the resulting broadcast over the public announcement system was muffled and inaudible. Bus operators activate the announcement system using a switch, located on the floor of the bus, with their left foot. Two bus operators indicated that since they must also use their left foot to activate their turn indicators, they cannot activate the foot switch and turn indicator concurrently.

Adequacy of Street Name Signs

In general, the letter heights on the current street name signs in the Kitchener-Waterloo area are not large enough to be read by operators in advance of bus stop locations. Intersections have obstructed (e.g., by trees) or poorly placed (e.g., located at far left

side of intersection) street name signs. Some intersections have no street name signs. Street name signs are essential for bus operators who are not very familiar with a particular route. Inexperienced bus operators are the ones who would mostly likely rely on street name signs as the learn new bus routes.

Steps to Improve Stop Announcement Accuracy

Observations of operators making manual stop announcements were made under high workload conditions (i.e., busy routes with many stops during peak periods in the afternoon and evening). Since operators did not have prior experience making manual stop announcements, this secondary task required the highest degree of concentrated effort. With more practice it is expected that modest improvements in stop announcement accuracy should be achievable as the process becomes an automated behaviour. However, there are several challenges related to operator workload that will inhibit improvements in stop announcement accuracy.

First, time pressures associated with keeping a schedule will place operators in a difficult position where they may not have enough time to review the stop name sheet while stopped. Thus, operators may have to choose between taking risky glances to the stop name sheet while the bus is in motion, contrary to operating policy, or fall behind schedule while taking the time to review upcoming stops while the bus is stopped.

Second, since operator schedules dictate that they are required to drive along several different routes during any given duty period, this requires that they memorize several hundred stops during a typical duty period. Schedules are rotated several times a year, making it difficult for operators to develop the rhythm necessary to allow manual stop announcement to become an automated behaviour.

Third, the inadequate legibility of street name signs in the Kitchener-Waterloo area requires operators to rely primarily on the stop name sheet to identify the names of upcoming bus stops.

Another challenge to improve stop announcement accuracy is operator attitude and motivation. Incentives could be offered to operators who achieve performance above a certain threshold (i.e., 95%). Note that while a target of 100% accuracy is theoretically possible for an operator who is familiar with a given route and driving under low volume conditions (i.e., passenger and road traffic), a system-wide goal of 100% performance is not realistic for the above stated reasons. Based on operator feedback it is expected that employee turnover could increase if all bus operators are required to announce all stops on all routes.

Steps to Mitigate Risk Associated with Manual Stop Announcement Task

There are several ways to mitigate the risks associated with manually announcing stop announcements. First, bus route schedules need to be lengthened in time by up to 4% in order to allow operators enough time to review and memorize upcoming stops without having to do so while the bus is in motion. This time allowance was calculated by dividing the total time that operators spent looking at the stop name sheet while in motion by the total time spent on the route. Note that even with this added time allowance there is still a concern that operators do not spend as much time looking at

their mirrors when departing from a bus stop while carrying out the manual stop announcement task.

Second, operators need to receive training with respect to the crash risk associated with looks away from the road to the stop name sheet while the bus is in motion. Some method of enforcement may be considered in order to discourage this risky behaviour.

Third, the existing infrastructure of street name signs requires upgrading. New street name signs, with larger letter heights, should be installed on the traffic signal arms at signalized intersections.

CONCLUSIONS

Operators were able to make manual stop announcements with an accuracy of 79%. While announcing “all stops” bus operators spent 25% less time looking at their mirrors when departing from a bus stop (4.01 vs. 5.06 seconds) as compared to when announcing “no stops”. Bus operators reported a significant increase in workload and a significant decrease in perceived safety when asked to announce “all stops” compared to “no stops”.

There was no effect of operator experience on (1) stop announcement accuracy, (2) frequency or duration of glances to the stop name sheet, (3) mirror glance time per stop, (4) subjective ratings of operator workload, or (5) operator perception of safety.

Despite receiving training and being specifically instructed not to look at the stop announcement sheet at the start of each test session, all operators made glances to the stop name sheet while the bus was in motion. Bus operators made 41% to 69% of their glances to the stop name sheet while in motion. In addition, by attending to the stop name sheet while at bus stops, operators spent less time looking at their mirrors. There was an increase in operator workload when announcing All Stops as compared to not announcing stops.

A study by Klauer et al. showed that crash risk doubles in association with long glances (2 seconds or longer) away from the road, such as glancing away from the road to the stop name sheet (1). Based on the frequency of these long glances away from the roadway on Route 7 (high density) and Route 12 (long, many stops) by operators with very limited experience with the stop announcement task, if all operators on all routes were required to announce all stops on all routes (over 550 stops per operator per day), in the worst case there could be an increase of 2.8 to 5.6 crashes per year.

Manual stop announcements were made using a foot-activated announcement system. This system presented at least two challenges to operators. First, announcements were occasionally muffled and interfered with by other audio sources within the bus, including bus vibrations, GRT radio chatter, and loud passenger conversations. As a result, these announcements were inaudible. Second, the system is activated using a foot switch which presents a conflict for operators who are required to use their left foot to activate the turn indicators and their right foot to activate the accelerator and brake pedals.

In general, bus operators required to announce stops will be reliant on the stop name sheet because the current street name signs in the Kitchener-Waterloo area are not

legible at a distance great enough to allow operators to read them in advance of bus stop locations.

ACKNOWLEDGEMENTS

This project was funded by Grand River Transit. Peter Zinck was the contract monitor.

REFERENCES

(1) Dingus, T.A., Klauer, S.G., Neale, V.L., Petersen, A., Lee, S.E., Sudweeks, J., Perez, M.A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z.R., Jermeland, J., and Knipling, R. *The 100-car naturalistic driving study. Phase II - Results of the 100-car field experiment*. Report No. DOT HS 810 593. National Highway Traffic Safety Administration (NHTSA), Washington, DC. 2006.

(2) Hart, S.G. *NASA-Task Load Index (NASA-TLX) 20 years later*. In Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting (pp. 904-908), Santa Monica, CA. 2006.

(3) Ålm, H. and Nilsson, L. The effects of mobile telephone tasks on driver behaviour in a car following situation. *Accident Analysis & Prevention*, *27*(5), 707-715. 1995.

(4) Matthews, R., Legg, S., and Charlton, S. The effect of cell phone type on drivers' subjective workload during concurrent driving and conversing. *Accident Analysis & Prevention*, *35*, 451-457. 2003.

(5) Frank, T.L., Noy, I., and Klachan, C. *Occlusion paradigm as a tool to assess visual distraction from in-vehicle telematics*. In Proceedings of the Human Factors & Ergonomics Society 46th Annual Meeting, Santa Monica, CA. 2002.

(6) Corwin, W. *The NASA Task Load Index as a measure of pilot workload in the commercial transport environment*. SAE Report No. 892682. 1989.

(7) Jones, J.M., Ma, R., Starkey, R.L., and Ma, Z. *Information complexity and appropriate interface design in nuclear power plant control rooms*. Human Factors and Power Plants and HPRCT 13th Annual Meeting, pp. 45-49. 2007.