Literature Review

Distracted Driving and In-Vehicle Devices

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Executive Summary

This literature review explores the topic of distracted driving and to what extent the use of technological devices while driving has an impact on the driver. From prior research, New Zealand's current legislation seems to be inadequate to ensure the safety of the public from emerging technological devices that could be used while driving a motor vehicle. The goal of the literature review was to investigate this issue in more depth and offer recommendations that are relevant for the New Zealand Ministry of Transport. Funding was provided from the New Zealand Ministry of Transport and Victoria University of Wellington, with supervision from Victoria University Information Systems School.

For the purposes of this literature review the definition of a device has been declared as anything electronic that requires some sort of interaction from its user to be used. The devices that were explored include smartphones, navigation systems, built-in display units, and emerging technological devices. Devices which are created to prevent accidents, known as accident prevention devices (APDs), were also explored as well as more recent emerging devices such as Google Glass.

This literature review split the types of distractions into three categories: physical, cognitive, and emotive distractions. The literature shows that emotive distraction is the most risky to experience while driving. The main reason emotive distractions are seen to be problematic for drivers is that they arouse stimuli in the brain and can significantly disrupt the driver's focus.

Distractions overall were shown to contribute to 22% of injury related crashes and 16% of fatal crashes in 2011 from statistics in the United States. In New Zealand, similar statistics between 2010 and 2012 showed that distraction was a factor in 12% of all casualty crashes, 11% of fatal crashes, 10% of serious injury crashes and 13% of minor injury crashes. With the ongoing evolution of technology, more devices are being developed that can be used while driving, increasing the potential for distractions. Evidence indicates that a combination of devices does not have a greater impact on the driver's crash risk than a single device, if both devices require the same or similar interaction methods and thought processes. However, if the devices require different interactions, such as a voice recognition device in combination with a touch screen device, problems arise.

Four devices have been identified as a high risk rate due to their primary usage distracting the driver emotively. These devices are smartphones, hands free kits, portable television systems, and Google Glass. However, there are several devices which may not impair the driving in their primary use, yet one of their secondary uses may cause the driver to become distracted emotively. An example of this is an in-built display unit, which primarily would be used for navigation, but could also act as a way to converse with another person through software such as Skype. There is thus a large pool of devices which may cause emotive distractions, with new innovations also being capable of being used in ways that are emotively distracting. This makes it difficult to regulate the usage of a specific device or feature. Such legislation would also be difficult to police and very difficult to phrase in an optimal manner.

Based on the handheld mobile phone restriction while driving, The New Zealand Medical Association was able to find a slight reduction in crash rates, but not the major decrease that was intended. Evidence suggests this lack of change is due to drivers simply switching to hands free kits and that the emotive distraction involved with conversing is still prominent. Other literature suggests that the lack of change may be due to the penalty for being caught breaking the legislation being minimal, that the need for or addiction to cell phone devices is too high, that the risk of driving distractions is perceived to be very small, and that it is too difficult to police such legislation to begin with.

If legislation were to be introduced, rather than prohibit being involved in an emotive distraction, it is recommended that the driver is able to do so in a situation that is as safe as possible. This would mean creating legislation that prohibits the other distractive elements of the device and situations that could put the driver in a dangerous position. An example of this would be to legislate to ensure the safe and secure mounting of devices, so that the level of physical distraction is mitigated.

A significant issue in distracted driving that many scholars have looked into is a driver's perception. One of the greatest causes of becoming distracted is that people are over confident and are unaware of how engaging with a device affects their crash risk. The majority of drivers have the perception that they can handle the risk should they choose and that society norms have very little influence in preventing this type of distracted driving. To target this issue it is recommended that awareness campaigns relatable to drivers are created, either through television advertisements or other channels

Other recommendations have also been made such as prohibiting the use of in-vehicle devices for a specific group, such as people under the age of 25 or with little driving experience. These people have been identified as having trouble managing the multiple information channels in conjunction with the driving task. Therefore, the prohibition of the devices for them will prevent them from information overload while driving.

Another group that suffers from the effects of emotive distractions while driving is employees. Especially in high level positions, study has found that workers have a need to be available for phone conversations when driving and are also the largest group of people that engage in phone conversations. A recommendation has been made that companies and human resource departments take a more active role in enforcing policies to prohibit or prescribe how high risk devices be used while driving, and when. Legislation could also be introduced that requires companies to become more involved in influencing distracted driving policies, and offer standardized guidelines to employers.

Finally, the literature review identified the ability of Internet Service Providers to disable certain devices or functions while driving and redirect messages. It is recommended that this function is explored in greater depth. Having new technologies disable themselves while their user is driving a vehicle could also be a possible requirement.

Contents

Problem Analysis:

From prior research, New Zealand's current legislation seems to be inadequate to ensure safety around the use of emerging technological devices while driving a motor vehicle. These types of devices and existing devices should be explored in terms of their crash rate and how much of an impact they have on the ability to drive. The underlying problems that these devices may bring also need to be looked into and what other countries have suggested as a solution to this problem. From this point recommendations need to be made and if legislation does need to be introduced or changed, it must be sustainable in the long term.

Contextual Analysis

This literature review was created with funding from the New Zealand Ministry of Transport and Victoria University of Wellington. Supervision was by Victoria University of Wellington's Information Systems School. The purpose of this literature review was to gain insight into the technological distractions that drivers can experience while driving a motor vehicle and the adequacy of New Zealand's current legislation in this context. The literature review's main focusing questions that have been applied throughout this research are:

1. What are the main devices used when driving?
2. How do these devices affect vehicle crash rates?
3. Does legislation address these devices sufficiently?

Prior research in the United States shows that distractions have been a major contributor to vehicle related crashes equating to a near 22% of crashes where injury has occurred and 16% that resulted in fatalities (National Highway Traffic Safety Administration, 2009). In New Zealand similar statistics were discovered. "Over the years 2010 to 2012, 'attention diverted by' for drivers was a factor in 12 percent of all casualty crashes, 11 percent of fatal crashes, 10 percent of serious injury crashes and 13 percent of minor injury crashes. Seventy-four percent of the fatal crashes, 53 percent of the serious injury crashes and 34 percent of the minor injury crashes occurred on the open road (speed zones over 70km/h)" (Ministry of Transport, 2013). Interaction with a device while driving often requires the driver to forfeit attention from the road to the device, which creates a form of distraction and the potential to result in loss of vehicle control.

As the use of technological devices inside motor vehicles has increased, the number of potential driver distractions has also increased significantly. This increase in distractions has been identified as a global problem that the New Zealand Ministry of Transport faces. This literature review will explore these devices by identifying how they are used, their benefits, and further discussing any key findings. The devices that will be explored include smartphones, navigation systems, built-in display units, and emerging technological devices. Devices which are created to prevent accidents known as accident prevention devices (APDs) will also be explored and more recently emerging devices which could be problematic in the future, such as Google Glass. The legislation from other countries will also be explored in order to gain a better insight into the topic and allow greater evidence when generating recommendations.

This research will then explore the literature on the driver distraction theme. Preliminary findings show that the literature can be split into two different areas which have been common amongst scholars that have investigated this field (Charlton, 2011) (Horrey & Kidd, 2010) (McEvoy, Stevenson, & Woodward, 2006). These areas include:

- The different types of risks that in-vehicle devices cause
- The driver's perception of device usage and risk management

Based on the findings and summaries from various academic sources, recommendations are made to the Ministry of Transport based on the evaluation from the literature, and what should occur in order to address any identified problem.

Since the majority of devices explored in this article have only in use during the past decade or so, a large weight of information in this literature review has come from conference papers and articles that are pending approval into scholarly journals. Also this research has been limited by time constraints and holds the promise of being explored to a further extent.

Types of Devices

Collin's English dictionary defines a device as "a machine or tool used for a specific task" (Collins, N.D). For this literature review, the definition of a device is anything electronic that requires some sort of interaction from its user. The devices that this literature review discusses share the following similarities. They are able to send visual or audio information to the driver, they consist of electrical components, and the majority of them have a graphical user display.

This research will cover various devices, in particular devices with a form of user interface. The main devices that will be featured are Smartphones, GPS systems, Inbuilt Vehicle Interfaces, accident prevention devices, and recent emerging technologies.

Distractions were shown to contribute to 22% of injury related crashes and 16% of fatal crashes in 2011 (Trempel, Kyrychenko, & Moore, 2011). Similar statistics showed that distraction was a factor in 11% of crashes in New Zealand over the 2010 to 2012 period (Ministry of Transport, 2013). Because of this it is unclear how future devices will impact on this crash rate. With the evolution of technology, more devices are being used while driving and more potential distractions are coming into fruition.

The main method to measure visual distraction is done through glance time. It is deemed risky to have more than two seconds' glance time away from the road, or twelve seconds of total glance time when operating a device, over a two minute period (Zhang, et al., 2013).

It is assumed that a combination of the use of these devices increases the probability of a potential crash as each device requires the driver to forfeit more time concentrating on the driving task. However evidence indicates that the combination of devices does not have a greater impact of the driver's crash risk than a single device, if both devices require the same similar interaction method and thought process (Merat, 2003). However if the devices require different interactions such as a voice recognition device in combination with a touch screen device problems arise (Blanco, Biever, Gallagher, & Dingus, 2006).

In this research, each specific device is described, and how it interacts with the driver. The research will look into the device's physical properties, the benefits of using the device, and the requirements that are needed to operate the device.

Types of Distractions

The type of distraction that faces drivers can be split into two different categories, external and internal (Stutts, et al., 2005). External distractions refer to any distraction that is outside the vehicle and disrupts the driver's focus. Examples of external distractions range from pedestrians, to weather conditions. This type of distraction is the least concerning in regards to crash risk and is not controllable by the driver (Stutts, et al., 2005). Internal distractions, in contrast, are risks that happen inside a vehicle and are often controllable by the driver of the vehicle. This category of risks has been deemed to be the most dangerous type of risk, and also results in amongst the highest crash rates (Stutts, et al., 2005). Since internal distractions can ultimately be prevented, many internal distractions have been the focus of legislation, media campaigns, and awareness schemes, in order to prevent accidents from occurring.

Delving further into types of internal distractions, the types of distractions can be even further grouped together in order to understand which distractions are problematic. These types are known as physical distractions, cognitive distractions, and emotive distractions. Many articles have different interpretations of distraction types, often including more than the three mentioned above or narrowing it down to only the two fields of visual or cognitive (Cuenen, et al., 2013). Some of these distractions have been deemed not to be very significant for research purposes as they show little impact in comparison to more emerging technology devices.

These types of distractions can not only show where problem areas occur, but also show the underlying traits that devices may have and perhaps common themes that legislation should target. These types of distractions have been explored further below in order to gain a better insight.

Physical Distractions:

Physical distractions can be defined as distractions that require the driver to physically engage with and use, such as food, devices or objects. (Stutts, et al., 2005). By requiring the driver to handle the device, for the duration of the task the driver is physically impaired. For example, when operating a handheld mobile phone device while driving, the driver is unable to use one of their arms. Research suggests that even though the driver does not have the use of one arm, the driver is able to adjust to this impairment and that the problem lies in another form of distraction that mobile phones offer (Horrey & Wickens, 2006).

Rather than the physical impairment of these distractions, research has shown that these devices are more problematic through the glance time the devices require from the driver. This is often referred to separately as visual distractions in the literature. (Cuenen, et al., 2013) (Zhang, et al., 2013). According to Zhang et al, the driver is more at risk if the distraction takes away more than two seconds of glance time in a single instance. Additionally research has found that if glancing at a device combines to a period of over fourteen seconds for, while performing the secondary task one time, the same problems arise (Zhang, et al., 2013). In the study that found these results, the maximum time period given to complete a task was stated to be two minutes (Zhang, et al., 2013). What this

shows is that even though a driver might not glance for a long period of time at a given moment, the driver can still be at a severe risk if they continuously switch between the distraction and the road.

Rating	Definition	Example
0.00	No Visual Activity	Self-Explanatory
1.00	Visually register/detect image	Observe a warning light turn on
3.70	Visually discriminate (detect visual difference)	Determine which traffic light is on
4.00	Visually inspect/check (static inspection)	Check side mirror position while parked
5.00	Visually locate/align (selective orientation)	Change focus to a car
5.40	Visually track/follow (maintain orientation)	Watch a moving car
5.90	Visually read (symbol)	Read a native language
7.00	Visually scan/search/monitor (continuous)	Look through glove compartment

Table 1 (Green, 2010)

The above table shows common distractions without technology involvement. They have been rated in terms of one another depending on how visually demanding they are. Even without technological devices there are distracting elements that are fairly basic and are problematic. However, as technology evolves there are more visually demanding elements incorporated into driving.

Cognitive Distractions:

Cognitive distractions are distractions which happen inside a driver's mind and can be very problematic even if the driver has full view of the road. From Dr Samuel Charlton's input (Charlton, Research Project Email, 2013) and further research it should be noted that any device contains cognitive distraction elements (Charton, 2008). In a study aimed at finding out if hands free mobile devices were an improvement on handheld mobile devices while driving, the results were similar, even though no physical distraction was involved (New Zealand Medical Association, 2013) (Horrey & Wickens, 2006).

Branching off of this the idea, research was conducted to discover whether audio output in devices increased crashed risk due to the cognitive distraction that they imposed. Research in this setting found that audio output through navigation systems and music systems did not actually affect crash rates, in some cases even reducing it (Berfu Ünal, de Waard, Epstude, & Steg, 2013) (Sodnika, Dickea, Tomazic, & Billinghursta, 2007). These results could be concluded to be because of the lack of engagement from the driver in the music setting. However, with navigation systems one of their main forms of output is audio based and has human speech involved. Crash rates were also not affected negatively and the audio was of no increased risk to the driver. This was theorised to be because of the monotonous audio of the navigation system, or the conversation channel not arousing stimuli in the brain due to little thinking.

From these findings, it could be concluded that cognitive distractions do not play a major part in increasing crash statistics However, any combination of different cognitive distractions - from as few as two - has been seen to lead to information overloading of the driver if too many devices are present (Willis & Ratliff-Corporation, 2001).

Visual Recognition / Processing	
Action	**Time**
Reading Speedometer Speed	2 second
Reading Gas Gauge	2 second
Reading RPM	2.5 second
Tuning Radio to Desired Channel	
Preset Channel	2 second
Non-Preset Channel	5-20 second
Select a New Track on a CD	5-10 second
Reading a Route Guidance System Map	10-60 second
Recognize and Read a Two Line DMS	10-15 second
Dialing a Cellular Telephone	
Speed Dial from "Phone Book"	30-60 second
Random Number Dial	10-30 second
Voice Recognition Dial	10 second
Detecting a Change in a Visual Image and Recognizing Dangers	2-4 second
Selecting and Reading an Email Message on a PDA	10-40 second
Changing a CD (Select New, Extract Old, Insert New, and Return Old to Storage)	30-60 second
Requesting Yellow Page Information and Directions from Guidance System	30-60 second

Table 2 (Willis & Ratliff-Corporation, 2001)

The table above shows the time needed to process devices and to what extent each action is time consuming. It is shown that if devices that evoke elements from different cognitive channels are engaged, the driver will have trouble interpreting information. "If a human is analyzing a complex image he may have difficulty in simultaneous processing information via an audio sensory channel" (Willis & Ratliff-Corporation, 2001).

Emotive Distractions:

Research has shown that the cognitive distractions do not increase crash risk, but that mobile phones do increase crash risk. This led the research to discover a third category of distractions altogether. This category, known as emotive distractions, can be seen as any type of distraction that engages with the driver and is capable of affecting a driver's emotions (Chan & Singhal, 2012). This type of distraction can also be external to the vehicle, but for this study it is only being examined on an internal basis.

The main reason this type of distraction is seen to be problematic for drivers is that they arouse stimuli in the brain and disrupt the driver's focus at very high levels (Astleitner, 2013)

(Jallais, Roge, Fort, & Gabaude, 2013). This type of interaction has been shown to narrow vision, and disrupt the driver's control over the vehicle (Jallais, Roge, Fort, & Gabaude, 2013).

Research has shown that emotive distractions are also problematic in cell phone usage while driving. Because the driver is engaged in a situation where their emotions change throughout a conversation, dangerous driving patterns were seen to result. Research also showed that more heated conversations, such as discussing marital affairs, would be more problematic while driving (Horrey & Wickens, 2006).

In terms of listening to music while driving, research has found that the emotive distraction of music affects driving, however not at levels that have majorly affected crash risk and in some respects, the opposite. Music has been shown to increase response time and improve following distance (Berfu Ünal, de Waard, Epstude, & Steg, 2013). This shows that the emotive element clearly has the ability to influence the way a person drives. The results from listening to music are often desirable and increase the driver's level of comfort.

It was also found that a driver's emotions affected their crash risk depending on whether they are angry or sad (Jallais, Roge, Fort, & Gabaude, 2013). Because some devices are able to trigger these emotions and stimuli, it can be deduced that emotive driving is the core type of distraction that increases crash risk.

Emotive distractions also share some traits with physical distractions. An object outside of the vehicle, such as a bill board's advertisement has the ability to evoke emotions, dependent on the language or information shown. (SWOV Institute For Road Safety Research, 2012). More vulgar information is said to be more risky and it is recommended that these types of advertisements remain away from busy traffic conditions (SWOV Institute For Road Safety Research, 2012).

Unlike other distractions, the emotive distraction has a more lasting effect. In some cases the emotive distractions are more difficult to stop, such as if they are from a passenger, or the driver has already been affected by the message from the device. In this instance the driver should refrain from driving the vehicle and stop driving until they are in a suitable headspace.

Smartphones

Physical Details:

The term “Smartphone” derives from New Grinch in 1990 (Mitchell, 2013). A Smartphone device is an evolution of the more commonly known mobile phone and is a handheld device capable of a multitude of tasks. These tasks include the ability to converse, multimedia playing, sending and receiving messages, internet browsing, and many more through software applications. (Coustan & Strickland, N.D).

Figure 1 (IT World Canada, 2013)

The above figure shows a diagram of a “BlackBerry” brand of smartphone. As the diagram illustrates, the smartphone interface is navigated through touch screen interactions and various buttons adjust the smartphones configurations. The device also has an inbuilt microphone for speech recognition software. What the diagram does not illustrate is the Bluetooth and GPS functions that the majority of smartphones incorporate. They also incorporate gyroscope and accelerometer features. Each smartphone is customizable though 3rd party applications that are installed on the brand’s online application market. For Apple devices this is known as the I-Tunes store and for Android devices this is known as the Android Store. (Coustan & Strickland, N.D)

Benefits:

Because the smartphone device is capable of performing many different tasks, this also leads to many different benefits that a driver can have when operating this device.

Using a smartphone while driving gives the owner the ability to communicate through text messaging, electronic mailing, and phone calls. What this means for the driver is that they are able to respond to other people and make arrangements while travelling. There are two high risk groups involved in using a mobile phone while driving. The first are younger people with little driving experience (Starkey, Wilson, Charlton, Thomson, & Group-B1, 2013) (Taylor, MacBEan, Das, & Mohd, 2007). The second group of people identified are workers aged 20-40, particularly those in higher positions as they often use the time driving to engage in work related phone calls (Benner, Lajunen, & Haigney, 2006) (Brusque & Alauzet, 2008; Ismeik & Al-Kaisy, 2010). In some cases studied, employers require their employees to be available at any stage especially for employees in higher tiered occupations, as their phone conversations have a great impact on the business they work for (Benner, Lajunen, & Haigney, 2006) (Lam, 2002). Driving with access to communication is deemed to be crucial for employees in increasing efficiency, and with bans on driving while interacting with handheld devices, employers simply insist on the hands-free alternatives. The smartphone has additional ways to communicate through Bluetooth and speaker options, with some new vehicles being fitted with holders and devices to maintain this benefit. (Elmer, 2013)

Another benefit that Smartphones allow for is the ability to play music while driving (see Figure 4). What this means for the driver is that the ambience in the vehicle is improved to the driver's discretion and increases the driver's level of comfort (Coustan & Strickland, N.D). This increase in comfort has been shown to have little impact on driving. However, if the music is too engrossed in the music or it is too loud it can play a part in increasing the mistakes a driver makes and also increasing the speed of the vehicle (Yannis, Papathanasiou, Postantzi, & Papadimitriou, 2013). Because music very rarely affects driving performance, it has been concluded to be a low risk.

A third benefit that Smartphones have is the ability to become other types of in-vehicle devices through applications. Through the use of applications a smartphone is able to become a GPS navigation system, an accident prevention device, and even more as time progresses (Saiprasert, Pholprasit, & Pattra-Atikom, 2013) (Sumi, et al., 2013). Being able to change into a lot of these devices grants smartphones the same benefits discussed in the following sections of this literature review. Most importantly though, having each of these different systems all under one device means that the driver does not need to have a combination of devices.

How it is used:

Newer vehicles have mounts for smartphones that are adjustable. However the majority of drivers fix these devices to their dashboard using portable holders (Shinder, 2011). What this means is that in new vehicles, the device positioning is very limited to adjustment as the holder is inbuilt to the vehicle. This could cause problems, should the driver be familiar with a certain position in relation to muscle memory.

In order to operate the device itself, the most common input methods are done through a touch screen interface (Coustan & Strickland, N.D). This can be quite a time consuming task as the driver is required to input specific lettering on a device on which it is very easy to make data entry errors due to its size. It is shown that the size of the screen plays a big part in a person's sense of safety and more people feel safe using a device with a larger interface (Ishiko, Nkano, & Zheng, 2013). This type of interaction requires a fair amount of glance time (Ishiko, Nkano, & Zheng, 2013).

The other way that the device can be used is through the use of voice recognition. In many academic studies, voice recognition is shown to be less risky than physical input methods (Tsimhoni, Smith, & Green, 2004). Voice recognition does take a fair amount of training in order for the driver to actually achieve the input result they require and does have accuracy issues due to different dialects (Tsimhoni, Smith, & Green, 2004). What this means is that errors occur often and if the driver is affected by a cold or other voice impairment they are required to revert back to a touch screen interface.

Discussion:

Smartphone usage is definitely considered important for people to have access to in vehicles, due to the need to be contactable in emergencies, the importance in employment relations, and various forms of addiction (Hooper & Zhou, 2007) (Lam, 2002) (Benner, Lajunen, & Haigney, 2006). Studies have shown that a large portion of people, particularly teenagers and young people, feel incomplete without their mobile phones (Hooper & Zhou, 2007). Because people feel the need to always have mobile phones in their possession, mobile phones are deemed addictive (Hooper & Zhou, 2007). With New Zealand's legislation change in 2009 on handheld mobile phones while driving, it is clear that operating a device in-vehicle poses some risk. After implementing this legislation crash rates have not reduced by an amount that was expected by implementing this law as New Zealand Medical Association has discussed in their research. (New Zealand Medical Association, 2013).

There are many possible reasons behind low crash reduction after handheld phone legislation was implemented. One of these is that people simply swapped to hands free devices and that using hands free devices does not reduce the risk of crashing while operating a mobile phone (New Zealand Medical Association, 2013). Hands free phone call usage shows very similar crash rates to handheld phone usage. This shows that there is an underlying risk that phone conversations share regardless of the type of phone conversation. These factors are due to the engagement of the driver and converser which can distract the driver regardless of whether or not their eyes are on the road (New Zealand Medical Association, 2013) (Owens, McLaughlin, & Sudweeks, 2010) (McEvoy, Stevenson, & Woodward, 2007).

The act of conversing with a passenger is shown to be of the greatest distraction that leads to crashes in a motor vehicle (Young & Lenne, 2009). It has also been identified in academic research that driving while conversing with someone exterior to the vehicle is of even greater concern as the converser is not able to acknowledge areas in the driver's journey which require more concentration (Charton, 2008).

Another issue of concern is that drivers are reportedly still operating handheld devices while driving due to the minimal penalties (New Zealand Medical Association, 2013). A reason that this occurs is that drivers see current legislation with regard to conversing from a handheld phone while driving as having minimal apprehension chances (New Zealand Medical Association, 2013). Expanding on this, the legislation is difficult to police, and legislation does allow phone calls in instances of emergencies or to report dangerous driving (New Zealand Government, 2013).

Most commonly, phone conversations on handheld devices happen at red lights or in periods where the vehicle is not moving (Ismeik & Al-Kaisy, 2010), which could also indicate that people believe this is a period where there is little chance for crashes to occur. However the conversation is likely to last longer than the time it takes for traffic lights to change colour, and the driver often has to drive into a segment of traffic which requires great concentration.

As mentioned above, a factor that needs to be considered while operating smartphones as other devices is their level of safety and accuracy. It has already been noted that the size of the screens is not viewed by drivers as safe and if critical information is not clear enough, it may require longer periods of glance time from the driver or be missed completely (Owens, McLaughlin, & Sudweeks, 2010) (Ishiko, Nkano, & Zheng, 2013).

Also mentioned is that smartphones are able to become many different devices through application software, turning into navigation systems, and more. It does, however, mean that the device is more frequently used and the changing between applications can pose a risk as it draws complete focus away from driving the vehicle. New applications that the driver installs onto their smartphone may also require learning and a high demand of focus. This means that the application could require more attention to operate initially than an application is very familiar to the driver. How much experience a person has with a distracting task could correlate with the level that they are impacted by the distraction.

It is arguable that the gyroscope features of a smartphone are not as accurate as actual systems that are made for an accident prevention device. Even though an application for a smartphone is designed completely for accident prevention, the hardware in the smartphone does not have this same focus in mind. Manufacturers of the devices do not create the device for that sole purpose, which means that smartphones are likely to be less accurate for preventing accidents than devices with hardware that is specialized for doing so. What this means is that information to prevent accidents is much more suitable for these dedicated devices rather than less successful versions in a smartphone application form.

Another important aspect that needs to be addressed is the impact companies have on smartphones while driving. A major stakeholder in the distractions involved with smartphone devices is the employer and the pressures they place on employees to be available when mobile, with little enforcement to stop the car first. An example which shows this pressure is the Texas Coca-Cola case (Insurance Journal, 2012). In this case a woman was prosecuted for driving while conversing, but her employers also faced high prosecution charges equating to twenty four million dollars in USD. (Insurance Journal, 2012). A statement from the employee's company said that they do not condone driving and conversing, however will look into enforcing greater rules. Since companies play a great part in this equation and the most common people to converse while driving are employees, there is definitely a need for

companies to take the ethical approach and have a greater social responsibility presence. It would be a great opportunity for human resource departments or executives involved in employee relations to increase this responsibility as part of their business strategy as the results would be very beneficial.

Navigation Systems

Physical Details:

Navigation systems have been implemented through many different devices. These include portable units purely made for navigation (Figure 2a, below), as software for in-vehicle display systems, and as applications for smartphone devices (Brain & Harris, N.D). The device has location tracking features in order to make calculations in terms of destination, time, and optimal driving pace. Below is a picture of one of the many portable devices (Brain & Harris, N.D). Navigation systems are also more commonly known as Global Positioning Systems (GPS) and have been referenced as such in a vast amount of academic literature.

Figure 2a (Absolutely GPS, 2011)

This picture shows a typical navigation device made by the TomTom company. The main interface is touch screen based and covers the majority of the device's surface (Brain & Harris, N.D). After entering in a destination using the interface and options such as scenic route, or quickest route, a route is displayed using the devices current location (Brain & Harris, N.D). The display itself shows a map and path that should be taken by the driver and updates frequently as the vehicle is moving (Brain & Harris, N.D). Upon taking a wrong turn, the device updates to allocate this change in route. The display also shows important driver related aspects such as speed, time, and direction to turn, in order to reduce the time that the driver spends looking at other in-vehicle distractions. (Brain & Harris, N.D)

Benefits:

Having a navigation system in a vehicle has been proven to increase the efficiency of drivers with little repercussions (Jenness, Lerner, Mazor, Osberg, & Tefft, 2008). Because of this many businesses now make sure that these devices are incorporated into their work vehicles and new vehicles often have GPS software options as a core part of their internal display units (Nissan, N.D).

Also by offering a digitized map, the driver does not have to lose concentration finding the appropriate directions (Jenness, Lerner, Mazor, Osberg, & Tefft, 2008). This is valuable for drivers that are unfamiliar with the area and would often have to spend extra time searching for the correct street to take and often taking detours due to loss of bearings. This is also a much safer option than looking at their physical alternative. It, allows for the driver to save time in calculating the quickest route themselves.

Tourists benefit to a great extent when having access to a GPS device. Provided the maps in their GPS device are up to date, they are easily able to locate where they are residing and find interesting attractions - often aiding the tourism industry internationally. Many tourists are very reliant on these devices and most of their journeys become generated from the data in these devices (Pearce, 2011). Compared with physical maps, the maps in the navigation tend to be much more up to date and much easier to make amendments to with little repercussions.

A navigation system has the ability to optimize journeys. There are many different options to best deploy such resources for the vehicle (Brain & Harris, N.D). For instance if the driver sets their GPS device for the fastest arrival time, then the best route would be generated that allowed the driver to get there the fastest rather than one that includes attractions and landmarks. Settings range from finding the most scenic routes, routes which incorporate food stops, fuel efficiency journeys, and more, tailored to the driver's preferences. Businesses are able to get full utility from these settings, as they are able to maximise on saving fuel cost and also finding the quickest routes.

This device is also able to interact with newer taximeter systems (IPEXL, N.D).This makes it convenient for the operators of taxi's to easily find the destinations of their passengers, calculate costs of fares, and allow passengers to know the direction they are going if they are unfamiliar with the area.

How it is used:

Navigation systems are typically used via touch screen interfaces, while some allow for voice recognition commands. Voice recognition does allow for more input errors, and as the navigation system requires accurate destinations in order to direct drivers, these input errors can cause significant issues. (Brain & Harris, N.D).

The figure below depicts how a typical navigation operates.

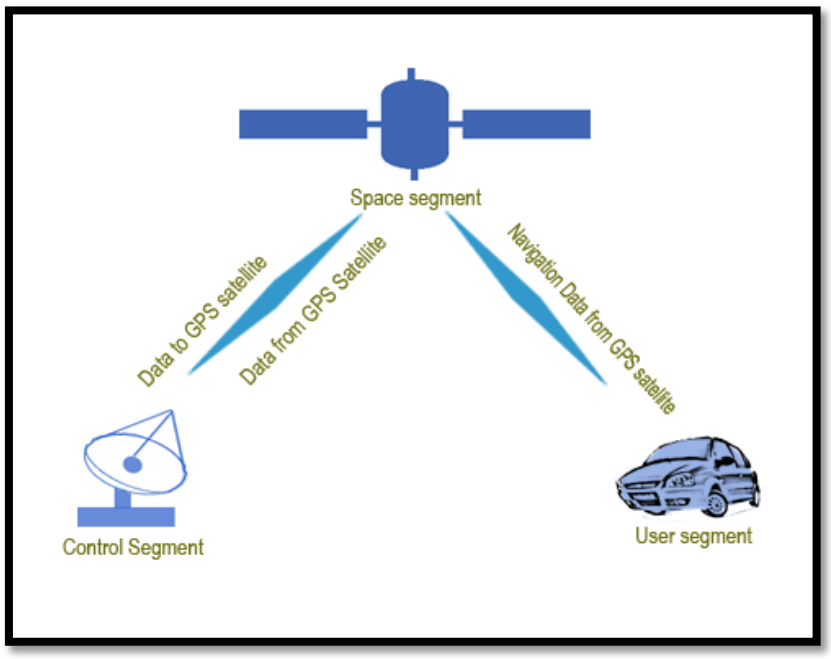

Figure 2b (Engineers Garage, N.D)

This diagram shows how information is processed between the device and information repository holding the road details. As the diagram shows, the user segment receives signals from the space segment in order to determine the vehicles location. The space segment contains multiple satellites, each sending data from its atomic clock. From the multiple signals and respectively receiving data from the space segment, the GPS system can show where the vehicle is as it moves. The control segment in the diagram makes sure that the satellites are maintained and are in the appropriate orbit. (Brain & Harris, N.D).

Upon driving and making turns, the navigation system relays directions to the driver through a speaker and audio voice. In the majority of devices, this audio voice can be changed depending on the driver's preference. Once the driver reaches their destination the navigation system resets itself and does not commence again until the driver enters in a new destination or has previously nominated where to go prior. (Brain & Harris, N.D).

Discussion:

The main problems that navigation devices present are that they distract the driver via glance time, when inputting destinations, and when relaying information. (van Nes, Cristoph, Knapper, & Wesseling, 2012) (Ishiko, Nkano, & Zheng, 2013). It should be noted that they do present a much more efficient option than a physical map. However, a major problem that may arise in the future is that users of may become too reliant on these devices and focus more on the data that the screen presents rather than actual signage on the road.

In terms of overall driver distraction, research has shown that navigation systems do not play a major part in crash risk - no different from any other in-vehicle distraction - and actually increase the driver's efficiency (Jenness, Lerner, Mazor, Osberg, & Tefft, 2008). It can be argued that these devices in fact reduce crash risk as the driver knows where they are travelling and does not have to lose cognitive focus from the driving task in order to problem solve. Most navigation systems present the vehicle's current speed, time, and other information of the vehicle all on the same interface. This means that the driver only has to look in one location to know all the relevant driving information in order to drive safely. This could also assist in showing how many navigation systems are more beneficial than harmful.

The inputting of destinations when driving creates a problem in taking a large length of focus time away from the driver, averaging to around 20 seconds (van Nes, Cristoph, Knapper, & Wesseling, 2012). The task of inputting destinations normally occurs before the vehicle is in motion and very rarely in the middle of travel. There is definitely a great concern to be noted if the driver is spending time changing destinations when driving and inputting data in this manner. Other countries such as Japan have already banned in-travel changes as a premeasure to countering this distraction (Mie Prefectural Police Department, N.D). However, due to most activity happening pre-travel, no real impact on crash rates has been noted in New Zealand.

Because these devices pose very few problems in terms of crash risk, the main focus would be whether or not there needs to be a specific standard which navigation systems should follow to make them as safe as possible. Research has already looked into whether a touch screen or swipe screen interface poses greater risk in crashes, and has shown that a swipe screen is indeed safer (Tsimhoni, Smith, & Green, 2004). A swipe screen is deemed as any screen that uses finger strokes for navigation and input, whereas a touch screen acts more like a keyboard and only takes single finger presses. It has also been shown that the location of in-vehicle devices has a great impact on a driver's sense of safety, so regulation around where device placement could also be looked into (Ishiko, Nkano, & Zheng, 2013).

Further research in this area that could be undertaken that has not arisen much is the colours of the graphical images and whether or not brighter colours or some graphics are more distracting and take longer glance time away from the driver. The manufacturers of these devices have already begun looking into safety measures these devices have and making them as safe as possible, so it might be redundant to pose legislation when they are already self-regulating. An extract taken from the company Navman's website shows an example of this. "As your safety is a big priority, the MY450LMT in-car GPS device comes with Bluetooth Hands-free and Voice Destination Entry so you can keep your hands on the wheel and avoid fines." (Navman, N.D)

Another problem that needs to be considered is that the device and road databases must be kept up to date to allow for road changes and adjustment in speed limits. For instance, if a tourist was over dependent on the navigation system to reach their destination and the roads had been altered, the tourist may not be able to proceed and effectively would be unable to continue their journey without external support. Further investigation could look into warning the driving when the device may be out-dated on older models and warning users of their limited benefit.

An overreliance in the device from some tourists has also been known to lead to death in some parts of America due to misdirecting tourists into unsafe and restricted driving areas (Clark, 2011). This shows why the driver must still remain vigilant and still be aware of signage that is outside the vehicle. Companies involved with tourists or car rental companies have an obligation of corporate social responsibility for making sure that these devices have accurate and up to date information. It would be beneficial for these companies form strategic alliances with navigation system corporations.

Built-In Vehicle Information Systems

Physical Details:

A common feature incorporated into modern vehicles is a built-in information system designed to assist the driver throughout their journey. The display and input of this device is normally located on the dashboard between the passenger and the driver. The system consists of a small screen and may include any combination of touch screen, side button, side dial, or voice recognition input. (TomTom, N.D)

Figure 3: (TomTom, N.D)

This picture above depicts a typical built-in Information System situated above the air conditioning vents next to the driver. As the picture shows, input is done via side buttons and dials could also include touch and voice features. Also incorporated into the unit is a disk drive for multimedia which would also indicate the unit having media playing features.

Benefits:

Having this system inbuilt leads to many advantages, including centralizing information, reducing misplacement of devices, and the ability of navigating the driver (Gold, N.D). The units also allow for many other different features, a brief list of which is shown below. (TomTom, N.D)

- Rear-view cameras to help prevent accidents
- Hands free device capability
- Cruise control adjustment
- Speed and time display

- Media player configuration
- Internal messaging and email system

The features of the device are not limited to the list above and as technology evolves, the unit's features will expand further. The majority of these benefits can, however be enjoyed by simply bringing other devices into the vehicle to assist the driver. For vehicles without these systems, installation is possible (TomTom, N.D). Because these devices have such great adaptability they also include some of the benefits and problems of other devices identified in other sections of this literature review, such as Navigation Systems, Smartphones, Accident prevention devices, and even in some cases Emerging Technology.

However, what makes these devices unique is that they are becoming a key component in car manufacturing and also changing the common stereotypical mechanic from a "grease monkey" into a more technologically orientated one. (Borg, 2007) While the benefit of shifting the society into a more digitally minded era is arguably positive, there are also many opportunities and possibilities that open up.

Another feature that is specific to this device is that it is able to be positioned in a way that is not possible by other devices without great difficulty. Because the device is in-built into the vehicle's body, the device is normally fixed in the middle of the vehicle's dashboard. The unit is situated in a manner that is ideal for the driver's glance and positioned in a way that does not obstruct the driver's view, which other portable devices often do. (TomTom, N.D)

How it is used:

For navigation and driver assisting features, the device itself is used as a reference throughout the driver's journey via glance time with little input required while the vehicle is in motion (van Nes, Cristoph, Knapper, & Wesseling, 2012). For further reference, the navigation section illustrates greater detail.

Most other features operate in the same matter, giving the driver information either visually or via audio with few repercussions (Sodnika, Dickea, Tomazic, & Billinghursta, 2007).

Other features, such as television viewing provides both visual and audio displays which allow the driver to be watch a variety of multimedia such as movies and video clips. This media normally comes from being television stations and what they are currently broadcasting. However more modern versions of this software can have this media come from online streaming websites such as YouTube.

Discussion:

Built-in information systems can provide a way of increasing efficiency while driving, reducing crash risk, and also increasing the comfort levels of vehicle occupants.

One feature contained in some of the units is the ability to act as a television device while driving. Unlike other features, this feature does not assist in the ability to drive, and can distract the driver by overloading information channels and evoking emotive elements (Chan

& Singhal, 2012) (Willis & Ratliff-Corporation, 2001). Because of this it is assumed to be dangerous and irresponsible for a driver to use this feature while driving. It is of a great concern to road officials. Currently in New Zealand using this feature is illegal for the driver to view while the vehicle is in motion (New Zealand Government, 2013). In Japan this feature is only legal while the vehicle is stationary, yet the feature can be unlocked on the units for a fee (Hofilena, 2013). Manufacturers will willingly install the feature onto the device which does not work while the vehicle is moving, although there are many companies willing to make the illegal practice available to drivers after the vehicle is purchased. This feature is believed to contribute to a 10% increase in the amount of crashes that occur while staring at a screen in Japan, according to members of the Japanese National Police Agency (Hofilena, 2013). This is also a problem that other devices such as smartphones and portable tablets have. However using other devices in this manner has not received much attention from researchers yet, but could be a possible issue in the near future.

The problem with in-built information systems is that manufactures are legally allowed to build in television viewing capability even if using them is illegal. There is a reliance on the manufacturer that they consider people's safety, but there are companies that will not consider people's safety if it means making a profit. It is also difficult to police if a driver is watching a television programme on the unit or using the navigation software due to the similarity the two features. (Yokouchi, Ideno, & Ota, 2000) Because of this low risk of detection, using this feature might not be a great concern to drivers and contribute to the problem of poor risk perception of drivers discussed in a later section.

Another problem that these units possess, especially as technology evolves, is that their features are nearly limitless. Any of them could increase driver fatalities. Already these units are being able to engage with drivers at critical levels, with newer units being able to have night vision features and accident prevention messages (TomTom, N.D).

An option for government departments could be that there are strict guidelines given to manufacturers of these devices for vehicles in New Zealand, similar to those the United States are implementing, such as what features are acceptable and what features are not (National Highway Traffic Safety Administration, 2012). It can, however, be assumed manufactures will address this issue as one of the focal selling points for vehicles is often on safety, particularly in vehicles which are family oriented. While other devices also present this concern, in-built systems have been created by car manufacturers and have the potential for very innovative features. They also allow for car manufacturers to shift their focuses onto different technologies and software, as well as other aspects of the vehicle such as performance and speed.

Accident prevention devices

Physical Details:

Accident prevention devices or APDs are an emerging technology in a very early stage in the adoption process. Currently they exist in two different forms. The first is through devices set up in vehicles that are purely created to prevent accidents from occurring, such as a flashing light system located in the driver's vision, or through software on common built in devices. (Benmimoun & Eckstein, 2012) (Sumi, et al., 2013). Devices such as hands-free cell phone kits can technically be classified as accident prevention devices. However for the purpose of this research only a device or software with the sole purpose of reducing crashes is relevant.

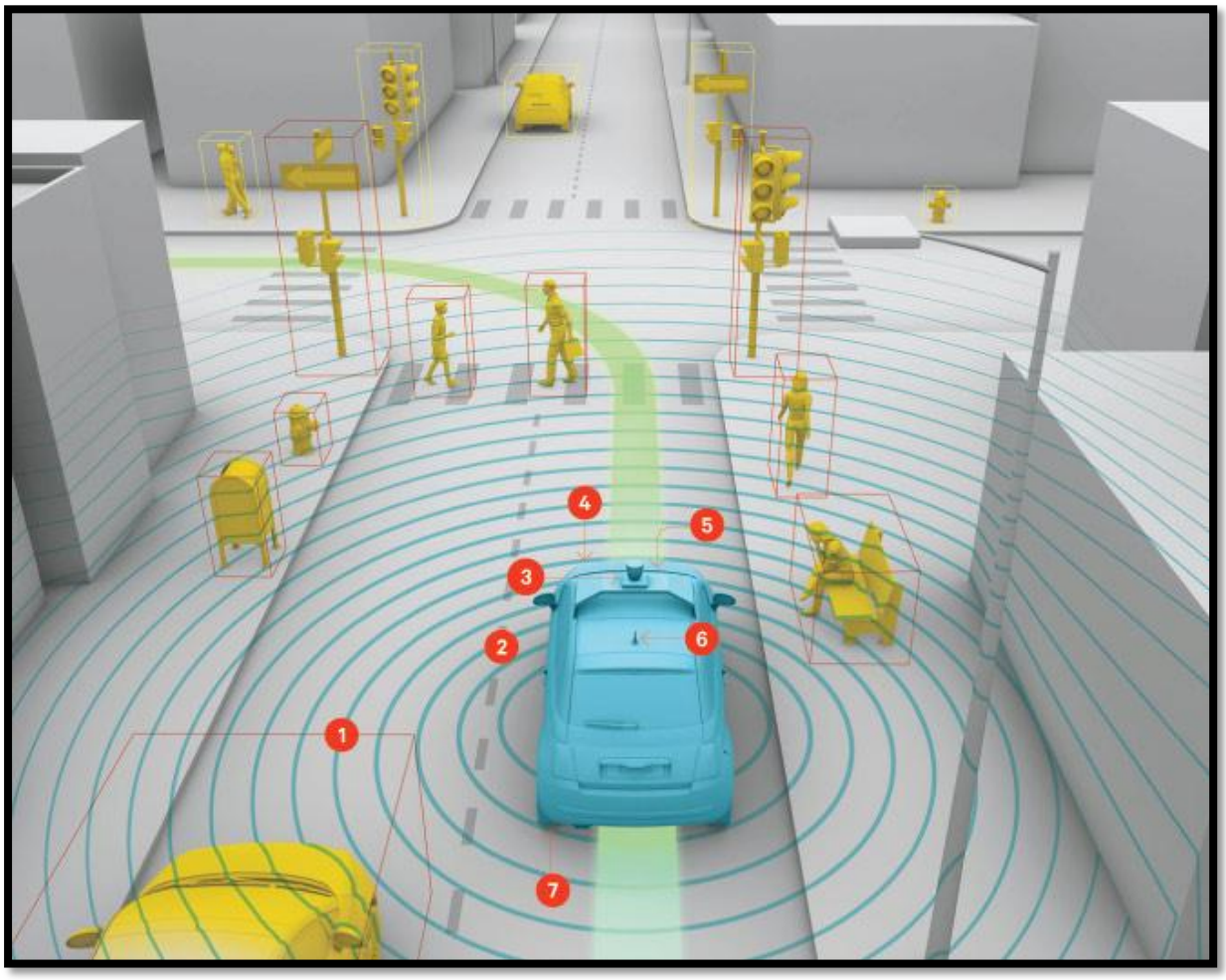

Figure 4a (Wired, N.D)

The above picture depicts a typical type of accident prevention device in which the driver is alerted of any hazards throughout their journey. The device scans the area and informs the driver of hazards through the use of any combination of flashing lights, alarm systems, or messages on an in-vehicle device with a visual display (Allard, Shrubsall, & Viegas, 2012)

(Benmimoun & Eckstein, 2012) (Varhelyi, 2002). Hazards are very specific to the type of accident prevention device. Most commonly hazards are identified through a front facing camera that searches for moving objects, although they can also be interpreted as anything that negatively impacts the driver's ability to drive, such as darkness or sun glare (Hollnagel & Kallhamer, 2003).

Different Types of APD:

Accident prevention devices have a very broad definition as mentioned above and are evolving rapidly. Some different types currently available have been listed below:

- Environment Scanning via Satellite (Benmimoun & Eckstein, 2012): Devices with this feature focus on alerting a driver of upcoming traffic conditions that come from a globalized repository. This type of device is also being looked into with regard to becoming incorporated into navigation systems and smartphones (Sumi, et al., 2013).
- Environment Scanning via Camera (Okajima, Kawakami, Sawada, Sugimoto, Takasu, & Kasuga, 2012): Devices with this feature scan the area in front of the driver and indicate hazards. This is done using different cameras and differs in what is identified as a hazard based on the manufacturer or type.
- Reverse Camera (Briggs, N.D): The most common feature that vehicles have at present is the ability to see directly behind their vehicle when reversing. This is achieved using cameras located at the back of the vehicle and the output being produced on the drivers in-built vehicle interface.
- Night Vision (Hollnagel & Kallhamer, 2003): This type of software allows the driver to have more clear vision while driving their vehicle in the dark. Some simple implementations use this system through another device inside the vehicle such as the navigation system or in-vehicle display (Hollnagel & Kallhamer, 2003). Further evolution of this system may be implemented through headsets or Google Glass devices.
- Augmented Reality (Moussa, Radwan, & Hussain, 2012): By using a headset or through a technology integrated windscreen, hazards are able to be detected in a manner similar to a combination of environment scanning and satellite detection. What differentiates augmented reality technologies from the other types is the way in which hazard detection is projected to the driver. (Figure 4b below illustrates).

Figure 4b (Worthington, 2010)

The figure above shows environment scanning via an IPhone camera. It is able to detect risks and hazards, while augmenting the driver's vision. It displays a type of graphical interface that the driver sees and identifies hazards by highlighting them and displaying a warning message near the top of the interface. The figure also shows the current speed the vehicle is going, highlights markings in the road, and shows how many frames per second that the device is processing. Colouring is also a critical element as not to confuse the driver. If a colour such as green or white was used to identify hazards, then it may not have as much of an impact and draw the driver's attention as quickly as the red colouring does.

How it works:

How a device works is very dependent on the actual form of accident prevention that is being used. All devices commonly involve being placed inside a vehicle and enhancing the driver's environment by making it safer in a particular manner. These devices may have slight differences, such as their level of detection, focus areas, or manner in which hazards will be alerted to the driver (Benmimoun & Eckstein, 2012).

Benefits:

The main benefit these devices provide is ultimately allowing drivers greater awareness of risks so that they can handle them accordingly. This can help the driver to react better or simply increase their level of awareness should they fail to identify a hazard while driving. These devices are believed to make driving a much safer task, for instance by alerting the driver when they are breaking the speed limit (Benmimoun & Eckstein, 2012).

Because the problem of distracted driving is becoming more problematic due to even more devices in vehicles, these types of devices have been suggested as a way to prevent crashes and overall reduce crash statistics.

Discussion:

Alerting the driver in order to prevent an accident is discussed in scholarly articles as being counterintuitive, as it is able to distract the driver further rather than actually reducing crash risk (Barfield & Dingus, 1998). This could be due to driver panic that is aroused through these devices, or the inability to handle the problem that the device presents to the driver. (Barfield & Dingus, 1998).

Another concern with these devices is that drivers will adopt an overreliance on technology in a sense that should the technology malfunction, or should the accident prevention devices be removed from the vehicle, then the driver would be unable to drive safely. (Tanaka, Bando, & Egawa, 2013). This same overreliance on technology can be seen in the overreliance on navigation systems addressed above in which misinterpretation or unclear road information could be fatal for drivers (Clark, 2011).

Because these devices are still very new, stating whether or not these devices are a concern is difficult as there is no statistical information from crash reports. Based on the preliminary research, it is unlikely that these devices will alarm the drivers when they detect a hazard, however this could change in the future. How the devices alarm the drivers should still be taken into consideration by the device manufacturers, as different factors such as a person's age or driving experience may change the most appropriate way to inform the driver of hazard. An example of this would be that an elderly driver may require a louder auditory alert than a younger driver.

Information overloading could be a problem should the driver also have multiple APDs trigging or the driver is manoeuvring in a difficult segment of the road. A viable option that could be incorporated into APDs is that only one device can be triggered at any given time and that the devices share some sort of communication between each other. Also the devices may want to refrain from alerting the driver in busy section of traffic where concentration is important, or the device's auditory alert is adjusted to a lower volume.

Emerging Technologies

A significant challenge that can face legislation is that it does not last long term and has to continuously be updated. In time, new scenarios emerge that would seem unimaginable when a part of legislation to address a certain problem is first created. This is seen in the current situation with regard to road regulations, where new technologies are being used while driving, which would seem completely obscure during the time the legislation was created. An example which shows how the legislation has evolved is through the addition of mobile phone bans in New Zealand legislation (New Zealand Government, 2013). The main problem with these bans in the new technological era is that it is almost impossible to make legislation for each new device that emerges. What this shows is that in order to be deemed successful, new legislation to address distracted driving from in-vehicle devices would need the following points.

1. Sustainable in the long term.
2. Target the common traits and features that devices share.
3. Consider background knowledge of emerging technologies.

With the evolution of technology, some newer innovations have already become great concerns and a great focus of scholarly research. Due to some of the newer technologies being made available to the public only recently, this segment of the literature was very limited to pending articles, conference papers, and stories in the media and did not necessarily cover them all.

One of the biggest technological revolutions that is now well known and is attracting a large amount of media attention for operating while driving a vehicle is the Google Glass device (Strickland, N.D). The Google Glass device resembles glasses and is placed on the operators head in the same manner. Using one of the lenses, the user is capable of engaging a very broad technical platform, capable of streaming videos, sending messages, and augmenting vision (Google, N.D).

The Google glass device is seen as either problematic, or a potential remedy for the distracted driving area (Ryan, 2013) (Martin, 2013). On one hand the device is capable of acting as a navigation system or accident prevention device, reducing risk (Martin, 2013). On the other, the device is able to act more problematically by acting as a messaging centre or displaying movies similar to an in-vehicle display (Martin, 2013). Based on this flexibility it is arguable whether or not Google Glass will actually impact the crash rate positively. Arguments against Google Glass also include the fact that the device is physically restricting the driver's vision and cluttering the field of view (Martin, 2013).

In one situation, an early tester of the device in California was reprimanded by authorities for driving with the device (Martin, 2013). The device was reportedly not in operation, but this was unclear to authorities, which shows how difficult policing such a device could be. Google failed to speak in response to this event, but have made it clear on their website that they want drivers to think in an ethical manner and make sure they are aware of the area's driving regulations. "Read up and follow the law. Above all, even when you're following the law, don't hurt yourself or others by failing to pay attention to the road." (Pritchard, 2013).

In response to this device, some jurisdictions have already begun outright banning of it during driving and others considering doing the same such as in New Jersey, Delaware and even the United Kingdom (Martin, 2013) (Grant, 2013). Banning the device might be the most efficient option altogether as resources are not wasted investigating and conducting research from transport officials. Although there is the possibility that Google Glass and other emerging technologies do not actually harm drivers and could be used to improve crash statistics.

Another type of emerging technology that could be problematic while driving is “Smart Clothing”. Smart Clothing allows the driver to benefit from various technological innovations built into the fabric in their clothes, such as storing information on the driver’s vital signs, and an anti-radiation mechanism (AiQ, N.D). If a problem were to occur, such as a health related injury, the driver would then feel a pulsating movement in their clothes. What this means is that this could possibly cause the driver to panic and cause injury through emotional distraction. While Smart Clothing does not currently having legislation prohibiting its use while driving, and there have not been any scholarly articles on its usage while driving, it could become a distraction in the long term. While there is no evidence to establish an argument of whether Smart Clothing is bad or not, new legislation may be introduced by other countries, specifically aimed at this technology. This shows that the current laws do not cope with multi-functioned devices and those that are more advance. It also shows that creating legislation that is most optimal for using these devices while driving is not just a problem that New Zealand is facing, but an international one.

The majority of countries investigated have not actively banned these devices and their current legislation does allow for these devices to be in use while driving. Because of this new laws are being implemented that specifically target these devices. However there are a few jurisdictions such as the United Kingdom’s that are using other legislation such as the mobile phone bans to enforce penalties when driving with these devices (Grant, 2013). In these countries the device is technically not enabled to be used while driving, however it is very unclear and is not an adequate way to legislate these devices, especially for people that are unfamiliar with the countries driving regulations.

Nomadic Devices

A nomadic device can be defined as a technological gadget that is portable and can be repositioned. Nomadic devices that a driver may operate include smart phones, media players, tablet devices, and laptops. Some of these have already been discussed in this literature review, but the category of Nomadic Devices has identifiable problems of its own.

What makes nomadic devices unique is that almost any nomadic device can easily become another type of device that this literature review has already analysed. Tablet systems are already being used as navigation systems and have the ability to become a type of phone through peer to peer applications such as Skype (Mazo, 2012). Because of this functionality, having adequate legislation for these devices becomes challenging as some of the features of nomadic devices can effectively reduce crash risk, while other features can increase it.

Rather than finding academic literature that targets nomadic devices as a whole, the majority of academic articles only analyze specific devices. However, the literature that has targeted nomadic devices has yielded some interesting findings.

One of the interesting findings is that Italy, the country with the most legislation targeting nomadic devices, and Sweden, the country with least amount of legislation targeting nomadic devices, share similar usage statistics (Jamson, What impact does legislation have on drivers' in-vehicle use of nomadic devices?, 2012). The reason for this may be because the only nomadic device for which people understand the legislation, or are aware of, is legislation which prohibits using hand held mobile phones while driving (Jamson, What impact does legislation have on drivers' in-vehicle use of nomadic devices?, 2012). Other findings show that the most common nomadic device that people possess is the smartphone, and the least common is the portable television unit (Jamson, What impact does legislation have on drivers' in-vehicle use of nomadic devices?, 2012).

The recommendations in the literature for targeting nomadic devices as a whole involve increasing people's awareness and perception of distracted driving (Jamson, What impact does legislation have on drivers' in-vehicle use of nomadic devices?, 2012). It has also been recommended that, should legislation be introduced, that this type of awareness campaign be conducted as a way to maximize the legislation's potential and increase the chance of it having a positive impact on reducing crash rates (Jamson, What impact does legislation have on drivers' in-vehicle use of nomadic devices?, 2012).

From literature not specific to nomadic devices, there have also been suggestions on how to make the device as safe as possible (Tsimhoni, Smith, & Green, 2004) (van Nes, Cristoph, Knapper, & Wesseling, 2012). These recommendations include:

- Forcing drivers to have these devices mounted when operated to eliminate aspects of their physical distraction.
- Not having a touch screen input while the vehicle is moving.
- Having audio functionality rather than a visual display.

Legislation

"Every statute, case in litigation and crisis we face today was once an ethical dilemma that was not resolved in the proper manner. Regulation, litigation and scandal result because an issue was not resolved properly, the problem grows and the public becomes aware and demands action." (Jennings, 1998)

Currently New Zealand land transport legislation deals with two of these in-vehicle devices, which are restricted to be used while operating a motor vehicle. These are handheld mobile phones and television display units (New Zealand Government, 2013) (New Zealand Government, 2004).

In 2009, New Zealand made changes in mobile phone usage while driving, prohibiting the use of handheld devices behind the wheel through amendments to the Land Transport (Road User) Rule 2004. (New Zealand Government, 2013). Prior to that, the Land Transport Rule (Vehicle Equipment) 2004 had been made to ensure that television displays in motor vehicles where used in a safe manner in which the screens where not visible to the driver (New Zealand Government, 2004). Upon first implementing the change in television displays, the legislation had unintentionally banned in-vehicle display units that early adopters such as taxi drivers relied on in every day work. This required those implementing the legislation to quickly apply an amendment to cater for these stakeholders, possibly showing hints of fragility and counter-intuitiveness in the legislation to begin with.

The following text from the Vehicle Equipment Rule's restriction on fitting televisions is somewhat vague and difficult to interpret, ~~given their many sub-clauses and possible exceptions.~~

> "Except as provided in 2.5(2), *any part of the image on a television screen* fitted in a motor vehicle must not be visible to the driver of a motor vehicle from his or her normal driving position while the motor vehicle is in motion" (New Zealand Government, 2013).

Similar difficulties can be found in the Road User Rule clause 7.3A restricting the use of mobile phones, particularly given the many sub clauses and possible exceptions.

> "(1A) Sub-clause (1) is overridden by Sub clause (2) to (7)"
> (New Zealand Government, 2013).

> "A driver may, while driving a vehicle, *use a mobile phone* in a way described in sub clause (1)(a) or (f), if both the following apply: (a) the phone is secured in a mounting fixed to the vehicle; and (b) if the driver manipulates or looks at the phone, he or she does so infrequently and briefly." (New Zealand Government, 2013).

This type of behaviour described may be a factor in the driver's perception of the legislation and how they comprehend what is legal. Before implementing the changes to the handheld law, a study was conducted into the amount of handheld mobile phone usage while driving. In comparison with these results and new data, the New Zealand Medical Association was able to find a slight reduction in usage while driving, but not to the major decrease that was intended (New Zealand Medical Association, 2013).

Various studies have indicated that simply changing legislation to prevent hand held mobile phone usage does not solve the cognitive distraction problem identified earlier, as people simply swap to hands free devices. "Insurance collision loss experience does not indicate a decrease in crash risk when hand-held cell phone laws are enacted" (Trempel, Kyrychenko, & Moore, 2011). The distraction evident in handheld mobile phones still remains in hands free phones, which shows that there is a type of distraction that is still an issue.

From this, a wide array of reasons have been offered which all hold valid points as to why crash risks have not seen significant reductions. These include the fact that the penalty for being caught breaking the legislation is very minimal, that the need for, or addiction, to cell phone devices is very high, that the risk of driving distractions is perceived to be very small, and that it is difficult to police such legislation to begin with. (Trempel, Kyrychenko, & Moore, 2011) (Horrey & Kidd, 2010) (Hooper & Zhou, 2007) (McEvoy, Stevenson, & Woodward, 2006).

Reflecting back on the indicated problem, there are an increasing number of technological devices which have the ability distract a driver. Currently legislation does not clearly affect a wide range of in-vehicle devices. It can be seen that the implementation of the 2009 hand-held cell phone ban while driving has had minimal success, not only in New Zealand, but also where similar legislation has been introduced worldwide. Should legislation be implemented to combat in-vehicle device distraction, not only would it need to be clear in what is unacceptable when driving, it would also need to make sure it is sustainable for emerging technological devices.

People's Perception

A major problem that has been at the core of a number of articles is that people's perception of risk is minimal and contributes to the increase in crash risk. This aspect is very dependent on age and previous driving experience, showing younger and inexperienced drivers with more problematic misperceptions (National Highway Traffic Safety Administration, 2012). Younger drivers also have been noted to have a correlation with older vehicles which may impact results from the literature examined (Watson & Newstead, 2009).

Identifiable in research conducted by William Horrey & David Kidd is the overconfidence in driving that people have in terms of their ability to drive and also their ability to handle risk (Horrey & Kidd, 2010). What this means is that drivers are more willing to put themselves in risky situations and perceive that their driving ability is much greater than their actual ability. Statistics show that three in five drivers under the age of 25 are confident enough driving in risky conditions such as answering a phone compared with one in four drivers overall (National Highway Traffic Safety Administration, 2012). Similar findings of overconfidence have also been found in New Zealand Drivers by the National Road Safety Committee (National Road Safety Committee, 2008). This shows that younger people are much more at risk because they are more likely to engage with in-vehicle devices. This trend could be countered with advertisements specifically aimed at younger people or through awareness campaigns in schools - as has already been explored in the US (National Highway Traffic Safety Administration, 2012).

In the past, New Zealand has dealt with many driving related issues such as drink driving and fatigue using advertisement campaigns (Macpherson & Lewis, 1998). These advertisements featured shock tactics and were aimed at the people that had the highest involvement statistics in that problem area. Results suggest that the advertisements need to be relevant to the target audience and not to be too surreal to have any impact (Macpherson & Lewis, 1998). Expanding from this, some advertisements have had great success due to becoming social media sensations (Prince, 2012). This has been shown to induce great memory recall through the advertisement and to have a great affect in that regard. However, social media have been shown to be an unreliable channel for future advertisements as the chances of advertisements becoming social media sensations is very low (Prince, 2012). Future advertisements have been recommended to relate more to the average driver and rather than depict drivers as "Bloody Idiots", acknowledge that drivers simply make mistakes on occasion (Prince, 2012).

Drivers are also not aware of the impacts of an in-vehicle distraction and to what extent it increases their crash risk. The common perception of engaging with a distraction is that it will have a very minimal effect regardless of the traffic conditions, glance time, cognitive effects, or any other type of distractions as identified in previous sections of this literature review (Horrey & Lesch, 2009). While the correlation between distractions and crashes while driving is not as strong as it could be, it is very underestimated by the common individual in New Zealand.

Branching off this, businesses are starting to take corporate social responsibility of this awareness, and in some cases employers will enforce the use of hands free mobile phones while driving as part of their employee contracts and rules (Insurance Journal, 2012). This shows that the power to change people's awareness about these issues does not solely belong to a government body, but also to corporate entities.

It should also be noted that legislation does not always change people's perception of risk. From the New Zealand hand held mobile phone banning legislation in 2009, results have shown that people continue to operate these devices while driving. One of the reasons is due to the fact that the legislation is difficult to police. However, even though it is difficult to police, legislation still has overwhelming benefits in its creation, such as raising great amounts of awareness, changing ethical standards, and also having some effect on crash risk, even if it is minimal (New Zealand Medical Association, 2013).

Another reason that legislation does not have a great impact on drivers, is that drivers do not see the penalty if they are caught as high enough to stop the act while driving (New Zealand Medical Association, 2013). What this means is that the penalty for legislation breaches needs to be at a significant level in order for those people to cease the prohibited act. Since there is very great difficulty in policing the use of driving distractions, the penalty should be at a fairly high level in order to be less likely for drivers to take the risk of being prosecuted. (Horrey & Kidd, 2010)

The US has seen people's perception as a major problem in distracted driving and has established many campaigns to address this in their publications (National Highway Traffic Safety Administration, 2012). In a variety of literature, driver distraction is perceived as one of the largest global problems, and is often given its own section in driving related literature.

Conclusion

With the evolution of technology the number of devices that can be operated while driving has increased dramatically over the past decade. These devices are being produced at rapid speeds, making the area more difficult to regulate and opening more opportunities for driver distraction.

From the literature reviewed, there is very little on more innovative technology that we see in the present, such as Google Glass. It should also be noted with regard to scholarly literature that when addressing the problem of distracted driving, publications are faced with a time lapse problem. In order to become a scholarly article, a rather long time passes before the article is published and used, ranging from half a year to two years. In this same period of time and with reference to Moore's law, technology evolves, possibly making the literature either no longer relevant, or biased. Because of this problem, the majority of the literature reviewed has come from conference proceedings and popular literature.

There is little reference to the newer technology in scholarly articles and academic based journals. Because of this, proposing legislation that is sustainable and targets these devices is difficult. There are, however, a few signs of this problem improving as emerging technology is becoming more of a focus at scholarly level than in the past. The type of in-vehicle devices available at present are very broad, ranging in appearance, purpose, and danger levels. Not only are the types of devices very broad, many are adaptable and can either assist drivers or distract them. This makes it difficult to create legislation against a

certain device when it is in operation as another type of device and even more difficult to police.

While visual distractions can increase crash risk, the most problematic risk identified is the emotive distraction some devices can cause a driver. Research has shown that emotively engaging the driver causes flustering and loss of control. Emotive distractions while driving can be seen in conversation devices, television units, and even some advertisements outside the vehicle.

The table below shows a summarized chart of different devices and how they can impact a driver. The risk of crash is an estimation based on whether a device's primary use is emotively distracting. A device with a high risk is believed to double the chances of crashing when used based on emotive distraction results from mobile phone studies (Box, 2009). A medium risk device is believed to show the same increase, however the device is less likely to be used in a way that is emotively distracting than a high risk device.

Device	**Main Usage**	**Other Usage**	**Primary Distraction**	**Secondary Distraction**	**Input Methods**	**Risk of Crash**
Smartphones	Conversing	Messaging Navigation Accident prevention Watching Media Radio / Music Reading Other Functions	Physical **Emotive** Cognitive	None	Voice Recognition Touch Screen Buttons	High
Hands Free Phone	Conversing	None	**Emotive** Cognitive	Physical	Voice Recognition Buttons	High
Navigation Systems	Navigation	None	Physical	Cognitive	Voice Recognition Touch Screen Buttons	Low
Built-In Vehicle Information Systems	Navigation Messaging	Hands Free Phone Watching Media Accident prevention Radio / Music Other Functions	Physical Cognitive	**Emotive**	Voice Recognition Touch Screen Buttons	Medium

Portable Television	Watching Media	Media Affairs	Physical **Emotive** Cognitive	None	Buttons	High
Accident prevention devices	Accident prevention	None	Cognitive	Physical **Emotive**	Not required	Low
Google Glass	Augmented Reality	Messaging Watching Media Conversing Navigation Accident prevention Radio / Music Reading Other Functions	Physical **Emotive** Cognitive	None	Not required	High **Perceived*
Smart Clothing	Human Analysis Heating & Cooling Location Tracking	Other Functions	Cognitive	Physical **Emotive**	Not required	Low
Media Players	Playing Music	Radio	Cognitive	Physical **Emotive**	Buttons Touch Screen	Low
Tablet or Computer Device	Entertainment Typing / Reading	Messaging Watching Media Conversing Navigation Accident prevention Radio / Music Reading Other Functions	Physical Cognitive	**Emotive**	Touch Screen Buttons Voice Recognition	Medium

Possible Options

From this point there are several options which the Ministry of Transport could consider in order to combat distracted driving.

Prohibit specific devices: One option that the Ministry could choose would be to prohibit specific devices, similar to current legislation. This would involve naming the devices, for example, no tablet devices, laptops, or cameras may be used while driving. The problem with this type of legislation would be that it is not sustainable for emerging technology and would require frequent updating and holistic judgment to decide which devices to prohibit. A more viable option would be to prohibit a trait all devices have, such as any device with access to media elements. However, this could be counter-productive and restrict many devices, even if they are not used in an unsafe manner.

Outlaw any internal distraction: The Ministry of Transport could go as far as prohibiting any in-vehicle device, similar to some cities in Canada. This would definitely reduce the crash rate, yet there is also a great need among many parties to have some of these devices in action while driving. Some tourists require travel assistance and some businesses would prefer that their employees use navigation software in company vehicles to increase efficiency. There is also a social need that people require access to a mobile phone and also a constant link to emergency services or family. This also raises the ethical dilemma of a

utilitarian point of view in terms of the greatest good for the greatest number, in which it would be more ethical to not rule out internal distractions completely.

Advertisement campaigns: One option that is quite effective and that America has already used successfully is advertising campaigns to increase the awareness of drivers. This would be very beneficial, especially if aimed at a younger audience or inexperienced drivers. Driver perception has already been shown as a major issue so this would definitely be a viable option. The downside would be that if a device is risky to use while driving, it will remain a problem no matter how aware people become of the risk. Also there is no guarantee that a campaign would raise people's perception especially as there is already a need for in-vehicle devices. Overall it should be included as an option to consider as there is low risk and high reward if an advertisement campaign is conducted. On its own advertising is definitely not a solution to targeting driver distraction, yet it would definitely be a valuable part of any long term plan. It should also be noted that the advertisements would need to be relatable to drivers and that social media has been so far shown to be an unreliable marketing channel.

Make recommendations or regulations for device manufacturers: Another option would be to make recommendations for the manufactures of the devices, something that America has also already done to combat distracted driving. For the majority of well-known device manufacturers, due to corporate social responsibility, user safety is an important factor already and even in some cases a selling point. While most companies are self-regulating and value their customers' safety, there are those that don't, which could be problematic in the long run. This should not be seen as a big issue for New Zealand at the present time as America has already made recommendations, and the majority of manufacturers, in essence, have already been covered. Those that have not been covered by these recommendations have little market presence in New Zealand. Therefore this option does not seem necessary at the present time. However, it could be a possibility in the future, but is unlikely to be New Zealand specific.

Have newer vehicles disable devices while driving: One of the groups that are most at risk from distracted driving is younger drivers and inexperienced drivers. This segment also shows high correlation with having older vehicles, which would mean enforcing the disabling of devices in newer vehicles would have little impact on their crash risk. As mentioned, there is also a need for some people to have that constant link to family and emergency services while driving. However, having newer vehicles disable devices while driving could be a viable option as newer vehicles will likely have more emerging technological distractions as time progresses. This could also target the problem area as high level employees are one of the biggest segments that converse on phone devices. The disabling of some devices while driving would also allow information overloading to be limited so that devices that did not need to distract the driver, were unable to while driving. Overall having this recommendation to not allow certain devices to be active while moving would be beneficial. These devices would be those that are identified as having an emotive distraction as the main form of distraction in the above table.

Increase penalty of current legislation: The current legislation on cell phone usage while driving has had little impact on drivers, and it has been noted that drivers perceive the risk of distractions as not being an issue. By increasing the penalty, drivers may still not see the risk as an issue, yet they would see the penalty of being caught as a greater deterrent against breaking the law if penalties increased. Also literature has shown that drivers operate hand-

held mobile phones and other distractions in traffic light areas. It should be noted that these locations would be ideal places for policing for enforcement to occur.

Not create legislation: There is the option not to create any legislation at all. However, the other options do not seem contributable enough to combat driver distraction on their own. There is also the factor that even though legislation might be difficult to police and not seem viable, it helps to create awareness and change people's ethics on a certain action and redefine their judgements. Creating new legislation is an effective way to show people what is acceptable in society and draw in people's attention to any given issue. Because driver perception of current legislation and using devices while driving is such a major problem, this attention is definitely needed. This is why if legislation is not introduced, driver's awareness may still be a major concern.

Legislation to combat distracted driving would be difficult to implement. Legislation against in-vehicle devices would ultimately not be able to restrict people on its own, and policing it would be extremely difficult. Yet it would be to send a very clear message that driving with some devices is unsafe for those who do not fully see that risk.

If new rules were to be implemented, an example of this has been created below to outline an ideal scenario. These rules are only suggestions and possibilities that the Ministry of Transport could consider, and are not evidence that future legislation will be implemented.

Ban on Inappropriate Device Usage While Driving

(1) A driver must not while operating a motor vehicle –
    (a) Operate a portable device that is not securely mounted to the vehicle
    (b) Operate a technological device for purposes unrelated to the driving task while the vehicle is in motion
    (c) Have vision to a technological device that is unrelated to the driving task while the vehicle is in motion
(2) A purpose that is unrelated to the driving task includes –
    (a) Reading any form of media or imagery
    (b) Watching any form of media or imagery
    (c) Using any form of messaging system
(3) A device unrelated to the driving task may be operated in a vehicle if its only form of output is audio based.

Recommendations

Based on the findings from the literature review there are several core facts that have been identified. While driving a vehicle, people face the severe issue of being distracted by a wide range of devices should the driver operate them. Such distraction may be through reduction

in vision, information overload, or other driving impairments. Four devices have been identified as a high risk, should the driver use them while driving. This is due to their primary usage playing part in distracting the driver emotively. An emotive distraction can lead to the driver being flustered, losing control of the vehicle, and has been shown to narrow vision.

Also identified in the literature is that there are several devices which may not impair driving in their primary use, but one of their secondary uses may cause the driver to become distracted emotively. There is a large pool of devices which may cause emotive distractions, with new innovations also capable of being used in ways that are emotively distracting. This makes it difficult to prohibit or regulate the usage of a specific device or feature legislatively in an optimal manner.

If legislation were to be introduced, rather than prohibit involvement in an emotive distraction it is recommended that the driver is able to do so in a situation that is as safe as possible. This would mean creating legislation that prohibits the other distractive elements of the device and situations that could put the driver in a dangerous position. An example of this would be to legislate to securely mount devices, so that the level of physical distraction is mitigated.

The two problem segments that are at the biggest risk from emotive distractions are inexperienced or young drivers and employees.

Inexperienced and young drivers both share the problem of being unable to deal with the high levels of distraction due to extra attentiveness this requires when driving a vehicle. One recommendation that could assist this problem is the prohibition of any in-vehicle device unless drivers are a certain age, or have a specific amount of on-road experience. Another option could be that operating a number of devices is part of the New Zealand driving test, or that a specific permit is required to use these devices first.

Employees on the other hand also are the largest group of people that are likely to be emotively distracted, especially those in higher positions. This shows a need for companies to improve the state of distracted driving by creating and enforcing policies against driving with a device that is capable of distracting the driver emotively. It is highly recommended that more employment policies address this issue and human resource departments conduct investigations into dealing with this problem. Legislation could also be invoked to create guidelines for companies and set a universal standard while driving a vehicle in employment conditions.

Another major part of emotive distractions is that the perception of interacting with devices is unrealistic and very dangerous for drivers. It is advised that social marketing campaigns take place, targeting risky practices and emotive distraction in a way that is not only relatable to the driver, yet it also creates a greater awareness on the issue of emotive distractions.

Finally the literature identified the existence of the ability to disable certain newer devices or functions by Internet Service Providers and telephone companies, which could be done through redirecting message systems. It is recommended that these Internet Service Providers further enhance this system for use while driving in order to target emotive distractions. Doing so would help to deal with the addictiveness of mobile phone use and restrict a driver from feeling the social need to reply to a message as quickly as possible.

Requiring new technologies be able to disable themselves while their user is driving a vehicle could also be a possible requirement.

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