Driver Distraction in Public Transport

Kristie Young, *Monash University Accident Research Centre, Melbourne, Australia*
Paul Salmon, *Brunel University, Uxbridge, United Kingdom*
Michael Regan, *French National Institute for Transport and Safety Research (INRETS), Lyon, France*

ABSTRACT

There is converging evidence that driver distraction is a contributing factor in car crashes, in Australia and overseas. Surprisingly, no known previous research has attempted to identify and assess the potentially distracting activities undertaken by the drivers of public passenger vehicles. This paper describes research undertaken on this issue. The research was partitioned into three phases: an analysis of the functions and tasks currently undertaken by public passenger vehicle drivers; the identification of actual and potential sources of driver distraction; and the assessment of potential risk deriving from distraction. This paper describes the research activities conducted during these phases and the outcomes of these activities.

INTRODUCTION

There are many devices, objects and activities inside and outside the vehicle that have the potential to distract drivers[1]. These include systems that are built into the vehicle, such as, radios, CD players, and route guidance systems; portable devices brought into the vehicle such as mobile phones and iPods; everyday activities, such as talking to passengers, drinking and eating; and external objects and events, such as advertising billboards, pedestrian activity, and buildings. Early estimates of the proportion of crashes that is attributable to the driver being distracted by an object, event or activity inside or outside the vehicle range from 10 to 12 percent,[2,3] although findings from the recent '100-car study' suggest that this figure may be closer to 23 percent.[2] As more technologies find their way into the vehicle, the role of distraction in crashes is expected to escalate.

Driver distraction can be defined as the "diversion of attention away from activities critical to safe driving towards a competing activity".[4] Much of the previous research into distraction has focused on private automobile drivers (e.g. [5,6]). However, it is apparent that distraction could also be a major problem in the public and commercial transport sectors (i.e. bus, taxi and train driving, and long-haul truck driving). This assumption is made on the basis that drivers who are *working* might be exposed to additional distracting factors as part of their work task. For example, while driving buses, drivers undertake a number of additional 'bus operation' tasks, such as selling tickets, communicating with control room operators and monitoring passengers, which involve interaction with non-driving-related devices (e.g. ticket machines, two-way radios) and passengers.

This chapter describes the findings derived from a program of research that was undertaken by the Monash University Accident Research Centre (MUARC) for a major public transport company in the Australian State of New South Wales (NSW) in order to investigate the potential for bus drivers to be

distracted while driving buses. Specifically, the research aimed to identify what sources of distraction bus drivers are exposed to while operating buses, their potential impact on performance and safety, and what can be done to minimize driver exposure to these distractions.

THE BUS DRIVING ENVIRONMENT

Urban bus driving is an example of a high-stress working environment that is characterised by high workloads and conflicting demands. Driving in any environment is a demanding task: drivers have to maintain lateral (lane keeping) and longitudinal (speed and headway) vehicle control, while navigating to their destination, negotiating other traffic and scanning the road environment for hazards. Bus drivers, however, are required to undertake a range of tasks over and above those expected of private vehicle drivers. These additional tasks include monitoring passengers and bus stops, responding to passenger queries, selling tickets, monitoring and responding to radio broadcasts, and keeping to a strict time schedule and the specified bus route. The size of the bus also imposes a greater level of demand on the bus driver to maintain vehicle control than do passenger vehicles.

This combination of high workload and the performance of multiple additional activities can make bus drivers more vulnerable to the negative effects of distraction. That is, given that bus driving demands a high level of mental workload, drivers will have less spare attentional capacity to engage in competing activities (whether they be non-driving-related or driving-related). Thus, the performance of competing tasks may more adversely affect bus driving performance and safety relative to that of car drivers.

Currently, very little is known about what distracting tasks bus drivers engage in when driving and how these might affect driving performance and safety. The study described in this paper represents the first known attempt to examine the issue of distraction within the bus driving domain.

STUDY OF BUS DRIVER DISTRACTION

In response to a number of recent distraction-related incidents, a NSW public transport company commissioned MUARC to assess the risks associated with its bus drivers engaging in potentially distracting activities while driving. The research was partitioned into three phases:

- an analysis of the functions and tasks currently undertaken by bus drivers;
- the identification of actual and potential sources of bus driver distraction; and
- the conduct of a risk assessment and Human Error Analysis of distraction for bus drivers.

METHOD

Phase 1 - Analysis of Functions and Tasks Undertaken by Bus Drivers

The first phase of the study involved the identification of the different tasks, both driving and non-driving, that bus drivers currently undertake while operating buses. This involved a review of relevant company documents, including training manuals and standard operating procedures; the conduct of semi-structured and walkthrough/talkthrough style interviews with various Subject Matter Experts (SMEs; driver training personnel, experienced bus drivers); three focus group discussions with a

sample of current bus drivers; and observational studies of bus driving on a range of representative routes. The information derived from this work was used to inform the development of a Hierarchical Task Analysis (HTA)[7] of bus operation, which provided an exhaustive description of the tasks and the associated task steps involved in driving a bus.

Phase 2 - Identification of Potential Sources of Driver Distraction

The next phase of the research involved the identification and documentation of the various sources of bus driver distraction that bus drivers are exposed to while operating buses. This phase involved a range of activities, including analysing the data derived from the review of company documentation, focus groups, observational studies, SME interviews and the HTA, conducted in Phase 1. A number of other activities were also undertaken, including a bus driver survey completed by 19 company bus drivers, the conduct of ergonomic assessments of a range of company buses, examination of selected company surveillance camera footage, and a review of the range of technologies used by company bus drivers while driving.

Phase 3 - Risk Assessment and Human Error Identification Analysis

The final phase of the study involved the assessment of risk deriving from bus driver exposure to distractions. This involved the ergonomic assessment of a range of buses used by company bus drivers; a review of existing company procedures and policies on distraction; current Australian laws relating to the use of potentially distracting devices while driving; a review of current incident data held by the company on driver distractions and their contribution to crashes and incidents; a review of the demographic characteristics of company bus drivers; and the conduct of a distraction-based Human Error Identification (HEI) analysis for bus operation, which identified the errors that bus drivers are likely to make when they are distracted. The aim of the risk assessment was to assess the extent to which bus drivers are exposed to the sources of distraction identified in proceeding tasks and to determine the consequences associated with bus drivers being distracted from the primary task of driving the bus safely.

RESULTS

Phase 1 - Functions and Tasks Undertaken by Bus Drivers

Based on the focus groups, SME interviews, observational study and the HTA of bus operation, it was established that bus drivers currently perform a wide range of different functions and tasks while operating buses. These tasks were classified into seven categories, each of which is described below.

1. *Preparation Tasks*. Preparation tasks include tasks that bus drivers perform to prepare the bus before setting off on a particular run. These include conducting pre-departure checks designed to determine whether the bus is roadworthy and performing appropriately, such as making engine compartment and electrical checks, checking the wheels, tyres and vehicle posture, and checking for leaks and loads. The bus drivers are also required to perform a walkthrough of the bus to check instrumentation and identify any protruding objects. Once the pre-departure checks are complete, the

bus driver then makes any pre-driving adjustments required. These include adjusting the driver's seat, checking and adjusting the mirrors and visor, becoming familiar with the required route and modifying the destination board.

2. *Physical Vehicle Control Tasks*. The physical vehicle control tasks category includes the physical tasks that the bus driver has to perform while driving the bus. These include steering the bus, operating the accelerator and brake pedals, changing gears and operating indicators and other vehicle controls.

3. *Cognitive Vehicle Control Tasks*. Cognitive vehicle control tasks include the cognitive tasks that the bus driver has to perform while driving the bus. These include route planning, checking the mirrors, monitoring other road users and pedestrians, forecasting and anticipating other road users' behaviour, navigation, perceptual and decision-making tasks, and maintaining situation awareness (i.e. an awareness of the current and anticipated events and activities occurring in the surrounding road environment).

4. *Route/Timetabling Tasks*. The route/timetabling tasks category includes tasks that the bus driver is required to perform in order to keep to the desired route and timetable. These include checking their route journal and planning the route, entering the section points (bus zones) on the ticket machine and also checking the current time against the time specified by the route journal.

5. *Passenger-Related Tasks*. Passenger-related tasks include the tasks that the bus driver is required to perform when dealing with passengers. These include opening and closing the bus doors, lowering and raising the bus, operating the ticket machine and issuing tickets, changing section points, checking tickets, monitoring passengers and assisting passengers.

6. *Communication Tasks*. The communication tasks category includes tasks that bus drivers perform in order to maintain communications with the transport operations centre (TOC). These include listening to general and personal broadcasts, using the radio and handset to initiate communication with the TOC, reporting incidents and making emergency calls in events of a crash or breakdown.

7. *Personal Comfort Tasks*. The personal comfort tasks category includes tasks that the bus driver performs in order to maintain personal comfort while driving the bus. These include making adjustments to the seat, sun visor, mirrors and driving controls, drinking and eating and using personal entertainment equipment (e.g. portable radio).

Apart from the preparation tasks that are completed by drivers before setting off, all of the other tasks identified can be performed by the bus driver while he/she is driving the bus. According to company policy, only the physical and cognitive vehicle control tasks should be performed while driving the bus (company policy prohibits the drivers from performing the other tasks while driving). Therefore, the other tasks (e.g. passenger, communication and personal comfort-related tasks) are all considered secondary tasks that the driver should perform only while the bus is stationary. Data collected from the focus groups indicate, however, that a significant proportion of bus drivers currently undertake at least

some of these secondary tasks while driving. It was therefore concluded that these secondary tasks represent potential sources of distraction to bus drivers.

Phase 2 - Potential Sources of Driver Distraction

Distraction Taxonomy

Based on the data collected from the focus groups, driver survey, SME interviews and observational studies, a taxonomy of bus driver distraction sources was constructed. The taxonomy of distraction sources contains all of the different potential sources of distraction identified during the study. The potential distraction sources were categorized into seven main categories. A summary of each category is presented below.

1. *Technology-related distractions*. Technology-related sources of distraction include any technological devices that the driver interacts with while driving the bus, including mobile phones, radio, the broadcast radio and handset, and the ticket machine.

2. *Operational distractions*. Operational sources of distraction include any aspects of bus operation that may be distracting, including operating the ticket machine, communicating with the TOC, listening to general and personal broadcasts and reading and/or modifying the route journal.

3. *Passenger-related distractions*. Passenger-related sources of distraction include any aspects of managing passengers that can potentially distract the bus driver, including passenger conversations, monitoring passengers, talking to passengers, issuing tickets, providing passenger assistance, dealing with unruly passengers and passengers talking loudly to each other or on their mobile phones.

4. *Environmental distractions*. Environmental sources of distraction include any environmental conditions that might distract the driver such as weather conditions (e.g. glare from the sun). Environmental conditions can become a distraction if they encourage the driver to perform activities to reduce the discomfort brought about by the conditions, such as adjusting the climate controls or sun visor. This is an example of a driving-related activity that has potential to compete with activities critical for safe driving; that is, to distract the driver.

5. *Bus cabin-related distractions*. Bus cabin-related sources of distraction include any features of the particular bus and bus cabin in question that might distract the driver, including annoying rattles (e.g. cabin door, ticket machine), adjusting the sun visor, seat, controls and the seat belt.

6. *Infrastructure-related distractions*. Infrastructure-related sources of distraction include any features of the road infrastructure that the driver might find distracting, such as road side advertising (e.g. on bus stops and vehicles).

7. *Personal distractions*. Personal sources of distraction include any personal factors that might distract the bus driver or make the bus driver more susceptible to distraction, such as daydreaming,

incapacitation and medication (the latter may increase the propensity to be distracted, or act as a direct source of distraction).

Specific sources of distraction within each category are presented in Table 1. Within the table, those sources of distraction that are representative of violational activity (i.e. activities prohibited by company policy while the vehicle is in motion) are marked with a 'V'. Performance of any of these tasks while driving could distract drivers physically (e.g. hand[s] off the steering wheel), cognitively (e.g. driver's mind/attention being taken off the road) and/or visually (e.g. driver's eyes being taken off the road).

Table 1 Sources of Bus Driver Distraction

Sources of Distraction Taxonomy						
Technology	**Operational**	**Passenger**	**Environmental**	**Bus Cabin**	**Infrastructure**	**Personal**
Radio (V)	Issuing tickets (V)	Passenger conversations	Weather conditions (e.g. sun glare)	Annoying rattles (ticket machine)	Advertising	Daydreaming
Handset (V)	Listening to general broadcasts	Passenger enquires (V)		Sun Visor (faulty, adjusting)	Inadequate lane width	Incapacitation (V)
Ticket machine (V)	Listening to personal broadcasts	Talking to passengers (V)		Adjusting seat	Road layout	Sickness
Mobile phone (V)	Recording broadcast details (V)	Unruly passengers		Adjusting seatbelt	Road signage	Medication
Personal entertainment	Communicating with TOC (V)	Non-paying passengers		Adjusting steering column		Inexperience
	Keeping to timetable	Schoolchildren		Operating climate controls		Eating
	Reading route journal (V)	Elderly passengers				Drinking
	Amending route journal (V)	Disabled passenger				
	Changing route section points	Passengers with infants				
	Bus raising alert	Issuing tickets				
	Hand-brake warning alert	Monitoring bus stops for waiting passengers				
	Raising/lowering bus (V)	Assisting passengers (V)				
	Opening/closing bus doors (V)					

Phase 3 - Risk Assessment and Human Error Analysis

Ergonomic Assessment

An ergonomic assessment was undertaken of three bus types that company drivers operate. The aim of the ergonomic assessment was to identify the design features of these buses that may be a source of distraction for bus drivers. The assessment involved three human factors experts undertaking a walkthrough type assessment of three buses with a SME. The experts were taken through the tasks that the bus drivers perform while driving the bus and also interacted with the bus controls and other devices. Instances of ergonomic design that could potentially lead to driver distraction were recorded and verified by the SME.

The findings from the ergonomic assessment indicated that a range of devices on-board the buses could potentially distract the driver while driving. These included the broadcast radio display and handset, ticket machine, sun visor and also audible rattles within the cabin, such as the driver cabin door and the ticket machine. A number of ergonomic design features that could potentially impair driving performance were also identified, including inappropriate placement of vehicle controls, functionality and control type, particularly the bus door controls, use of non-retractable seatbelts and no navigation support (such as could be provided by route navigation systems). Finally, a number of audible alerts that could potentially distract drivers were identified, including the bus stopping alert, wheelchair ramp alert, faulty ticket machine alert, general and personal broadcast alerts (and the broadcasts themselves), and oil pressure alert. While driving-related, they are alerts that are rarely issued that have potential to divert attention away from activities critical for safe bus driving.

A distraction checklist, developed by the authors, was used to assess and estimate the level of distraction imposed by the different devices on board the buses. The findings from the above activities suggested that, of the non-driving-related devices on board, the ticket machine and the broadcast radio display and handset devices could be expected to impose the greatest level of distraction when they are used by bus drivers while driving. Due to the exploratory nature of the study, a more rigorous quantitative assessment of the level of distraction imposed by the different devices and activities was not possible.

Human Error Identification Analysis

Human Error Identification (HEI) techniques allow analysts to predict potential errors that might arise during a particular activity or interaction with a device[8]. A distraction-based HEI analysis was conducted using the HTA of bus operation as input. In order to identify the errors that could potentially arise when the driver is distracted, a modified Systematic Human Error Reduction and Prediction Approach (SHERPA)[9] analysis was conducted. This involved taking each bottom-level task step from the HTA and predicting the driver errors that might arise in the event of the driver being either physically, visually or cognitively distracted while performing the task in question. For each credible error identified, a description of the error, any consequences associated with the error and any error recovery steps that would need to be taken were provided. The final step involved specifying any potential design remedies for each of the errors identified (i.e. how the device might be modified in order to remove or reduce the chances of the error occurring). An extract of the SHERPA-Distraction analysis is presented in Table 2.

The SHERPA analysis indicated that, when distracted, bus drivers could potentially make a number of safety-critical errors that could impact both safety and performance while operating the bus. The safety-critical errors identified included: *checking* errors (e.g. failing to check doors before closing them, failing to check mirrors, failing to check current speed and speed limit); *action* errors (e.g. failing to brake or braking too late, failing to maintain appropriate lane position, failing to use indicators); and

monitoring errors (e.g. failing to monitor traffic and pedestrians surrounding the bus and passengers on-board the bus).

Remedial measures suggested for preventing and mitigating the effects of the errors identified included a number of design changes to the bus cabin and the use of Intelligent Transport System (ITS) technology (e.g. intelligent speed adaptation systems, following distance warning systems, lane departure warning systems, and route navigation systems) to automate some of the bus operation tasks. Other suggested remedial measures included the use of training and company policy to remove instances of violational activities. However, it was also concluded that a number of the errors identified would require the development of novel ITS technologies and driver support systems, such as close proximity warning systems and situation awareness displays.

Table 2 SHERPA Distraction Analysis Extract

Task Step	Distraction	Error Mode	Description	Consequence	Remedial Measures
2.2.2.1 + 2.2.2.2	Physical				
	Visual	C1	Driver fails to check the front and back doors before closing them due to being visually distracted	There may be passengers located in or around the doors as the driver closes them	- Audible prompt to check doors before opening and closing - Intelligent doors that automatically open and close
	Mental	C1	Driver fails to check the front and back doors before closing them due to being cognitively distracted	There may be passengers located in or around the doors as the driver closes them	- Audible prompt to check doors before opening and closing - Intelligent doors that automatically open and close
2.2.1.3 + 2.2.1.4	Physical	A3	Driver moves door operation lever in the wrong direction	Doors remain open and do not close	- Intelligent doors that automatically open and close
	Visual	A3	Driver moves door operation lever in the wrong direction	Doors remain open and do not close	- Intelligent doors that automatically open and close
	Mental	A8	Driver fails to close the doors before attempting to pull away	The bus will automatically stop as the doors are still open	- Intelligent doors that automatically open and close
2.2.3.1 – 2.2.3.4	Physical				
	Visual	C1	Driver fails to check mirrors before pulling away	Driver may not see a pedestrian or other road user that is in close proximity to the bus	- Audible prompt to check mirrors before pulling away
	Mental	C1	Driver fails to check mirrors before pulling away	Driver may not see a pedestrian or other road user that is in close proximity to the bus	- Audible prompt to check mirrors before pulling away

CONCLUSIONS

This study investigated the sources of distraction that could potentially distract bus drivers. Our results suggest that bus driver distraction is likely to be a significant problem within the public transport sector. Moreover, the requirement for bus drivers to take on multiple, and at times competing, roles while driving may be exacerbating the problem of driver distraction in this sector. In addition to driving the bus, bus drivers are required to undertake a range of other tasks, including dealing with passengers

and communicating with the TOC. A significant proportion of the distraction sources identified during the study arose from the additional tasks that the bus drivers are required to undertake as part of their job.

A number of measures can be taken by the transport company and the wider public transport sector to reduce the distractions identified. Those distraction sources that are present during violational activities (e.g., using ticket machine or mobile phone) can be mitigated through the development and strict enforcement of company policy, rules and regulations and the provision of training programs designed to discourage drivers from engaging in such activities. Simple ergonomic bus cabin design and efficient maintenance procedures can also be used to remove sources of distraction within the bus cabin, such as faulty sun visors and annoying rattles. Finally, the provision of ITS within the cockpit could also be used to mitigate the effects of distraction. Systems such as intelligent speed adaptation, following distance warning, lane departure warning, and route navigation could all be used to automate aspects of the driving task, thus reducing the high workload associated with bus driving and, in turn, drivers' vulnerability to distraction.

It is clear that further research effort is required in this area. While it is evident from the current study that distraction may represent a significant problem in the public transport sector, our knowledge of the extent and nature of the problem is still in its infancy. As yet, we do not have accurate and complete data regarding public transport drivers' exposure to distracting activities or how these activities actually affect driving performance and crash risk. We therefore recommend that further investigations focusing on distraction in the public transport domain be undertaken. Conducting research that identifies the sources of driver distraction that exist in the public transport sector and their actual impact on driving performance is an important first step in establishing the role of distraction in crashes and incidents within this transport domain. In addition, further work investigating the effectivness of policy, rules and regulations, training programs, ergonomic bus cabin design and ITS technologies to reduce or mitigate the effects of distraction is recommended.

ACKNOWLEDGEMENT

The authors wish to thank the NSW public transport company who funded this research.

REFERENCES

[1.] Young, K., Regan, M., and Hammer, M., Driver distraction: A review of the literature, MUARC Report Report No. 206, Monash University Accident Research Centre, Clayton, Victoria, 2003.

[2.] Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., and Ramsey, D. J., The impact of driver inattention on near-crash/crash risk: an analysis using the 100-Car Naturalistic Driving Study data, Virginia Tech Transportation Institute, Blacksburg, Virginia, 2006.

[3.] Wang, J. S., Knipling, R. R., and Goodman, M. J., The role of driver inattention in crashes: New statistics from the 1995 Crashworthiness Data System, *40th Annual Proceedings of the Association for the Advancement of Automotive Medicine*, Vancouver, Canada, 1996.

[4.] Regan, M.A, Lee, J. D., and Young, K.L, *Driver Distraction: Theory, Effects and Mitigation.* Florida, United States: CRC Press, (In press).

[5.] Strayer, D. L., Drews, F. A., and Crouch, D. J., A Comparison of the Cell Phone Driver and the Drunk Driver, *Human Factors* 48 (2), 381, 2006.

[6.] Treat, J. R., A study of precrash factors involved in traffic accidents, Centre for Automotive Safety Research, Adelaide, 1980.

[7.] Stanton, N. A., Hierarchical task analysis: Developments, applications, and extensions, *Applied Ergonomics* 37, 55-79, 2006.

[8.] Stanton, N. A. and Baber, C., A systems approach to human error identification, *Safety Science* 22, 215-228, 1996.

[9.] Embrey, D. E., SHERPA: A systematic human error reduction and prediction approach, *The International Meeting on Advances in Nuclear Power Systems*, Knoxville, Tennessee, 1986.