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Driver distraction: Reflections on the past, present and future

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There is a large and converging body of evidence to suggest that certain activities, objects and events inside and outside the vehicle can, and do, distract drivers, leading to degraded driving performance, increased crash risk and crashes. This paper is a transcript of the opening Keynote Address given by the author at the International Conference on Driver Distraction held in Sydney, Australia, on 2 June 2005. The paper outlines recent and emerging technological developments and their potential impact on the driving task, including their potential to distract drivers. The paper then focuses on what is known more generally about driver distraction, what it being done to manage it, and what ought to be done in Australia to limit its impact on driver performance and safety.

Introduction

Five years ago I submitted to one of our transport safety authorities here in Australia - that shall remain nameless - a proposal for funding to undertake research on driver distraction. The proposal was rejected. At the time driver distraction was barely on the Australian road safety radar scope and there were other safety issues perceived at the time as being of higher priority. It is pleasing, then, that in Australia, the time is finally right to hold a conference on this important topic.

It is important from the outset to put distraction, and indeed this conference, into perspective. A fighter pilot probably wouldn't understand why we are here today. The primary control task for a fighter pilot is to fly the plane, and what we might regard as distracter tasks, such as monitoring for and defeating enemy threats, are for the pilot just part of the job. Fighter pilots are carefully selected for their jobs - only people who are superior at performing two or more tasks at the same time are chosen to fly. Not only that, they are given proper training in how to effectively multi-task - because we know that training and practice can improve our ability to resist distraction. If during the design of a fighter aircraft, it is determined that all of the tasks that have to be performed—even with automation—are too much for one pilot to cope with, then the aircraft is designed for two pilots, so that what we might regard as the distracter tasks can be shared or delegated to the co-pilot or navigator.

The point I am making is that we are here today because we have a totally different mindset about distraction in the road safety domain. The mindset of the vehicle manufacturer is that control of the vehicle should be in the hands of the driver only. The mindset of the driver is that the passenger is a back seat driver rather than a co-pilot, even though the passenger has an extra set of eyes, ears and hands. The mind-set of the road safety community is that driving means looking out for hazards, navigating to a destination, and controlling the vehicle. But that's just the way it is now. Already, cars have been developed that can drive themselves. It may be that we need to redefine in future what we mean by "driving".

In short, driver distraction would not be a problem if the motor car was specifically designed for two-crew operation, if drivers and passengers were trained in how to operate as a team, and if the passenger shared or was delegated tasks which are secondary to driving. But that is not so, and that is why we are here today.

I'd like to start this presentation by outlining some recent and emerging developments in vehicle technology and their potential impact on the driving task. I will then focus, in particular, on driver distraction - on what we know about it, what we are doing about it, and what we ought to be doing about it in Australia.

New vehicle technologies

In recent years, the motor vehicle has undergone some major transformations. For the most part, these have been invisible to the driver and the cockpit itself has remained largely the same. All of that is starting to change, however, and this is being driven by the migration into the cockpit of a range of new technologies (Regan, 2004a; Regan, 2004b). These can be categorized as entertainment systems, information and communications systems and advanced driver assistance systems, although the boundaries between the categories are becoming increasingly blurred. I'll consider each of these in turn.

Entertainment Systems

The car radio has now been augmented by a range of new entertainment systems. These include cassette players, Compact Disk - or CD - players, video, television and DVD players. In addition to factory-fitted systems, there is an emerging trend towards the provision of entertainment services to the driver though portable devices such as the mobile phone or Personal Digital Assistant - or PDA. In the United States, Europe and Japan, for example, information about the nearest restaurant, the latest movie, or other sources of entertainment can be obtained from one or more of these devices, which can be brought into the vehicle.

Information and Communication Systems

Information and communication systems represent the second category of devices entering the vehicle cockpit. These are usually referred to as "telematics" devices. Mobile phones have been used in the vehicle cockpit now for over a decade. More recently, however, we have seen a wider range of communications systems and services enter the cockpit. These include text messaging, video messaging, internet, email, and fax facilities. Some of these devices are being built into vehicles as factory-fitted units, whilst some are being offered as services which can be accessed through portable devices such as mobile phones and PDAs.

So-called "plug and play" products are also becoming available as aftermarket devices. These employ "open architectures" which allow portable devices carried into the vehicle to interact with other devices installed in the vehicle. Wireless communication technologies like Bluetooth ™, for example, will allow vehicles to access files and display information from nearby portable devices such as mobile phones, PDAs and lap top computers.

Emerging information and communication systems will be able to advise drivers of the quickest route to take when their normal route is congested, and how long it will take to reach their destination. They will also allow drivers to *remotely* turn on and off the lights, heating, appliances, watering system and garage doors in their house, to check the weather in the area they are driving into, to check if there is still a spot left in the early bird car park, and to find the nearest petrol station. A prototype vehicle system with these and other

features (known as the AT Signature Project) has already been developed here in Australia by Holden and other industry partners, and will be demonstrated at this conference.

Advanced Driver Assistance Systems

Advanced Driver Assistance Systems - or ADAS - represent the third main class of telematics technology entering the vehicle cockpit. These form a sub-set of a broader category of systems known as Intelligent Transport Systems (ITS).

ADAS – Crash Prevention

Most Advanced Driver Assistance Systems have been developed as safety systems. These warn drivers, via visual, auditory, and/or tactile displays inside the vehicle, if they are driving in an unsafe manner. Some of these are designed to prevent crashes from occurring. These include systems which warn the driver:

- if they are exceeding the speed limit;
- if they are following a vehicle ahead too closely;
- if they are about to collide with vehicles, objects or pedestrians in front of them, behind them when reversing, in their blind spots, when merging or changing lanes, or when driving through or turning at intersections;
- if they are about to drive off the roadway; and
- if they are falling asleep.

ADAS – Trauma Minimisation

Other Advanced Driver Assistance systems are designed to minimize the trauma to occupants if a crash occurs. These include systems which:

- remind drivers and their passengers to fasten their seatbelts, or prevent the vehicle from being started if someone is unbelted; and
- warn the driver if he/she is exceeding the speed limit - or exceeding lower speeds if weather and traffic conditions are poor.

ADAS – Comfort

Finally, some Advanced Driver Assistance Systems have been designed primarily as driver comfort systems, although they have some secondary safety benefits:

- Adaptive Cruise Control (ACC) systems, for example, automatically increase the following distance to the car ahead if the cruise control in your own vehicle is set to a speed that is faster than the speed of the vehicle ahead; and
- Route Navigation Systems allow the driver to program in a destination address, following which the system issues turn-by-turn instructions - both voice and visual map-based instructions - until the destination is reached.

The systems I've described that are capable of warning the driver of danger can be made to go a step further - to take control of the vehicle if the driver fails to heed warnings. Collision warning and avoidance systems, for example, have been developed to automatically brake the vehicle if the system predicts that a forward collision is imminent. These have been trailed in the United States, Europe and Japan. Intelligent Speed Adaptation (ISA) systems, trailed in Europe, can automatically limit vehicle top speed to the signed speed limit.

ADAS - Configurations

Advanced Driver Assistance Systems can be configured in different ways. Some systems, like route navigation, can be self-contained within the vehicle. Others, such as intersection collision warning systems, rely on road-side sensors - such as cameras and radars - to detect vehicles approaching the intersection and transmit this information, via in-car

displays, to each of the drivers on a collision course. Alternatively, each car can be equipped with transmitters, Global Positioning Systems and receivers that enable it to signal to another car, via on-board displays, that they are on a collision course. These are currently operating in parts of Japan. Services can also be accessed whilst driving through a portable device, such as a mobile telephone or a PDA. In Australia, for example, you can now use your PDA as a route navigation system. Finally, some Intelligent Transport Systems, such as Variable Message Signs, can be located on the roadside to warn drivers about imminent hazards - such as fog, slippery roads, or a crash ahead - without direct physical communication with the vehicle.

Summary
In summary, many new technologies exist and are being developed to make drivers safer, of entertaining them, of providing them with information, and of enabling them to communicate with virtually anyone in the world whilst on the move.

Very little is known, however, about how drivers do—and will—use and adapt to these technologies over time (Regan, 2004c). Will they use them in the manner intended by system designers? Will drivers understand the technological limitations of emerging systems? Will they become over-reliant on them? And if so, what happens if the system fails? As vehicles become more automated, and drivers have less to do, will they engage even more in secondary task activities such as using mobile phones? Or will automation have the opposite effect of sending the driver to sleep? In the very near future, Australian drivers will receive information from conventional road signs, electronic road signs, entertainment systems, information and communication systems and Advanced Driver Information Systems – from both inside and outside the vehicle, and from a range of portable devices, such as the mobile phone. This information will be able to be presented anywhere, in any language, at any time, and via visual, voice and even tactile displays. The potential benefits of these technologies will be undermined, however, if the information they display - and the mental and physical operations they require - overload, distract or confuse the driver.

The wave of new technologies entering the vehicle cockpit can affect driver performance and safety in a variety of ways. Distraction is just one by-product of the information and communications revolution - but it is an important one because it is the only one so far to emerge as a road safety issue. On top of all this there is a range of other everyday activities, such as eating, drinking smoking, chatting to passengers - and even having sex - which can distract the driver (see Young, Regan, & Hammer, 2003, for a review). I do a lot of talk back radio so I know what goes on out there.

I'll turn now to what we know about distraction, what we are doing about it, and what we should be doing about it.

What is driver distraction?

Everyone talks about driver distraction as if they know what it means, but it is a concept that is very poorly defined in the literature and there has been very little modeling of the factors that underlie it.

Distraction occurs when a driver engages, willingly or unwillingly, in a secondary activity which interferes with performance of the primary driving task. The human brain has a limited supply of attention. We can perform two tasks at the same time - without one degrading performance of the other - only if the tasks demand no more than the limited

supply of attention. In addition, they must be as dissimilar as possible. Driving a car (which is a visual/manual task) and having a conversation with a passenger (which is an auditory/verbal task) are dissimilar tasks. So, provided the traffic is light and the conversation is simple, the two tasks can be combined with relative ease. If an unexpected traffic event occurs, however, the driver will usually stop talking because the combined demands of the tasks are too high. Similarly, if the conversation becomes too complex, driving performance will suffer.

We can differentiate between four types of distraction:

- visual - visual distraction occurs when drivers look at, say, a route guidance map display instead of the road;
- attentional - attentional distraction occurs when people take their minds off the road, such as when listening to a passenger conversation or simply day dreaming;
- physical - physical distraction occurs when the driver holds a device, such as a mobile phone, rather than steering with both hands. It also occurs if rotating a radio control, say to increase the volume of your radio, causes you to rotate the steering wheel in the same direction; and
- auditory - auditory distraction occurs if a device, like a CD player, is turned up so loud that is "masks" other sounds, like ambulance sirens.

Attentional distraction usually accompanies most other forms of distraction.

Sources of driver distraction

There are many things that can distract the driver. The US National Highway and Traffic Safety Administration has identified several main sources of driver distraction (Stutts et al., 2001). These include those deriving from inside and outside the vehicle, those deriving from vehicle technologies and those deriving from everyday activities that people perform in the cockpit:

- Eating/drinking
- Outside person/object or event
- Adjusting radio, cassette, CD
- Other vehicle occupants
- Moving object in vehicle
- Smoking related
- Talking/listening on mobile phone
- Dialing mobile phone
- Using device/object brought into vehicle
- Using device/object integral to vehicle
- Adjusting climate controls
- Other distraction
- Unknown distraction

Driver involvement in distracting activities

We know very little in Australia, however, about the extent to which our drivers engage in these potentially distracting activities. Most of what we know relates to mobile phone use, and even then we know very little.

Around eighty percent of Australians own mobile phones, but the exact number of drivers who use them whilst driving is not known. In one survey (Khadem, 2003), about a quarter of

drivers admitted to using a hand-held phone while driving, even though it is illegal to do so in Australia. About 30 percent of drivers in that survey admitted to sending text messages while driving, 15 percent of them regularly. In another study (Taylor et al., 2003), 2 percent of drivers in Melbourne were observed using hand-held mobile phones whilst driving, most of them young males.

In the United Kingdom, about 40 percent of drivers report that they use their mobile phone whilst driving, with the figure increasing to about 80 percent for high mileage drivers and company drivers. Around 10 percent of all drivers report that they use the mobile phone often, whilst around half of high mileage drivers say they use it often (Green Flag, 2000; cited in RoSPA, 2002). The same data also suggest that younger drivers are more likely to use mobile phones than all drivers, and that most drivers who use a mobile phone use a hand-held phone. In the United Kingdom, there is no ban, as far as I know, on the use of mobile phones whilst driving.

Interestingly, drivers in the United Kingdom seem to be aware of the potential dangers of using mobile phones. In two separate studies (RoSPA, 1997, Green Flag, 2000; cited in RoSPA, 2002), around 90 percent of drivers said that the use of hand-held phones should be illegal. Interestingly, though, only 50 percent said that using a hands-free phone whilst driving should be illegal. There is a perception in the United Kingdom, as I suspect there is here in Australia, that hands-free phones are safer than hand-held devices. In another United Kingdom study (MORI, 2001, cited in Direct Line Motor Insurance, 2002), drivers reported text messaging as being the most distracting activity they engage in whilst driving a vehicle.

In a recent United States study (Stutts et al., 2003), video and other recording equipment was installed in the vehicles of 70 drivers for a week in an attempt to determine how much time people spend engaging in the full range of potentially distracting activities. It found:

conversing	15.0%
manipulating vehicle controls	3.8%
prepare food/drink	3.1%
external distracters	1.6%
smoking	1.6%
eat, drink, spill	1.5%
manipulate music/audio controls	1.4%
dial/answer/talk mobile phone	1.3%
reading/writing	0.7%
baby distracting	0.4%
adult/child distracting	0.3%
grooming	0.3%

They found that drivers spent on average just over 30 percent of their time engaging in distracting activities, with most of the time spent talking to passengers, manipulating vehicle secondary controls and eating and drinking. The fact that drivers were videotaped might account for the relatively little time spent using a mobile phone. Virtually all the drivers adjusted vehicle secondary controls whilst the vehicle was in motion, around 80 percent conversed with passengers, and around 70 percent ate and drank.

Impact of distraction on driving performance

Various scientific methods have been used to study the impact of distraction on driver performance and safety. The main techniques that have been used, fall into three general categories. The first is performance studies, which include on-road and test track studies, driving simulator studies, dual-task studies, eye glance studies and the visual occlusion technique. Epidemiological studies and crash studies are the other two main methods used to study distraction. I'll talk briefly about each of these in turn.

Performance studies

Many performance studies have been conducted to determine to what extent using various entertainment, information, communication and advanced driver assistance technologies whilst driving affect driving performance. These have also examined distraction deriving from everyday activities, like eating.

Mobile Phones

The impact of the mobile phone on driving has been widely studied. A wide range of driving performances are adversely affected whilst using a mobile phone.

Collectively, these studies have shown that using a mobile phone whilst driving can:

- impair your ability to maintain the correct lane position;
- impair your ability to maintain an appropriate and predictable speed;
- result in longer reaction times to detect and respond to unexpected events - one study (Burns et al, 2002) found that reaction times were 50 percent slower as a result of using a mobile phone, but only 30 percent slower when the driver had a blood alcohol concentration of 0.08;
- result in drivers missing traffic signals;
- reduce the functional visual field of view, which has been shown to be correlated with increased crash involvement;
- result in shorter following distances to vehicles in front;
- result in people accepting gaps in traffic streams that are not large enough;
- increase mental workload, resulting in higher levels of stress and frustration;
- encourage people to look straight ahead rather than scanning around the road ahead; and
- reduce drivers' awareness of what is happening around them in time and space.

Importantly, there is significant evidence that the use of both hand-held *and* hands-free phones whilst driving degrades performance. The physical act of holding a mobile phone appears to have little effect on steering control unless an unexpected event occurs that requires the use of both hands.

Only two published studies I know of have investigated the impact of text messaging on driving. A Swedish simulator study (Kircher et al, 2004) found that *retrieving* text messages increased braking reaction times to a motorcycle hazard, but little else. The findings from a recent MUARC simulator study (Hosking, Young & Regan, 2005), which will be reported at this conference by the NRMA, found that both retrieving *and* sending text messages adversely affects driving performance.

Other Technologies

Few other technologies have been studied in such detail.

Navigation systems

One exception is the route guidance system, as it has been in production vehicles for about a decade. Drivers simply program into these systems the address they wish to travel to, and the system issues turn-by-turn instructions on how to get there - usually voice instructions .like “in 100 metres turn left”. Most systems also display the same information visually on a display in the vehicle.

Generally, these systems have been shown, if well designed, to reduce mental navigation workload and the distraction associated with using paper maps and street signs to navigate. However, these systems are distracting if they allow drivers to enter destination information while the vehicle is in motion and if they provide visual guidance, especially complex guidance information, without any accompanying voice guidance. Even systems that allow the driver to enter destination information using their voice rather than manually have been shown to be distracting (see Young & Regan, 2005; Regan et al., 2001, for a review). The worst designed route navigation systems, however, are usually only marginally more distracting than conventional navigation using paper maps. The best systems incorporate a lock out feature which prevents the driver from entering a destination whilst the vehicle is in motion or travelling above a certain speed.

Email

A couple of studies have examined the effects on driving performance of retrieving, reading and responding to email messages. In one (Lee et al., 2001), drivers used voice commands to accomplish these activities whilst driving in a simulator. It was found that, even the requirement to issue voice commands and listen to the email, led to a 30 percent increase in reaction times to a braking lead vehicle and an increase in subjective estimates of mental workload. In a follow up study (Jamson et al., 2004) it was found that drivers adopted longer headways to compensate for the increased workload, but were again slower to brake in response to a braking lead vehicle and made less corrective steering movements when distracted. Interacting with email was less distracting when drivers had control over when they were opened.

Entertainment Systems

Entertainment systems have also been examined. Here, the main focus has been on the effects on driving performance of interacting with radios, cassette players, CD players and, more recently, DVD players.

Radios

A few studies have examined distraction deriving from the use of car radios. One found that drivers spent more time looking away from the road when tuning a radio than when dialing a mobile phone, which adversely affected lane control (Wilkman et al., 1998). In one of our own studies at MUARC (Horberry et al., 2003), we found that tuning the radio resulted in increased subjective estimates of workload, degraded speed control and delayed responses to unexpected hazards. Even listening to a car radio has been shown to degrade lane-keeping performance (Janke et al, 1994).

CD Players

Selecting, inserting, listening to and ejecting CDs whilst driving has also been examined. Generally it is found that these activities result in poorer lane keeping ability, more glances away from the road and greater variation in speed control than dialing a mobile phone.

DVD Players

Very little research has been done on how interacting with DVD players affects driving. In Australia, it is illegal for manufacturers to install DVD screens anywhere in the vehicle where

they can be seen by drivers whilst driving, even drivers of other vehicles. However just because drivers can't see them doesn't mean they won't pay attention to them; and it is likely that using their ears to keep up with the plot will be more attentionally demanding than listening to a radio. The flip side, of course, is that these devices are great for parents if the children in the back seat can watch and listen to them with ear phones.

Portable Devices

There are many services becoming available that can be implemented on portable devices, such as lap tops, PDAs and mobile phones. No research I know of has been conducted to examine the potential for these devices to distract drivers whilst driving. The main problem with these devices is that they can be viewed from anywhere in the vehicle and, if they are poorly ergonomically designed, could demand dangerously high levels of vision and attention. The information displayed by the devices may also be incompatible with information displayed by other systems installed by manufacturers within the vehicle.

Everyday Activities

Drivers also engage in a range of everyday activities that have potential to distract them from the driving task. The main such activities they engage in are eating, drinking, smoking and talking to passengers.

Eating and drinking can cause visual, physical and attentional distraction, especially if there is a spill. One study found that eating a hamburger was as distracting as dialing a mobile phone using voice commands (Jenness et al., 2002).

Smoking has the potential to be visually and physically distracting, and even attentionally distracting – although I haven't come across any studies that have specifically examined the impact of smoking whilst driving on performance.

The findings from studies which demonstrate that hands-free phone conversations are distracting for drivers imply that talking to passengers whilst driving should also be visually and attentionally distracting for the driver. Surprisingly, I have not come across any performance studies that directly confirm this. From first principles, however, it can be deduced that, for several reasons, conversing on a mobile phone will be more distracting than talking to passengers. First, passengers typically support the driver in self-regulating their driving performance - passengers often stop talking or tone down the conversation when they see that traffic conditions ahead are difficult for the driver. A person at the other end of a phone can't see what is going on around the driver. Secondly, there may be social imperatives to continue a conversation on a mobile phone, even though driving conditions don't warrant it. This might occur, for example, if the person at the other end of the phone is a business client. Finally, it is generally more difficult to hear and follow mobile phone conversations, because the reception is not always perfect and because you can't physically see the person you are talking to. A lot of communication between the driver and passenger is non-verbal.

External Distractions

So far I've talked about distractions deriving from within the vehicle. A US study (Stutts et al., 2001) has estimated, however, that about 30 percent of crashes where distraction is involved derive from outside the vehicle. Nevertheless surprisingly little research has investigated the effects of external distracters on driving performance and crash risk. One Australian laboratory study I am aware of has shown that distraction deriving from advertising billboards adversely affects the ability to detect peripheral hazards (Johnston & Cole, 1976), and a few studies have demonstrated that the presence of billboards is correlated with crash risk in some circumstances, but not others (eg Farbry et al., 2001).

One of my MUARC colleagues will present a paper during the conference that sheds further light on external distractions (Edquist, Horberry, Regan & Johnston, 2005).

Epidemiological studies

While performance studies provide information about the effects of distraction on driving performance, they do not take into account exposure. The degree to which a secondary activity adversely affects driving performance depends not only on how distracting it is in absolute terms, but whether a driver actually engages in the activity whilst driving, when they engage in it, how often they engage in it, and for how long they engage in the activity. Whilst talking to a passenger might not be as distracting, for example, as talking on a mobile phone, people spend relatively more time talking to passengers that may be more risky in the long term. Epidemiological studies have attempted to take into account driver exposure to a range of potentially distracting activities, and to quantify the level of risk associated with engaging in those activities.

There have been few such studies in the field of driver distraction, and virtually all have focused on mobile phone use.

The general finding to date is that using a mobile phone whilst driving increases crash risk by anywhere between 4 and 6 times, regardless of whether the phone is hand-held or hands-free, and that the risk is greater for young novice drivers. That is about the same increase in risk as driving with a Blood Alcohol Concentration (BAC) of 0.08.

There is evidence from epidemiological research that smokers and young novice drivers who carry their peers as passengers, are also at increased risk of crashing. Young novice drivers appear to be up to 5 times more likely to crash if they carry two or more friends as passengers (see Williams, 2001; Regan & Mitsopoulos, 2001, for reviews). Smoking has been found to increase crash risk by up to 1.5 times (Brison, 1990). In both cases, distraction has been cited as a contributory factor.

Crash studies

It is difficult to quantify the number and proportion of crashes attributable to distraction. The main problem for crash studies, as for epidemiological studies, is that it is rarely recorded on accident report forms whether or not a driver was engaging in a distracting activity – and even where provision is made to do so, drivers may not admit that they were doing so. Crash data from the National Highway Traffic Safety Administration in the US indicate that about 25 percent of all crashes are the result of inattention (Wang et al., 1996), with about half of these thought to be attributable to distraction. A recent US study estimates that crashes relating to mobile phones contribute to nearly 3,000 deaths and over 300,000 injuries per year (Cohen & Graham, 2003).

A recent US study examined detailed crash records from the Crashworthiness Data System between 1995 and 1999 (Stutts et al., 2001). Of the crashes examined, about 8 percent were claimed to be caused by the driver being distracted by some event, object or activity inside or outside the vehicle. The study categorised the sources of distraction contributing to these crashes as follows:

Distraction Source	Contribution
Outside events	30%
Tune radio/cassette/CD	11%
Vehicle occupants	11%
Moving object ahead	4%
Device/object brought into vehicle	3%
Adjust climate controls	2%
Eating and drinking	2%
Using/dialing mobile phone	2%
Smoking-related	1%
Other distractions	26%
Unknown distraction	9%

As you can see 30 percent derived from outside the vehicle and interacting with entertainment systems and conversing with passengers, seem to be the sources of distraction inside the vehicle that contributed most to crashes. I suspect that in this study there was significant under-reporting of mobile phone use as a contributing factor given that it is now illegal to use hand-held phones in many jurisdictions in the US.

In Australia, 30 drivers in NSW were killed or injured between 1996 and 2000 in crashes where a hand-held phone whilst driving was a contributing factor (Lam, 2002). While this represents less than 1 percent of all drivers killed, it is likely to be an underestimate as it was derived by police at the accident scene from injured drivers, passengers and other witnesses. Also, it does not relate to hands-free phone usage.

My estimate, taking into account all the available evidence, is that between 10 and 15 percent of crashes in Australia are attributable to driver distraction of one kind or another.

Summary of findings

So what can we conclude from all this information? Certainly there is a large and converging body of evidence to suggest that driver distractions of various kinds can and do degrade driving performance, increase crash risk and cause crashes. Ranking the degree of degradation, however, that different activities have on the driving task, from the most to least, is not an easy task for several reasons. However, if I had to make an educated guess, based on all the available evidence, I'd probably rank distractions deriving from within the vehicle - from most to least - as follows:

- internet/email (when widely available)
- mobile phone – text messaging
- mobile phone – talking (hand-held and hands-free)
- DVD (if portable and poorly located)
- talking to passengers (if driver is young/older)
- route navigation (if poorly designed)
- radio/cassette/CD
- climate controls
- eating/drinking
- smoking

It is difficult to know where to rank external distractions on such a list, given how little we know about them. Also missing from the list are portable devices, like mobile phones and PDAs, that can be used for other applications, such as route navigation. When these are more widely available, I consider that they would be somewhere at the top of the list.

There are further trends that emerge from the literature on driver distraction (see Young & Regan, 2005).

There is evidence that people are miscalibrated - that they grossly underestimate or sometimes even over-estimate the effects of distraction on their driving performance.

People appear to attempt to self-regulate, according to the demands of the driving task, the device they are using, and their own capabilities, when performing secondary tasks whilst driving. For example, a number of studies have shown that drivers compensate for the additional mental workload imposed by talking on a mobile phone by slowing down or increasing following distances. Obviously, though, this self-regulation is not always effective. At a higher level, older drivers have been found to self-regulate by generally not using mobile phones at all.

There is evidence that both young novice drivers and older drivers (55 and over) are, for different reasons, more vulnerable to the effects of distraction. Young novice drivers are more vulnerable because they have not yet automated many driving activities, and hence have less spare attentional capacity to devote to secondary tasks. They are also probably less effective in self-regulating their driving performances across tasks. Older drivers, on the other hand, require more glances at mobile phones and other devices to read information, require more time to complete tasks, require more time to move their eyes between the road and displays inside the vehicle, and have less attention to distribute between competing tasks.

Even in drivers of the same age and experience cohort, there are individual differences in the ability to simultaneously drive and use a mobile phone. Some people, it seems, are better able than others to do two things at once – to perform the two tasks together in a manner which minimizes the distracting effects of the mobile phone.

There is some evidence that training and practice can reduce, to some degree, the distracting effects of mobile phones.

Finally, and perhaps most importantly, it must not be forgotten that there is a flip side to distraction. Most advanced driver assistance systems are predicted to have significant safety benefits. Our own research at MUARC has clearly demonstrated this. Mobile phones can, and do, provide important safety benefits. Mobile phones and radios have been used for years by truck drivers to keep them awake. They also allow users to summon help or report accidents. They provide a wide range of important societal and work benefits.

The status quo

In Australia, we are doing very little at present, relative to other developed countries, to address the issue of driver distraction.

Australian Road Rule 300 bans the use of hand-held phones and as far as I know all Australian States have incorporated this Rule into their road safety legislation. The only other country I know of that has enacted the same legislation and evaluated its effectiveness

is Japan, which has reported a 53 percent reduction in the number of injury crashes involving a driver using a mobile phone 12 months after the legislation was introduced (RoSPA, 2002).

Australian Road Rule 299 prohibits TV screens and video display units from being seen by drivers whilst the vehicle is in motion, or stationary but not parked - and the device must not distract other drivers who are nearby.

Australian Design Rule 42 (Section 18) states essentially the same thing as Road Rule 299.

Other than that, police officers have discretion under their own State legislation to reprimand drivers who they think are driving carelessly or dangerously as a result of being distracted. Section 65 of the Victorian Road Safety Act contains such a provision for careless driving, but it appears to be used rarely for this purpose.

At the national level, The Australian National Road Safety Action Plan for 2005/2006 notes the accumulating evidence regarding the potentially distracting effects of hands-free phones and the need to monitor research on the topic and encourage the development of vehicle fleet policies that prohibit the use of devices that distract drivers.

Generally, little has been done in Australia to educate the public about the relative risks associated with distraction. Compared to the United States, Canada, Europe and Japan, governments here have invested relatively little - indeed almost nothing - on distraction research.

One of Australia's local vehicle manufacturers - Holden - has been proactive, however, in obtaining from the Federal government significant funding to set up a Cooperative Research Centre for Advanced Automotive Technology that will, among other things, undertake fundamental research to develop and refine vehicle technologies that limit driver distraction through effective ergonomic design. MUARC will be actively involved in those activities. The car industry, here and overseas, is certainly aware of the key issues and has been more active than other stakeholders in addressing the issue.

The future

There is a lot that we can do to prevent driver distraction from becoming a major road safety problem in Australia based on what is already known.

Data

The current lack of accident data in Australia is preventing an accurate assessment of the number of people being killed and injured in crashes attributable to distraction. Police report forms, therefore, need to be amended to record data about distracting activities. Most new vehicles are equipped with event data recorders which could also be used to automatically record information about the use of telematics systems, for example, what information was displayed and what controls were being operated just before and during a crash. This would help to clarify the role of these devices in crashes.

In the meantime, regular exposure surveys need to be developed, administered and analyzed to determine what, when, where, why, and how drivers engage in distracting activities. These are already undertaken in Australia to monitor a wide range of other risk factors, such as speed.

Education

Governments, Police, motoring clubs and other relevant agencies should conduct education and publicity campaigns to raise public awareness of the relative dangers associated with engaging in distracting activities, how to minimize the effects of distraction on themselves and others, and the penalties associated with engaging in distracting activities where these exist. Transport authorities in other countries, for example, provide advice on their websites about the safe use of mobile phones and other devices. As a matter of priority, it is important that the Australian public be made aware that text messaging is potentially more dangerous than using a hand-held phone, and that hands-free phones are just as risky as hand-held phones. The immediate focus should be on those groups most vulnerable to the effects of distraction.

Training

Learner drivers need to be trained in how to safely manage distraction: it needs to be determined at what stage in their training it is best to start being exposed to distracting activities, such as talking to passengers; they need training in how to optimally self-regulate their driving to reduce the effects of distraction; they need training in the optimal modes in which to program and interact with systems - both on-board systems and portable devices carried in and out of the vehicle - which create the least potential for distraction; they need to be made self-aware and calibrated, through training, of the effects of distraction on their driving performance; and passengers need to be trained in how to act as co-pilots rather than backseat drivers by doing things for the driver and behaving in a manner which minimizes distraction. We should be thinking about team training, not just driver training.

Legislation

There is currently very little regulation in Australia governing the design and use of vehicle technologies that have potential to distract the driver. There is a need to review the existing legislation and, where necessary, to create new legislation to limit driver exposure to distracting activities.

Regulatory measures currently being considered by Transport Canada (2003), for example, include regulations that:

- require manufacturers to follow a specified driver-system integration process when designing and testing new technologies to ensure that ergonomic design issues are properly addressed during the design process;
- require all devices known to be highly distracting – for example manual destination entry for route guidance systems – to be automatically disabled when a vehicle is in motion or travelling above a certain speed;
- require manufacturers to adhere to some or all of the performance requirements specified in North American, Japanese and European human factors and ergonomics guidelines for the design of telematics systems;
- prohibit or limit open system architectures, re-configurable interfaces and the design and number of functions available through multifunction devices; and
- finally, regulations that could be introduced that specifically prohibit the installation of devices known to adversely compromise safety - or, alternatively, ban drivers from using such devices (as is currently the case in Australia with respect to hand-held mobile phones). There is, in my view, sufficient evidence to support a ban on the use of hands-free mobile phones, especially by young novice drivers, if this is enforceable.

Vehicle Design

Other than preventing drivers from being distracted, the most effective way to reduce driver distraction deriving from technologies is to ensure that the human machine interface within the vehicle is designed ergonomically - by both vehicle manufacturers and the manufacturers of portable devices brought into the vehicle. Research has shown, for example, that dialing telephone numbers using voice commands is less distracting than manually dialing the same numbers.

In Australia we rely on industry to develop and apply voluntary safety standards for the ergonomic design of cockpit technologies and, as mentioned, vehicle manufacturers here and overseas are becoming more focused on ergonomics as a critical design criterion. The problem with this voluntary approach is that many ergonomic standards, even if industry were aware of them, still allow for some unduly distracting tasks to be carried out by drivers whilst driving and don't ensure that all features of in-vehicle telematics devices are safely integrated into the driver-vehicle system.

To resolve this problem, we could follow Canada's example. Transport Canada (2003) is entering into a Memorandum of understanding with industry that ensures that systems entering the market will meet certain minimum requirements. You will hear more about this during the conference. This is a practical approach which involves a number of voluntary commitments by industry:

- to comply, in designing their products, with best practice human factors and ergonomic guidelines and standards;
- to limit the implementation of open architectures for portable devices brought into the vehicle, and limit the degree to which devices offer re-configurable displays and controls.
- to design their event data recorders to record information about the use of telematics systems; and
- to implement and adhere to a driver-system integration process which, like ISO quality standard 9001, would identify the key ergonomic processes that a manufacturer should incorporate during the design and development process to address safety and driver-system integration issues relating to distraction. Such integration process documents have already been developed in the military and software development domains.

It is important that such an approach involves consultation with all relevant stakeholders - drivers, vehicle manufacturers, aftermarket system suppliers, information service providers and road authorities.

Transport Canada (2003) is also supporting the development of procedures and standards for testing the level of distraction imposed by new technologies, and working with stakeholders to develop tools and techniques for measuring driver distraction and defining criteria and limits on distraction from new devices.

Unfortunately, even the best designed human-machine interface may not solve the distraction problem because a well-designed device that reduces distraction might encourage drivers to use it more frequently while driving. This has been referred to as the "usability paradox" (Lee & Strayer, 2004). Ultimately, as I said at the beginning of this presentation, two-crew design and operation of the motor car might be the only way to limit the impact of driver distraction whilst at the same time allowing drivers to enjoy the safety, mobility and comfort to be derived from emerging technologies.

A promising development is the “workload manager”, an on-board technology that uses vehicle sensors to estimate driver workload and suppress mobile phone calls and other sources of distraction until driver workload reduces. Some rudimentary systems already exist in production vehicles overseas.

Road Design

The findings reviewed here suggest that distractions deriving from outside the vehicle are significant in number and type, yet very little is being done around the world to address this issue. There is a need to develop a taxonomy of those objects, events and activities which are potential sources of distraction outside the vehicle and to determine to what extent drivers are exposed to these. There is a critical need, as more and more traffic information is displayed inside the vehicle cockpit, for vehicle manufacturers to enter into dialogue with traffic engineers - to ensure that there are no incompatibilities in the design, timing and number of traffic messages and signals impinging on the driver from within and outside the vehicle. Road safety audits, routinely undertaken in this country, should include criteria for the identification and ergonomic assessment of traffic management activities, objects and events that could distract drivers and degrade driving performance. As for vehicle design, there is a need for Memoranda of Understanding with industry, and between different tiers of government, to ensure that the traffic management system is designed ergonomically to limit the adverse effects of distraction.

Research

There are a number of priority areas for research on driver distraction. These will be discussed by one of my MUARC colleagues during the conference. Areas in which our knowledge base is particular scant are: knowledge of driver exposure to distraction; knowledge of the self-regulatory strategies that drivers use to cope with distraction; ergonomic design of the human-machine interface to limit distraction; the quantification of crash risk; the definition and measurement of distraction; identifying levels of performance degradation due to distraction that constitute safety impairment; and estimating the costs and benefits of regulatory approaches to management of the issue in this country. Notable is the relative absence of research on distraction deriving from outside the vehicle and the effects of distraction on the performance and safety of pedestrians, motorcycle riders and other road users.

Enforcement

Intelligent transport system technologies now exist that could significantly enhance the ability of Police to enforce traffic laws. For example, it should be possible to configure mobile phones so that they can only be used if the phone is travelling at less than a particular low speed, or when stationary.

It is also important to survey Police to assess their experience and views about the extent of existing powers to deal with drivers who engage in distracting activities that are known to compromise their safety and that of other road users.

Employers

Almost half the crashes on our roads occur when people are driving vehicles for work purposes. Guidance for employers to raise awareness amongst their staff of the dangers of engaging in distracting activities is therefore critical. The guidelines should explain to employers their legal responsibilities and potential liabilities, methods for collecting and analyzing data on the role of distraction in incidents and crashes, and policies that could be adopted by them and by drivers to limit the adverse effects of distraction. This would include information that stimulates them to purchase vehicle types and technologies that maximize safety and minimise distractions.

Licensing
Finally, handbooks for learner drivers can draw attention to the relative risks associated with engaging in distracting activities. Knowledge tests should include items pertaining to the relative risks associated with these activities and strategies for reducing their impact on driving. The graduated licensing system should be used to systematically expose young drivers to distracting activities that are known to compromise safety and to test for their ability to manage them.

Conclusion

In this presentation I have tried to give you a feel for the kinds of technologies and services that are finding their way into the vehicle cockpit. Whilst these have tremendous potential to enhance the safety, mobility and enjoyment of driving, they also have potential to distract drivers and compromise their safety. I have outlined a range of measures that can be taken to limit the potentially adverse effects of distraction. In managing driver distraction, however, we need to be sensible. It is impractical to ban people from engaging whilst driving in everyday activities, such as eating and drinking. We must also recognize that it is human nature for people to involuntarily succumb to some distracting objects, events and activities. We also need to recognize the positive benefits to users that derive from the various technologies entering the vehicle cockpit, which in most cases outweigh any disbenefits. We are, however, at an early enough stage in the evolution of the vehicle cockpit to prevent distraction from becoming a greater problem than it already is in Australia. It is important, as members of the road safety community, that we exercise our duty of care to our constituents.

Acknowledgements

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PRESENTATION SLIDES

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Driver Distraction: Reflections on the Past, Present and Future

Michael Regan, PhD
Senior Research Fellow
Monash University Accident Research Centre (MUARC)
Melbourne, Australia

International Driver Distraction Conference
Sydney, Australia, 2-3 June 2005

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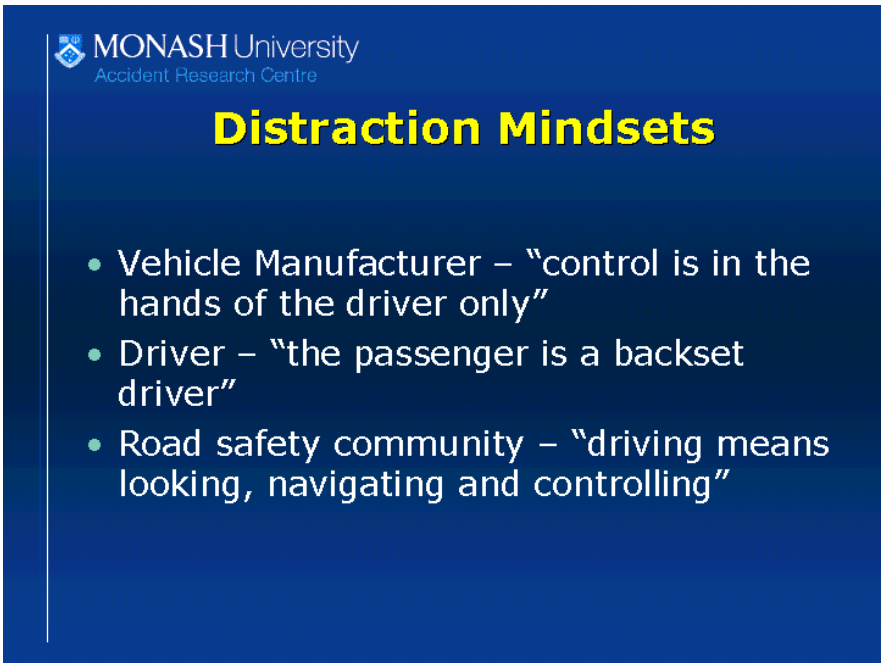
Involuntary Distraction

I didn't see the railing…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Distraction Mindsets
• Vehicle Manufacturer – "control is in the hands of the driver only"
• Driver – "the passenger is a backset driver"
• Road safety community – "driving means looking, navigating and controlling"


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Overview
• New vehicle technologies
• General impact on driving
• Driver distraction
• Conclusions

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New Vehicle Technologies

- Entertainment systems
- Information and communication systems
- Advanced driver assistance systems

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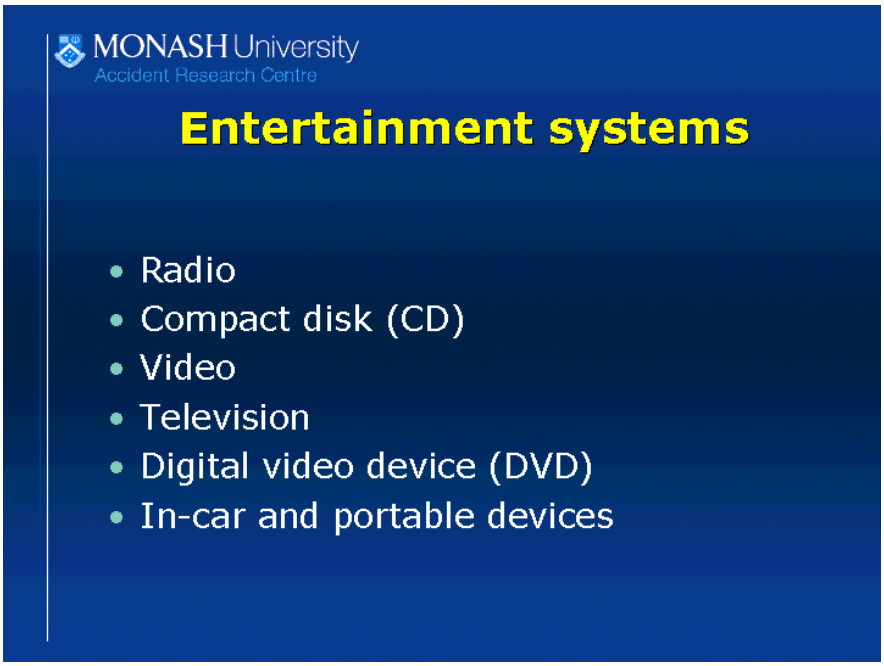
The Modern Cockpit

Information and communication at the touch of a button – but which button?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Entertainment systems
Radio
Compact disk (CD)
Video
Television
Digital video device (DVD)
In-car and portable devices


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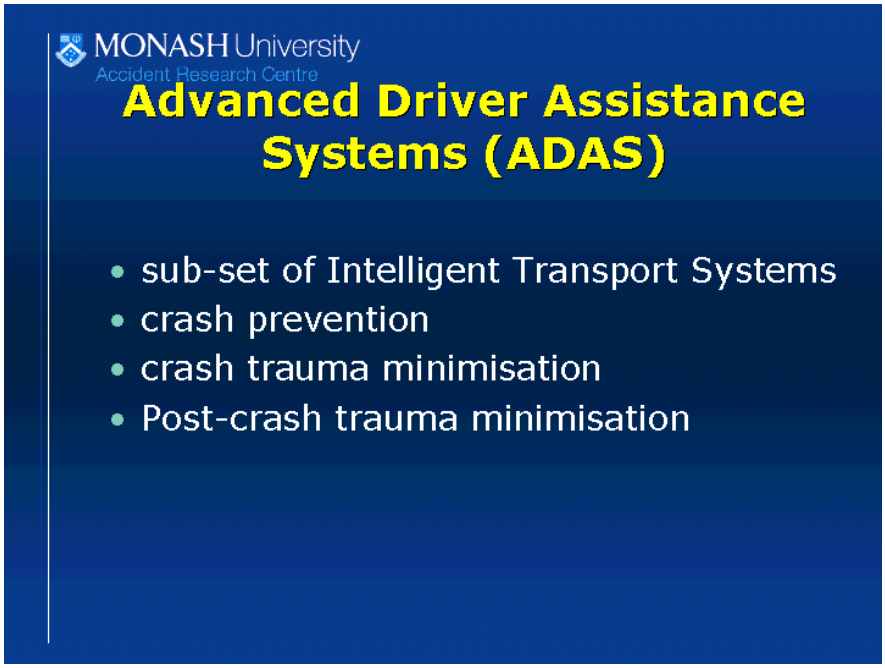
Information and Communication Systems
Speech messaging
Text messaging
Video messaging
Internet
Email
Fax
In-car and portable devices
Plug and play/open architectures
Endless possibilities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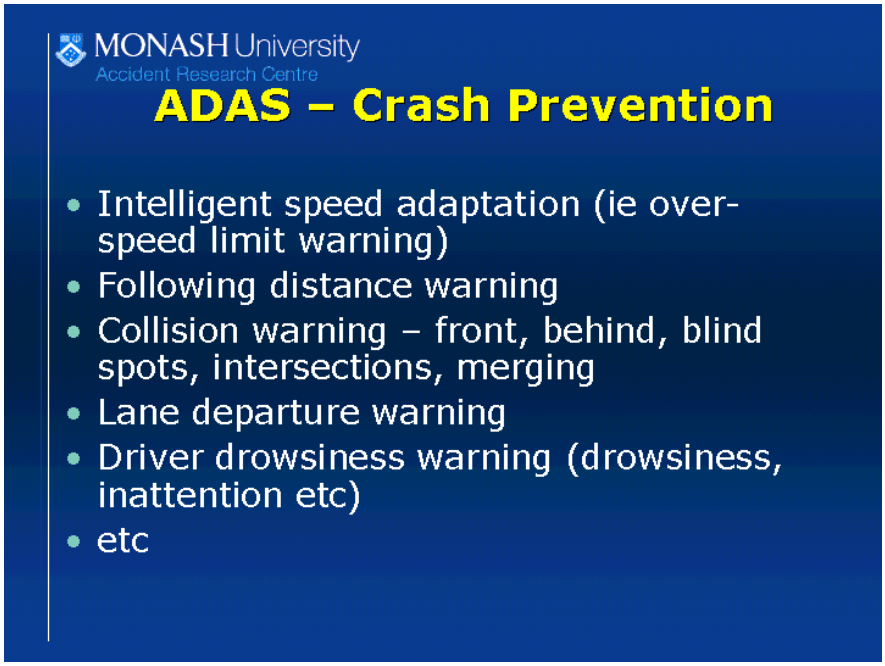
Advanced Driver Assistance Systems (ADAS)
• sub-set of Intelligent Transport Systems
• crash prevention
• crash trauma minimisation
• Post-crash trauma minimisation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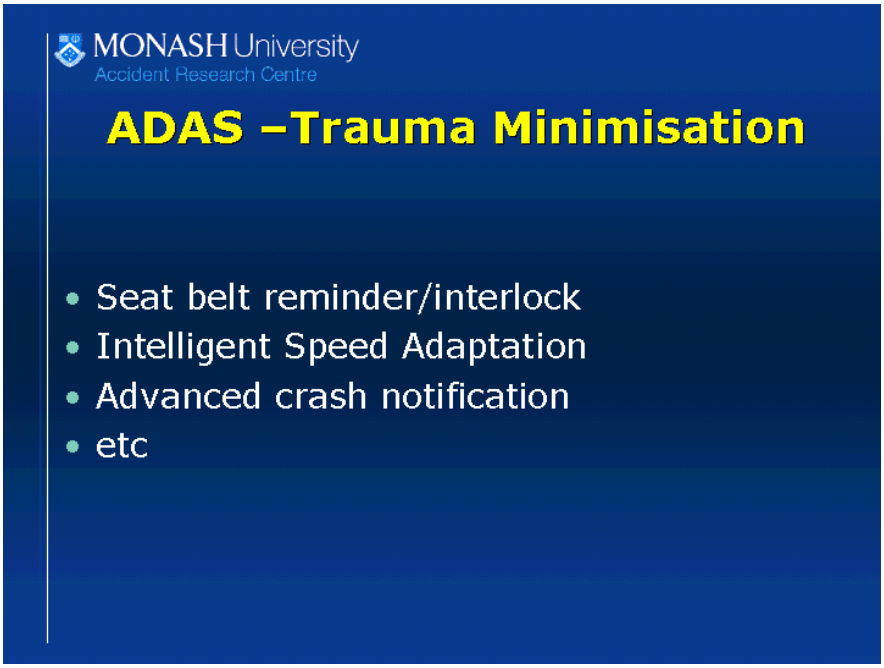
ADAS – Crash Prevention
• Intelligent speed adaptation (ie over-speed limit warning)
• Following distance warning
• Collision warning – front, behind, blind spots, intersections, merging
• Lane departure warning
• Driver drowsiness warning (drowsiness, inattention etc)
• etc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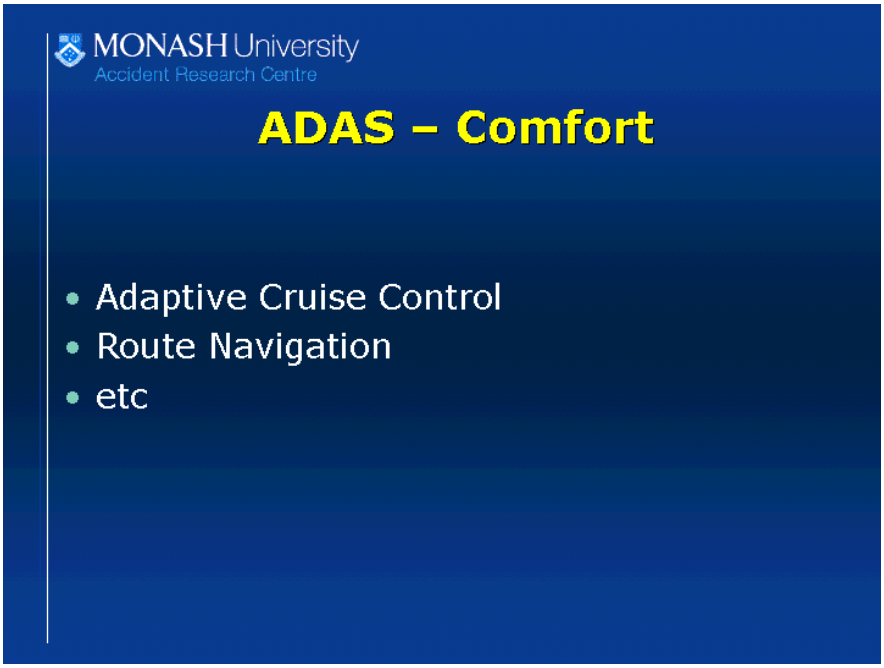
ADAS –Trauma Minimisation
Seat belt reminder/interlock
Intelligent Speed Adaptation
Advanced crash notification
etc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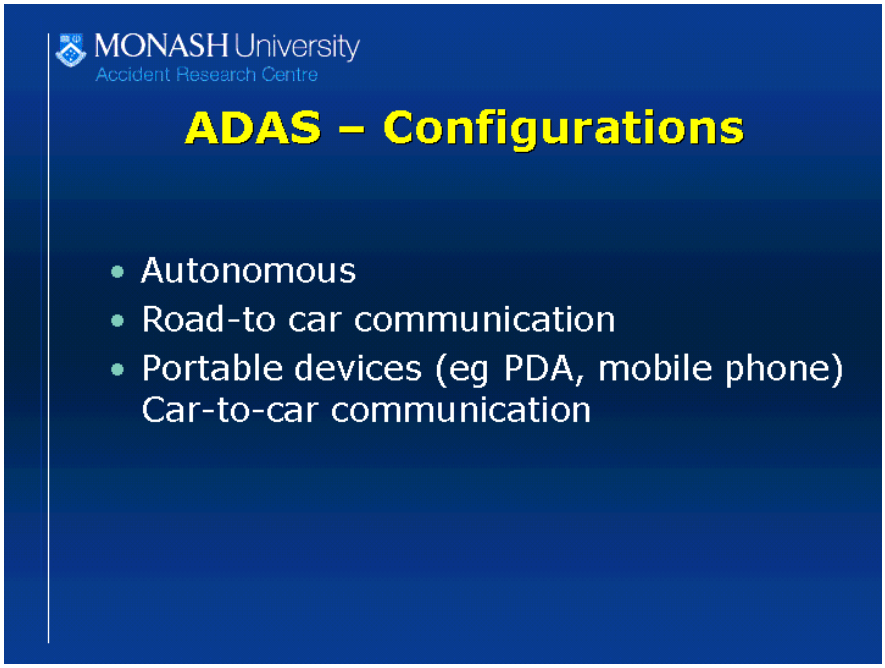
ADAS – Comfort
Adaptive Cruise Control
Route Navigation
etc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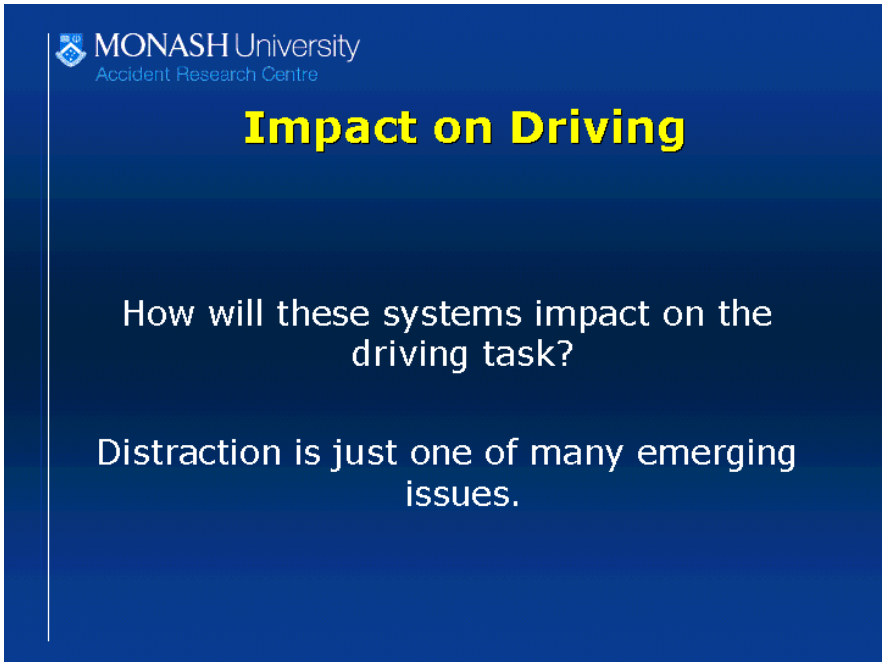
ADAS – Configurations
Autonomous
Road-to car communication
Portable devices (eg PDA, mobile phone) Car-to-car communication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Impact on Driving
How will these systems impact on the driving task?
Distraction is just one of many emerging issues.

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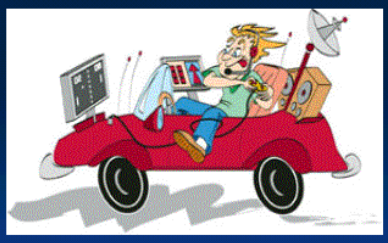
The Distracted Driver

If only I had a bigger car……and brain



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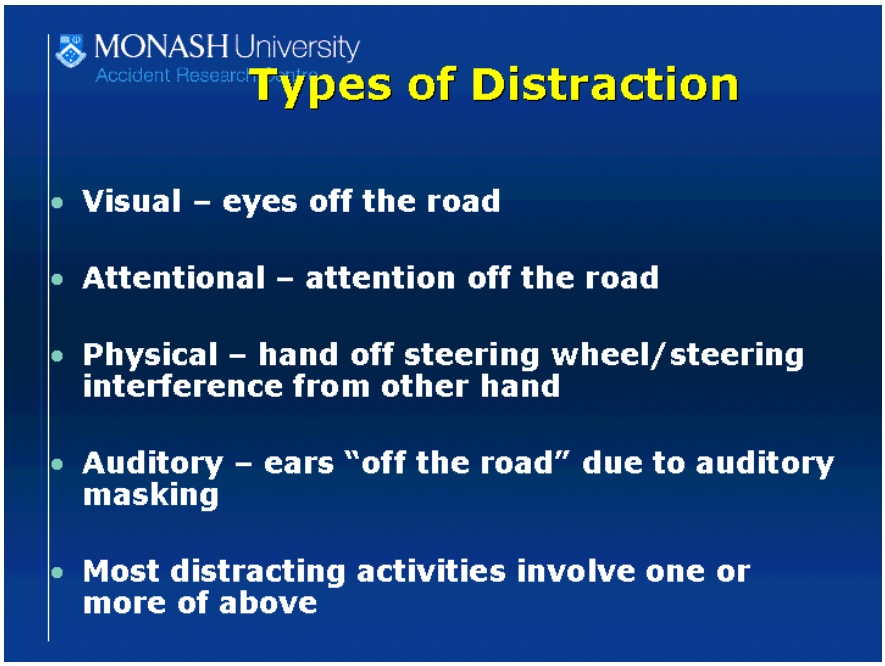
Distraction – A Definition

"Occurs when a driver engages, willingly, or unwillingly, in a secondary activity which interferes with performance of the primary driving task"

(Regan, 2 June 2005).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Types of Distraction
Visual – eyes off the road
Attentional – attention off the road
Physical – hand off steering wheel/steering interference from other hand
Auditory – ears "off the road" due to auditory masking
Most distracting activities involve one or more of above


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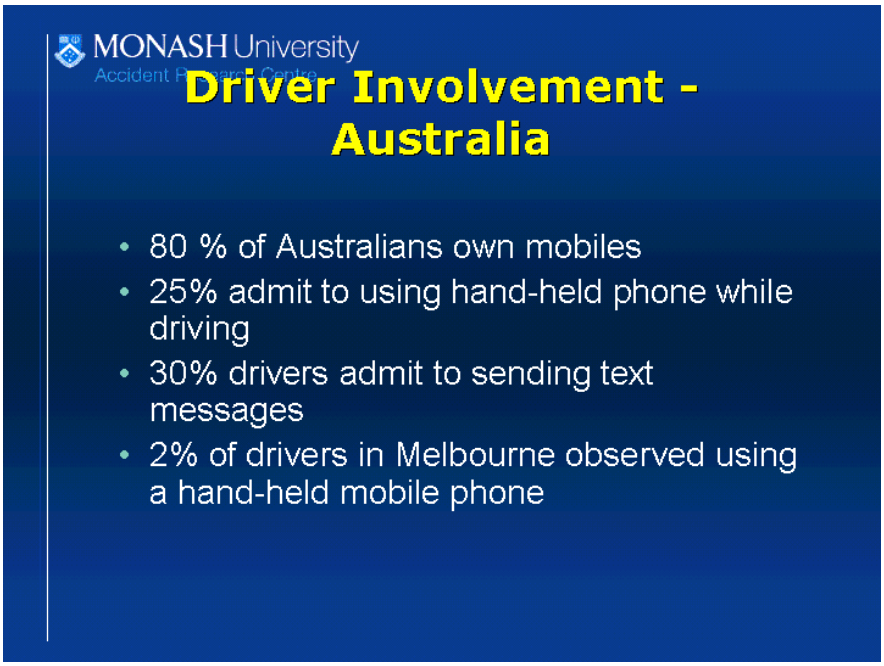
Sources of Distraction
Eating/drinking
Outside person/object or event
Adjusting radio, casette, CD
Other vehicle occupants
Moving object in vehicle
smoking related
Talking/listening on mobile phone
dialling mobile phone
using device/object brought into vehicle
using device/object integral to vehicle
Adjusting climate controls
Other distraction
Unknown distraction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Driver Involvement - Australia
• 80 % of Australians own mobiles
• 25% admit to using hand-held phone while driving
• 30% drivers admit to sending text messages
• 2% of drivers in Melbourne observed using a hand-held mobile phone


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Driver Involvement - UK
• 40% admit to using mobile phone while driving – 80% for commercial drivers
• Greater use by younger drivers
• 90% say ban hand-held phones
• 50% say ban hands-free phones
• Think text messaging is most dangerous

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Driver involvement: Other Activities

conversing	15.0%
manipulating vehicle controls	3.8%
prepare eat/drink	3.1%
external distracters	1.6%
smoking	1.6%
eat, drink, spill	1.5%
manipulate music/audio controls	1.4%
dial/answer talk mobile phone	1.3%
reading/writing	0.7%
baby distracting	0.4%
adult/child distracting	0.3%
grooming	0.3%

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Impact of Distraction

Performance Studies
- on-road and test track studies
- driving simulator studies
- dual-task studies
- eye glance studies
- visual occlusion technique

Epidemiological Studies
Crash studies

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A Common Sight

Can she see me?

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Mobile Phones

- Degraded lanekeeping
- Degraded speed control
- Longer RTs
- Missed traffic signals
- Reduced functional field of view
- Shorter following distances
- Accept smaller gaps
- Increased mental workload
- Reduced situation awareness


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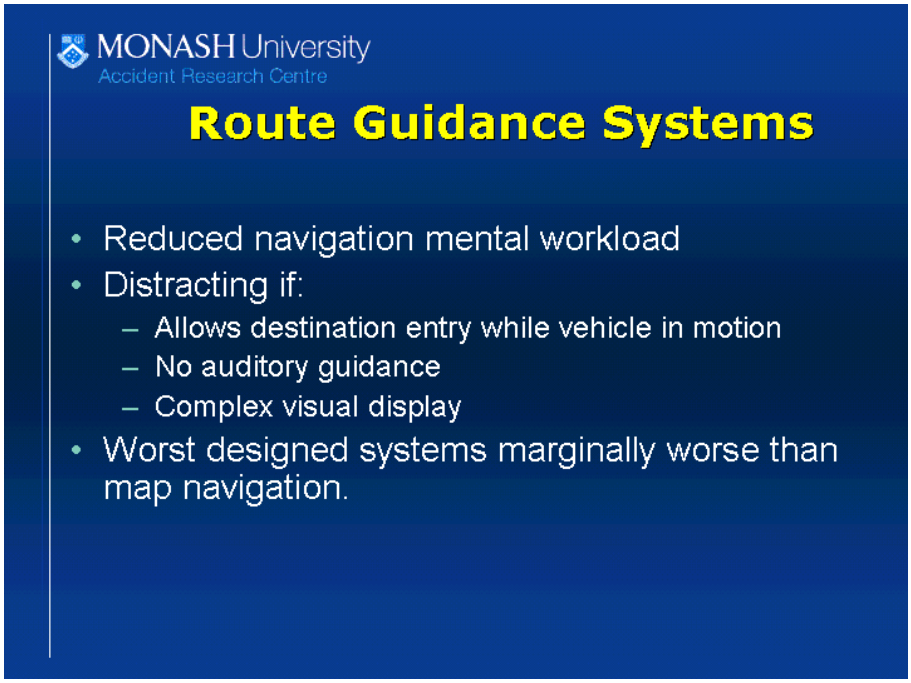
Mobile Phones
• Dialing and conversing interfere
• Hand-held and hands-free interfere
• Text messaging:
– Sending worst than retrieving
– More variable lane keeping
– More lane excursions
– Missed traffic signs
– 400 percent more time heads in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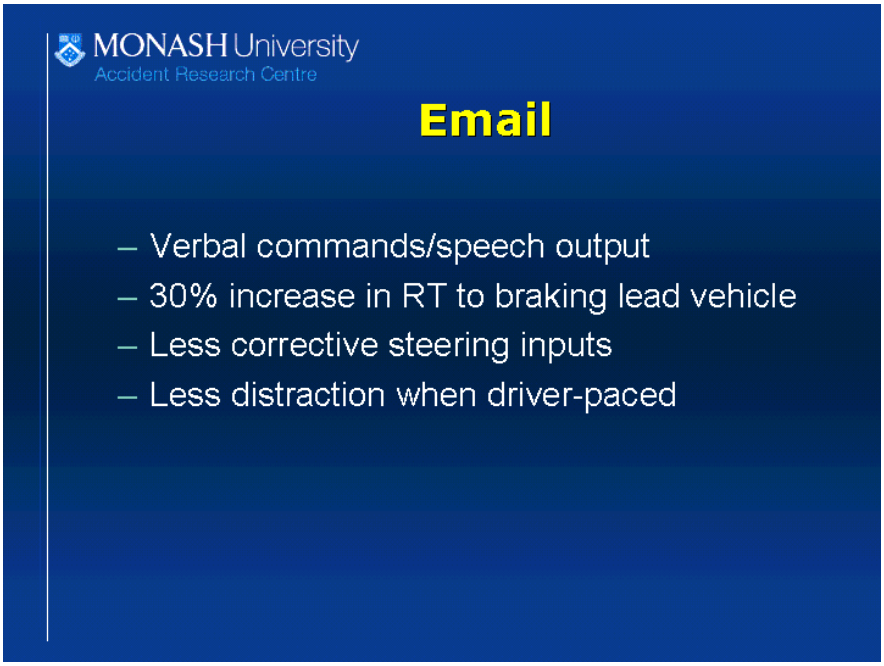
Route Guidance Systems
• Reduced navigation mental workload
• Distracting if:
– Allows destination entry while vehicle in motion
– No auditory guidance
– Complex visual display
• Worst designed systems marginally worse than map navigation.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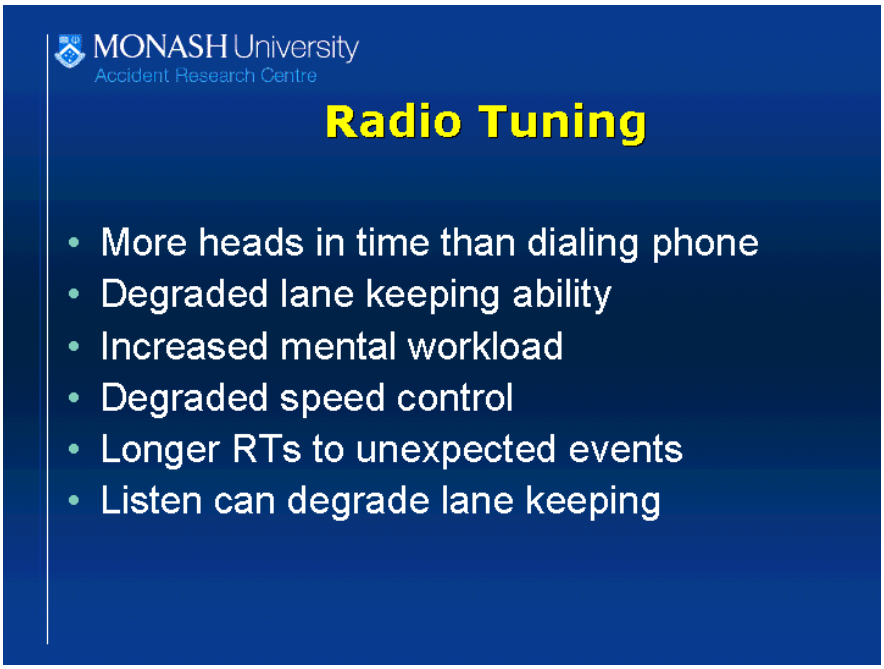
Email
– Verbal commands/speech output
– 30% increase in RT to braking lead vehicle
– Less corrective steering inputs
– Less distraction when driver-paced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Radio Tuning
• More heads in time than dialing phone
• Degraded lane keeping ability
• Increased mental workload
• Degraded speed control
• Longer RTs to unexpected events
• Listen can degrade lane keeping


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CD Players
Compared to dialing mobile phone:
• More degraded lane keeping ability
• More time heads-in
• More degraded speed control


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DVD Players
• No known published research data
• Likely to be more distracting than CD players
• Good if they can keep the kids quiet

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The Kids

Give me a DVD with head phones!!

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Portable Devices

- No known research
- Can be placed anywhere, despite regulations
- Very distracting if poorly designed
- Incompatibilities with in-vehicle systems


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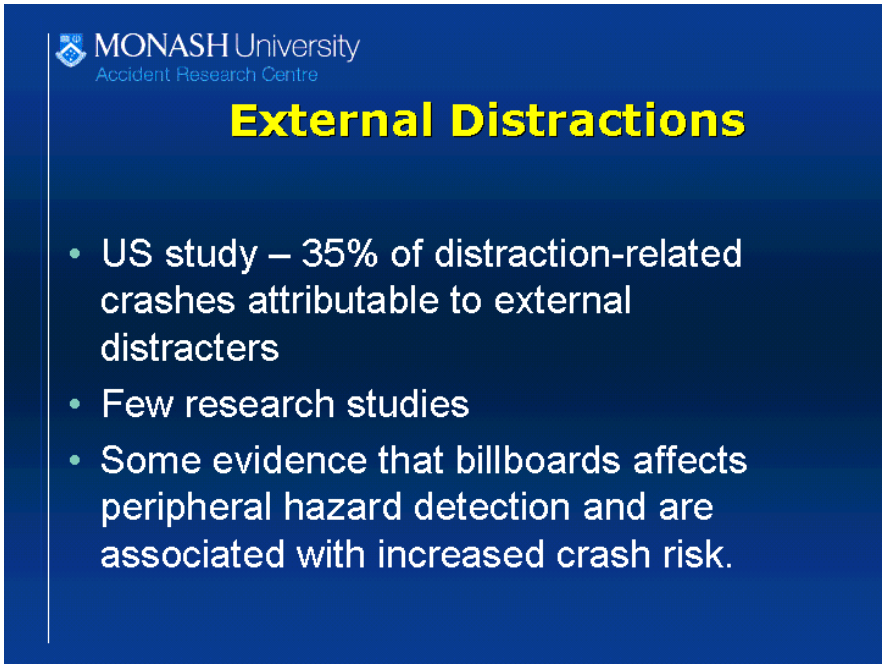
Everyday Activities
• Eating – eating hamburger as distracting as dialing a mobile using voice commands
• Smoking – no known performance studies.
• Talking to passengers – no known performance studies.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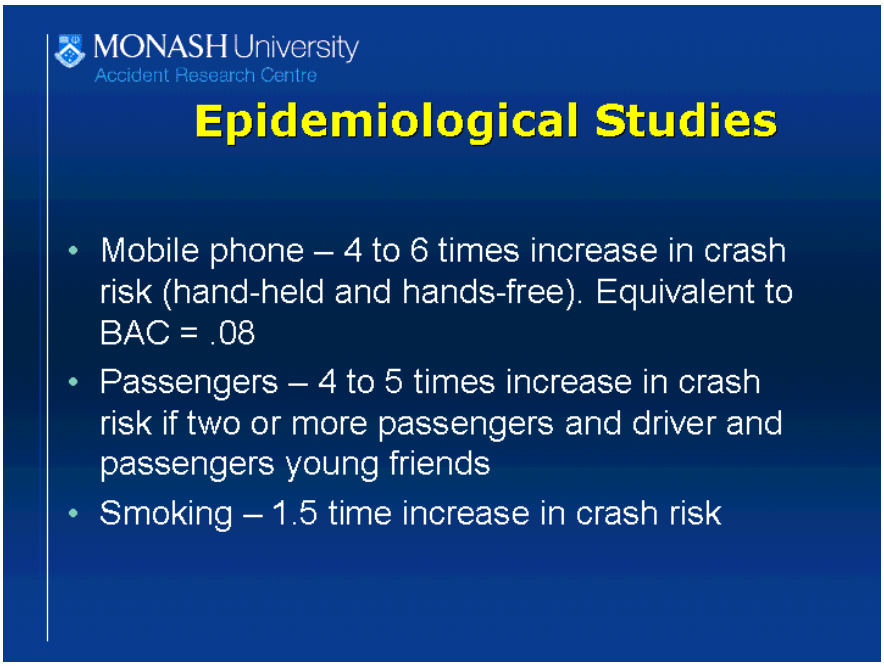
External Distractions
• US study – 35% of distraction-related crashes attributable to external distracters
• Few research studies
• Some evidence that billboards affects peripheral hazard detection and are associated with increased crash risk.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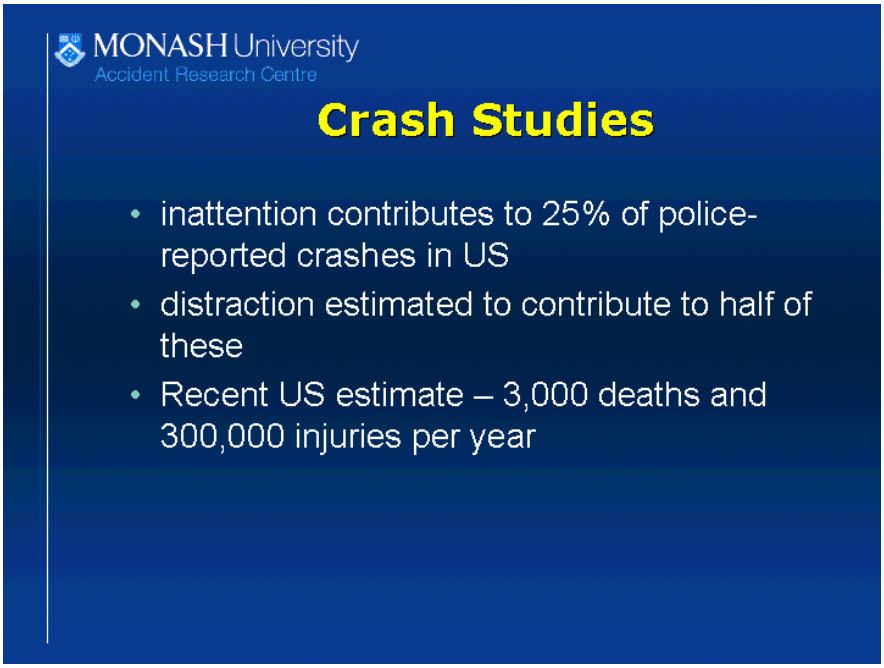
Epidemiological Studies
• Mobile phone – 4 to 6 times increase in crash risk (hand-held and hands-free). Equivalent to BAC = .08
• Passengers – 4 to 5 times increase in crash risk if two or more passengers and driver and passengers young friends
• Smoking – 1.5 time increase in crash risk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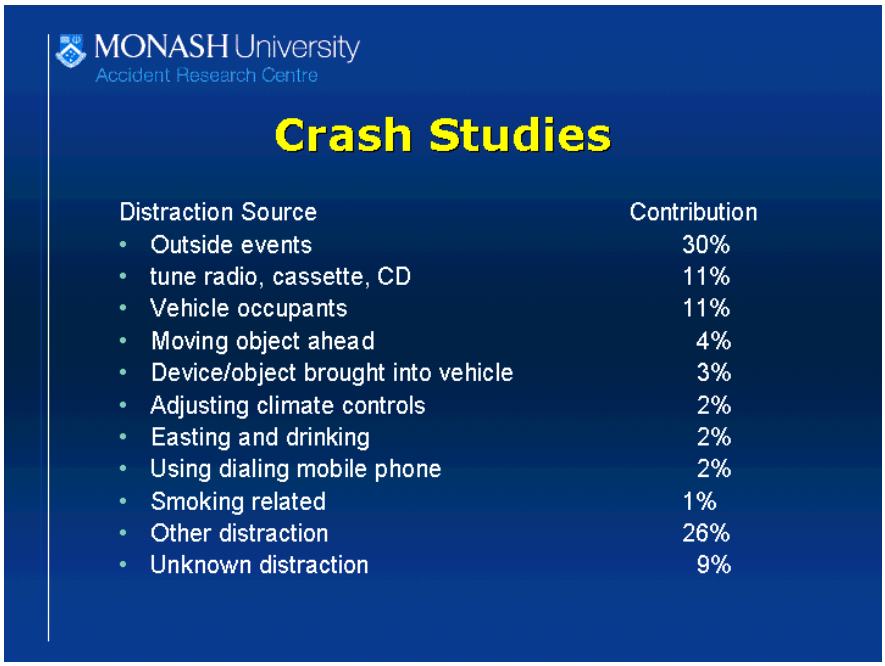
Crash Studies
• inattention contributes to 25% of police-reported crashes in US
• distraction estimated to contribute to half of these
• Recent US estimate – 3,000 deaths and 300,000 injuries per year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Crash Studies
Distraction Source
Contribution
Outside events 30%
tune radio, cassette, CD 11%
Vehicle occupants 11%
Moving object ahead 4%
Device/object brought into vehicle 3%
Adjusting climate controls 2%
Easting and drinking 2%
Using dialing mobile phone 2%
Smoking related 1%
Other distraction 26%
Unknown distraction 9%


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Summary: Rankings
Most to least Distracting:
Email/internet (when available)
mobile phone - text messaging
mobile phone – talking (hand held/hands-free)
DVD player (if portable and poorly located)
talking to passengers (if driver young/old)
route navigation (if poorly designed)
casette player/CD player
radio
climate controls
eating/drinking
smoking-related


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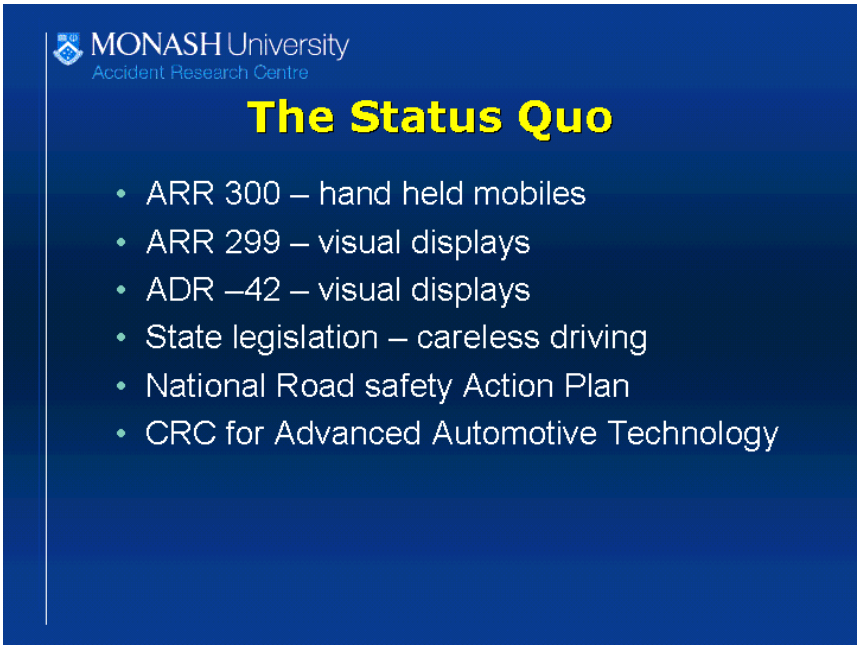
Summary: Other Trends
• People under/over-estimate risks
• People self-regulate – at least some do
• Younger and older drivers more vulnerable
• Some people are better than others at resisting distraction
• Training and experience can reduce effects of distraction
• There is a flip side… … …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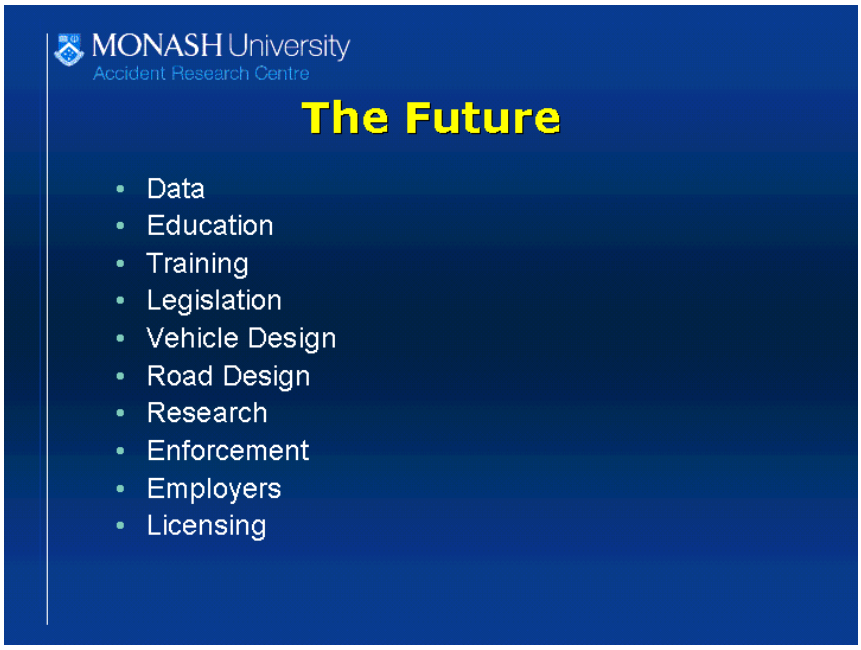
The Status Quo
• ARR 300 – hand held mobiles
• ARR 299 – visual displays
• ADR –42 – visual displays
• State legislation – careless driving
• National Road safety Action Plan
• CRC for Advanced Automotive Technology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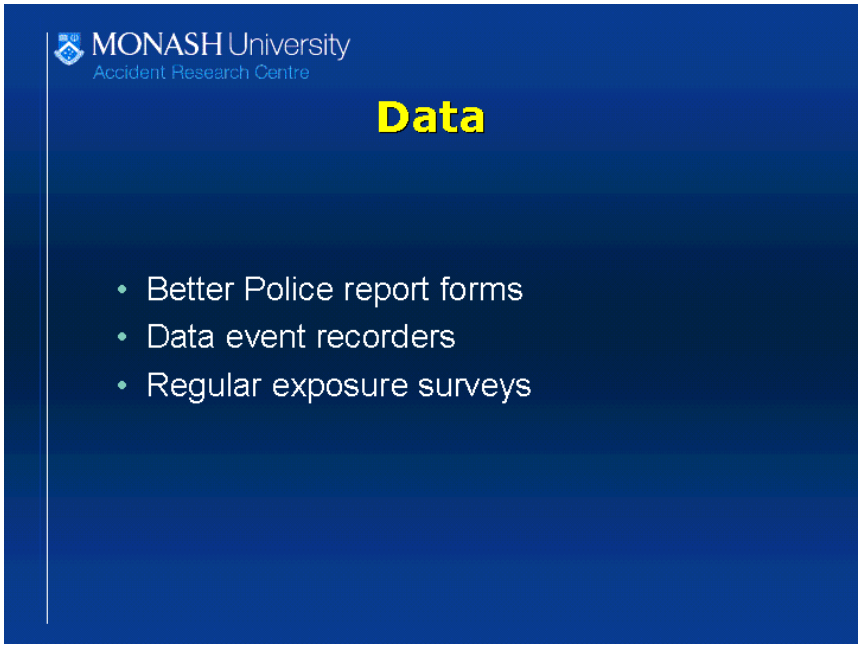
The Future
Data
Education
Training
Legislation
Vehicle Design
Road Design
Research
Enforcement
Employers
Licensing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Data
Better Police report forms
Data event recorders
Regular exposure surveys


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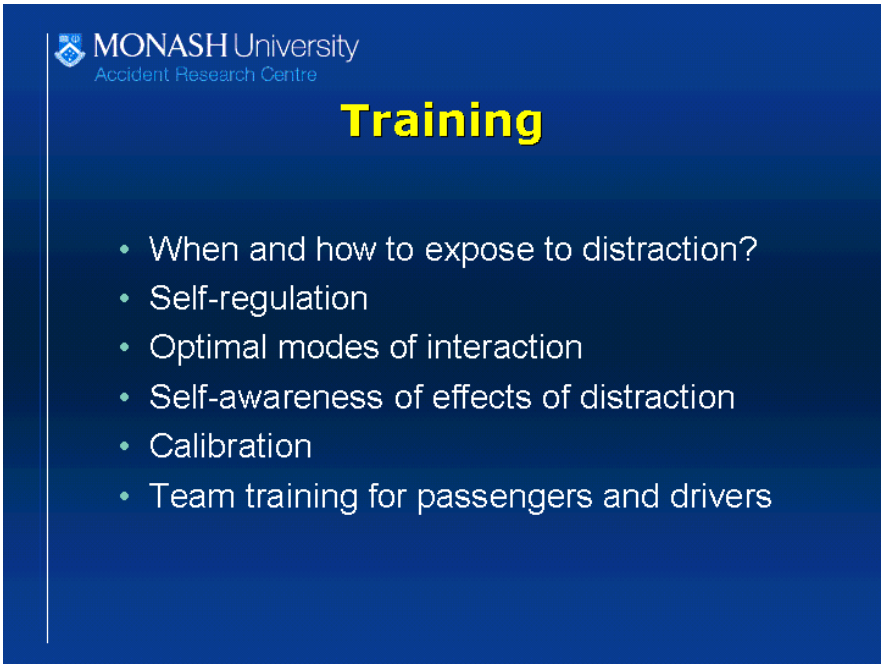
Education
Publicity campaigns:
Relative dangers
Managing risks
Penalties
Priorities:
Text messaging
Hands-free conversations
Young novice drivers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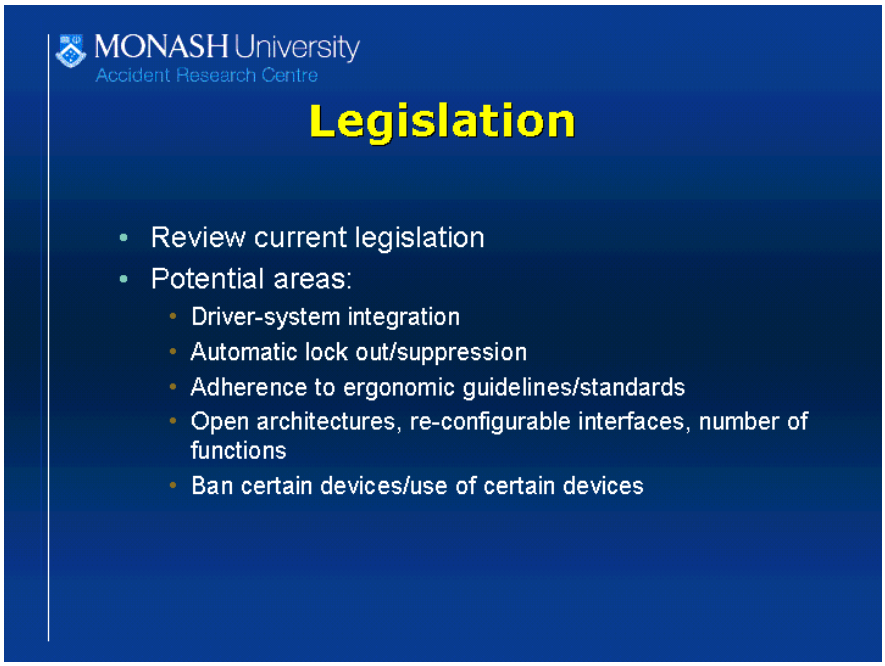
Training
When and how to expose to distraction?
Self-regulation
Optimal modes of interaction
Self-awareness of effects of distraction
Calibration
Team training for passengers and drivers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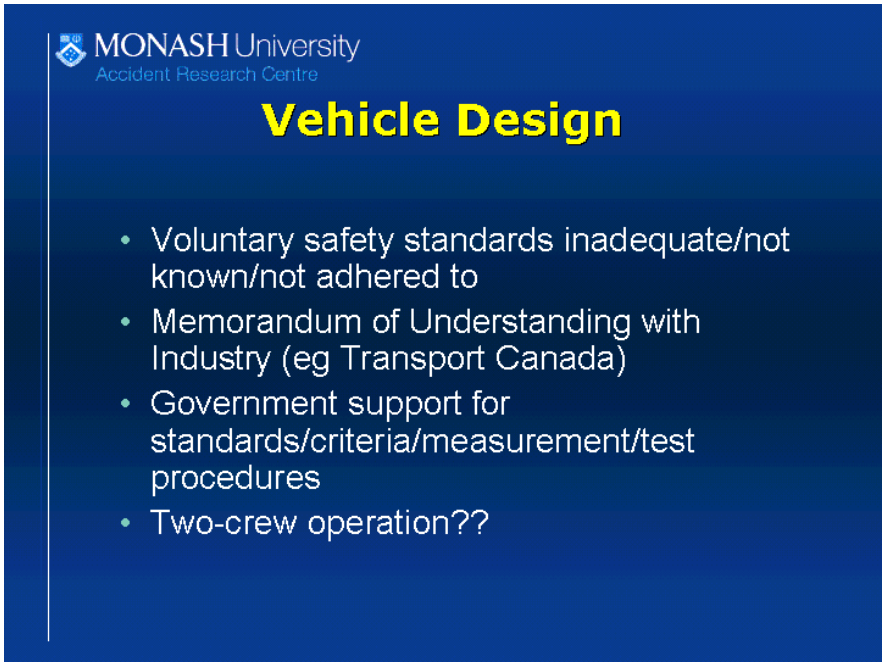
Legislation
Review current legislation
Potential areas:
Driver-system integration
Automatic lock out/suppression
Adherence to ergonomic guidelines/standards
Open architectures, re-configurable interfaces, number of functions
Ban certain devices/use of certain devices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Vehicle Design
Voluntary safety standards inadequate/not known/not adhered to
Memorandum of Understanding with Industry (eg Transport Canada)
Government support for standards/criteria/measurement/test procedures
Two-crew operation??


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Road Design
• Very little research
• Taxonomy of potential distracters
• Dialogue between manufacturers and traffic engineers
• Road safety audits – include ergonomic audits
• MOU between governments and industry


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Research
• Driver exposure to distractions
• Self-regulation
• Human-machine interface design
• Quantification of crash risk
• Definition, measurement, criteria
• Impairment levels that compromise safety
• Costs/benefits of regulation
• External distractions
• Distraction and other road users (eg motorcycle riders)


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Enforcement
• technology to support enforcement
• Survey law enforcement personnel


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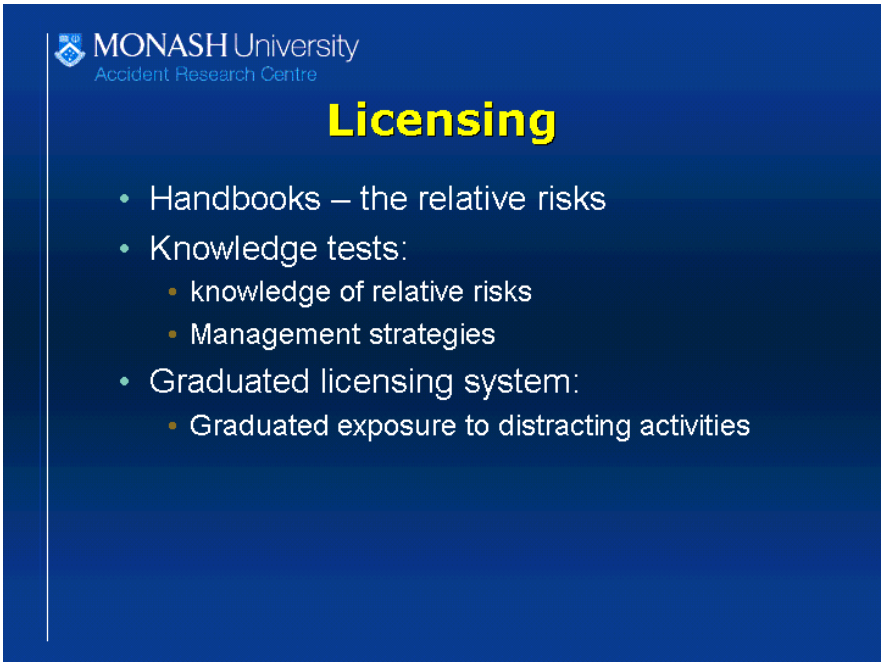
Employers
• Provide guidance for employers:
• Legal responsibilities/potential liabilities
• Ways of tracking distraction-related incidents/crashes
• Policies to limit adverse effects of distraction
• Promote purchase of vehicles and technologies that demonstrably minimize distraction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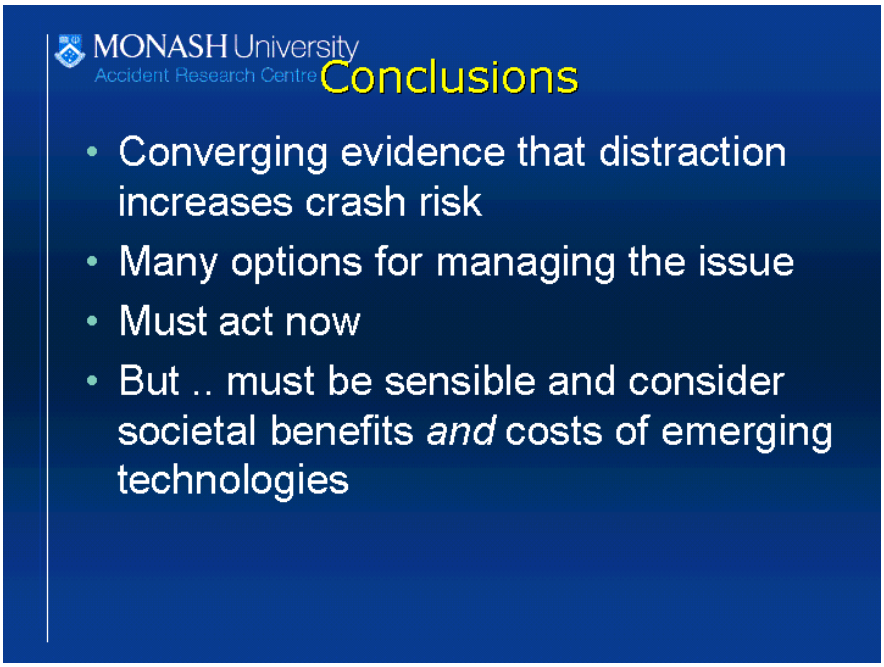
Licensing
• Handbooks – the relative risks
• Knowledge tests:
• knowledge of relative risks
• Management strategies
• Graduated licensing system:
• Graduated exposure to distracting activities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Conclusions
• Converging evidence that distraction increases crash risk
• Many options for managing the issue
• Must act now
• But .. must be sensible and consider societal benefits *and* costs of emerging technologies