SCOPING STUDY OF MOBILE PHONE USE WHILE DRIVING

Final Report

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EXECUTIVE SUMMARY

Background

The use of mobile phones and other mobile technologies has been increasing, and the effects on driver distraction are of concern. Australian jurisdictions regulate mobile phone use while driving and conduct enforcement, however there is a need to review current arrangements and consider the possibilities for change in the context of a rapidly changing technological environment. CARRS-Q was commissioned by The Department of Infrastructure and Regional Development to undertake this scoping study, examining: crash data; research evidence; regulatory and enforcement practices; technological solutions; and the implications of nomadic devices interacting with in-car systems.

Methodology

Crash data were sourced from publicly available sources and requested via agency channels. The National Coronial Information System (NCIS) was also investigated, as was police infringement notice data. The academic and grey research literature were reviewed for information on the crash risk associated with mobile phone use, and for evaluation of regulatory and enforcement approaches. Transport and police agency officers were interviewed to develop a picture of the regulatory frameworks and enforcement practices used in Australia, and to discern common areas of policy interest. Information on possible technological solutions to mobile phone distraction, and emerging technological challenges, were also reviewed and discussed.

Results

The available crash data show very low involvement of mobile phone use in crashes, due to the difficulty in determining whether a phone was being used at the time of the crash. Data from naturalistic studies suggests that distracted driving is very common, and is associated with increased crash risk, for example all forms of hand-held phone use combined were found to increase crash risk by 3.6 times in one major U.S. study. While there is a methodological debate about the validity of this figure and the risk of conversing on a mobile phone, there is agreement that non-conversation use is associated with increased crash risk. Given the high rates of illegal mobile phone use while driving, with 45% of respondents in a recent Australian study locating/answering a phone on a typical day, the risk ratio found in the U.S. study implies that contribution of mobile phone distraction to crashes in Australia is likely to be high. Police impressions from the jurisdictions are that use is rising and becoming harder to detect, consistent with the information from the literature.

Mobile phone use is regulated by Australian Road Rule (ARR) 300, which has been adopted as is, or with minor variations, by each jurisdiction. Most jurisdictions apply additional restrictions for P1 and P2 drivers, and there are other variations in offences. The size of the financial penalties varies between $250 and $511 between jurisdictions, the number of demerit

points varies between 3 and 4, and the application of double demerit points applies in some jurisdictions for either holiday periods or multiple offences within a year. While the core of the regulatory frameworks is ARR 300, there is variation across jurisdictions that could be addressed.

Enforcement data generally show little increase in enforcement, most likely a decrease compared with population growth, even though there is a strong impression that distracted driving has increased. Police report most commonly using motorcycles to detect mobile phone use among drivers, and to a lesser extent cameras, and there is variation between jurisdictions in the evidentiary provisions that apply to the use of cameras. A new camera system is being trialled and could be promising if it is possible to develop an image processing algorithm that will detect mobile phone use. Several jurisdictions commented that enforcement alone was unlikely to be effective, and proposed a need for technological solutions and for social change to enable people to manage their use of mobile phones in a safer way. The research literature does not provide much information about effective enforcement and penalties for guidance.

New technologies such as in-vehicle workload managers and workload management apps are being developed, but there is almost no evaluation of their acceptance and effectiveness. At the same time, new and potentially distracting technologies are also emerging. A similar situation applies with nomadic technologies, where better integration of systems through applications such as Apple CarPlay and Android Auto can enable voice activated mobile use, but at the same time may still require some manual operation and draw the driver's attention away from the road. While voluntary lock-out systems are already available as apps or proprietary software (e.g. Apple's 'Do Not Disturb' feature), they are unlikely to be used by drivers who constitute the greatest risk due to their prioritisation of staying connected. An EU report on good practice (in the absence of evaluation data on best practice) rated lock-out systems and workload managers as the least effective anti-distraction measures, instead favouring anti-collision warning devices that do not prevent distraction, instead warning distracted drivers of danger. It appears that the lack of maturity of lock-out technology has contributed to low acceptance, so that it may have potential in the future.

Limitations

Constraints on the time available for this review limited the amount and range of crash and enforcement data that could be collected, although the participation of agency representatives was almost universal.

Future Directions

A key focus of this study was to recommend ways that Australian jurisdictions could address mobile phone distraction more effectively. It was noted that the structure of government in Australia entails the need for consensus among the jurisdictions, and that the approach taken to road safety across Australia relies on an evidence-based approach. Consideration of these

points suggests that, in the short/medium term, the best way to work towards a nationally agreed policy direction is to:

- Consult researchers with relevant expertise to determine the evidence base on which policy can be developed, including a resolution of the current active debate on the validity of naturalistic driving study crash risk estimates, i.e. whether the data indicate that hands-free conversation constitutes a crash risk

- Investigate means of collecting valid, reliable and comprehensive data on mobile phone involvement in road crashes, such as in-vehicle recording of phone use immediately before a crash

- Explore enforcement options that can be implemented by all jurisdictions, including the possibility of automated enforcement based on technology currently being trialled in Western Australia

- Explore technology options that balance the costs and benefits of reducing or blocking connectivity of mobile phones in vehicles; at present there is evidence that these technologies are not sufficiently developed and as a result have low user acceptance

In the longer term, the social context of mobile phone use needs to be explored and addressed, though this would take place in a broader context and draw on social education approaches. Schools around Australia already address both negative and positive aspects of mobile phone use, however the notion of "mobile phone addiction" is an emerging issue that appears not to be systematically addressed as yet.

1 INTRODUCTION

The wide uptake of mobile phone and other mobile technologies has raised concerns about the prevalence and impact of driver distraction, and how to address the problem through regulation and enforcement. The Department of Infrastructure and Regional Development has commissioned the Centre for Accident Research and Road Safety - Queensland (CARRS-Q) at the Queensland University of Technology (QUT) in collaboration with the Australian Road Research Board (ARRB) to undertake a scoping study encompassing the following tasks:

- Review of available data on the contribution of mobile phone/device distraction to fatal and serious injury crashes in Australian jurisdictions.
- Review of current available Australian and international research evidence and regulatory approaches in relation to the risk of mobile phone use and device use - including calling, texting and social media use - while driving.
- Review of the current regulatory regimes and enforcement practices across Australia and the identification of common policy goals across jurisdictions.
- Consideration of the scope for existing and new technological approaches to assist in reducing the risk of mobile phone use.
- Consider how nomadic devices are used in relation to in-car systems and the interaction of these devices with other in-car technology.

This report outlines the methodology used to undertake the review, which covers the solicitation of crash and infringement data, a review of the literature on crash risk related to mobile phone use, consultation with transport and police agencies on the regulatory framework and enforcement approaches, and identification of technology challenges and possible solutions. Recommendations are made regarding future development of policies and regulations.

2   METHODS

2.1   REVIEW OF CRASH DATA

Publicly available crash data sources from each Australian State and Territory were examined for information on the contribution of distraction from any sources and mobile phones/devices in particular. These sources include annual reports published by Police services and Transport authorities, interactive self-service web pages where data can be downloaded in tabular and graphical form and de-identified unit records via open data portals. Requests for annual counts of the number of fatalities and seriously injured crash casualties where distraction and mobile phone use were contributing factors, were also made to the crash data custodians in each jurisdiction.

These sources were also searched for information on the number of infringements issued for improper use of mobile phones while driving. Specific requests for infringement data were also made to the data custodians.

An additional source of information on the contribution of mobile phone use in fatal crashes is the National Coronial Information System (NCIS). The NCIS contains information about deaths reported by coroners in Australia and New Zealand. The data records demographic information about the case, time, location and activity at the time of the incident and death, cause of death and for external cause of death, the mechanism of injury and the object or substance involved. Police narratives of the circumstance, pathology reports, toxicology reports and coronial findings are also attached to the case record. A request was made to the NCIS to count the number of motor vehicle fatalities who were injured in crashes involving a mobile phone, and to conduct a review of the coronial findings and police reports attached to a subset of these fatalities.

2.2   LITERATURE REVIEW

A comprehensive literature review of available practice and evaluation tools relating to the risk of mobile phone use and device use, and regulatory approaches was conducted. For the purpose of this review, we have investigated national and international literature on mobile phone use while driving, with a focus on Australia and New Zealand. Relevant material from elsewhere around the world is included, with emphasis on countries with similar road safety performance (nearly 5.4 fatalities per 100,000 population (WHO, 2015)) or scientific significance such as the U.K. and U.S.A. Particularly, we included literature when cultural and social differences have not played a significant role in shaping the results. Peer-reviewed and grey literature has been covered.

The review involved a systematic search of various sources (outlined below) including both published and grey literature. Relevant research findings were identified by searching:

- Transport, social science, health, and road safety online databases (e.g., Pub Med, Science Direct, Ebsco, Proquest, Blackwell Synergy, TRIS online);
- Generic internet search engines (e.g., Google scholar);
- Websites of recognised road safety organisations;
- Published government reports;
- Peer-reviewed conference proceedings (e.g. Australasian Road Safety Conference; Annual Meetings of the US Transportation Research Board; International Conference on Traffic and Transport Psychology etc);
- Manual searches of key road safety journals (e.g., Accident Analysis and Prevention); and,
- Cross-referencing of obtained studies.

2.3 STAKEHOLDER CONSULTATIONS

Stakeholder consultations were conducted in order to obtain information on the regulation and enforcement approaches taken by different Australian jurisdictions. The discussions encompassed regulatory approaches, their advantages and shortcomings. In addition, secondary sources available on transport and police websites for each State were reviewed. Discussions also canvassed the issue identified above regarding police reporting of mobile device use in crashes, in terms of system disincentives to report, and alternative approaches and police data sources (See Appendix A for interview guide).

Representatives from transport authorities and police in all Australian jurisdictions were invited to take part in an interview via phone with a member of the research team. Consultations have been held with representatives of transport authorities in all Australian jurisdictions. With regards to the police, at the time of submission of this final report, consultations have been held with representatives from all jurisdictions, with the exception of Victoria.

3 REVIEW OF AVAILABLE DATA

3.1 BACKGROUND

Each Australian State Police agency is responsible for collecting information on road crashes, and this data can be used to determine whether charges should be laid for individual crashes, to monitor trends in road crashes both overall and by category (e.g. road user type, severity level, crash type, crash location, offence involved), and to identify emerging problems so that they can be addressed. Crash report forms are designed to meet these needs, although in practice they often represent a compromise between the immediate needs of police and the research needs. Crash forms incorporate items that identify factors that are considered to have contributed to a crash, with the word "contributed" being preferred to "caused" for both legal and scientific reasons. Many of the crash report items and contributing factors have been standard for decades, however the widespread uptake of mobile phones and an increasing array of other mobile technologies that can distract drivers has created an ongoing challenge for police to identify and report on instances where distraction from such sources has contributed to a crash.

The main aim of this part of the scoping study was to examine crash data from Australian police agencies to ascertain how distraction by mobile phones and other mobile technologies is recorded, and the reported prevalence of crashes to which this form of distraction has contributed. At the outset, the expectation was that there would be low levels of reporting because of the difficulties involved in determining whether technology was being used just before or during the crash, and because drivers involved in crashes may not report forms of distraction. The likely scale of distracted driving will be addressed in more detail in section 4, where naturalistic driving studies have provided a previously unseen level of information about what drivers are doing at the time of a crash.

A second approach to this task involved ascertaining the possibility of obtaining data from the National Coronial Information System (NCIS). As a repository for detailed coronial information from around Australia, NCIS has the potential to provide rich data about the circumstances of fatal crashes, including qualitative judgements about the possible involvement of distraction in the crash. However, obtaining ethical approval to access the NCIS records, the expected timeline to have the request processed and financial requirements to access these records could not be fulfilled within the time constraints of this study.

Finally, as part of the consultation with agencies outlined in section 5, contacts from police and transport agencies were asked about the crash investigation process in each jurisdiction, i.e. how the potential contributing factors are investigated, prioritised and reported on. As part of this, we examined the possibility that legal and other considerations may provide a disincentive for police to report possible mobile device use, based on informal information that this was an issue in at least one jurisdiction.

3.2 POLICE AND SELF-REPORTED DATA FROM JURISDICTIONS

3.2.1 PUBLICLY AVAILABLE CRASH DATA

Queensland (Department of Transport and Main Roads, 2016) and Victoria (VicRoads, 2016) have published reports that include counts of the number of people killed and seriously injured in crashes when distraction was a contributing factor in the crash. New South Wales has published a series of reports, for example Centre for Road Safety (2016), that recorded the number of crashes where distractions from sources inside or outside the vehicle were a factor between 1997 and 2015. Between 1997 and 2011, this series also reported on the number of crashes where the use of a hand-held mobile phone was a contributing factor.

In Queensland between 2010 and 2014, an average of 12 (5%) fatalities per year were the result of a crash involving a distracted driver or rider. In 2015, this increased to 25 (10%). In Victoria, over the 3 years from June 2010 to July 2014, an average of 216 (4%) people per year were hospitalised from crashes involving distracted drivers or riders. In the 2014/15 financial year there were 223 (5%) people hospitalised in distraction related crashes. Information on the number of fatalities from crashes involving distracted or inattentive drivers or riders was not available.

Table 3.1 Fatalities by characteristic, Queensland, 2015 compared with 2014 and the 2010 to 2014 average

Characteristic	2010 to 2014 average		2014		2015		2015 vs 2014		2015 vs 2010 to 2014 average	
	n	%	n	%	n	%	n	%	n	%
Involving distracted/inattentive drivers/riders	12	4.7%	12	5.4%	25	10.3%	13	108.3%	12.8	104.9%
All fatalities	258	-	223	-	243	-	20	9.0%	-15.4	-6.0%

Table 3.2 Persons seriously injured by factors/components of individual road trauma, Victoria, 2013/14 compared with 2014/15

Factor/Component	2014/15		2013/14		2013/14 to 2010/11 (3 year average)		% change 2014/15 vs 2013/14	% change 2014/5 vs 3 year average
	n	%	n	%	n	%	n	n
Distracted drivers and riders	223	5%	267	5%	216	4%	-16.5	3.2
Total persons seriously injured	4951	-	5198	-	5266	-	-4.8	-6.0

In New South Wales between 1997 and 2011 (Centre for Road Safety, 1999, 2000a, 2000b, 2001, 2003, 2004a, 2004b, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012) there was an average of 1 (0.1%) fatal crash every two years associated with the use of a hand-held mobile phone. In comparison there was an average of 3 (0.6%) fatal crashes per year associated with a source of distraction inside a vehicle and 22 (5%) fatal crashes per year associated with a source

of distraction outside the vehicle. The involvement of distraction and hand-held mobile phone use had a similar pattern among all reported crashes in New South Wales over the same period. In New South Wales for all reported crashes, an average of 34 (0.1%) crashes were associated with hand-held mobile phone use, 988 (2.1%) crashes were associated with an inside vehicle distraction and 3071 (6.4%) crashes per year were associated with a source of distraction outside of the vehicle.
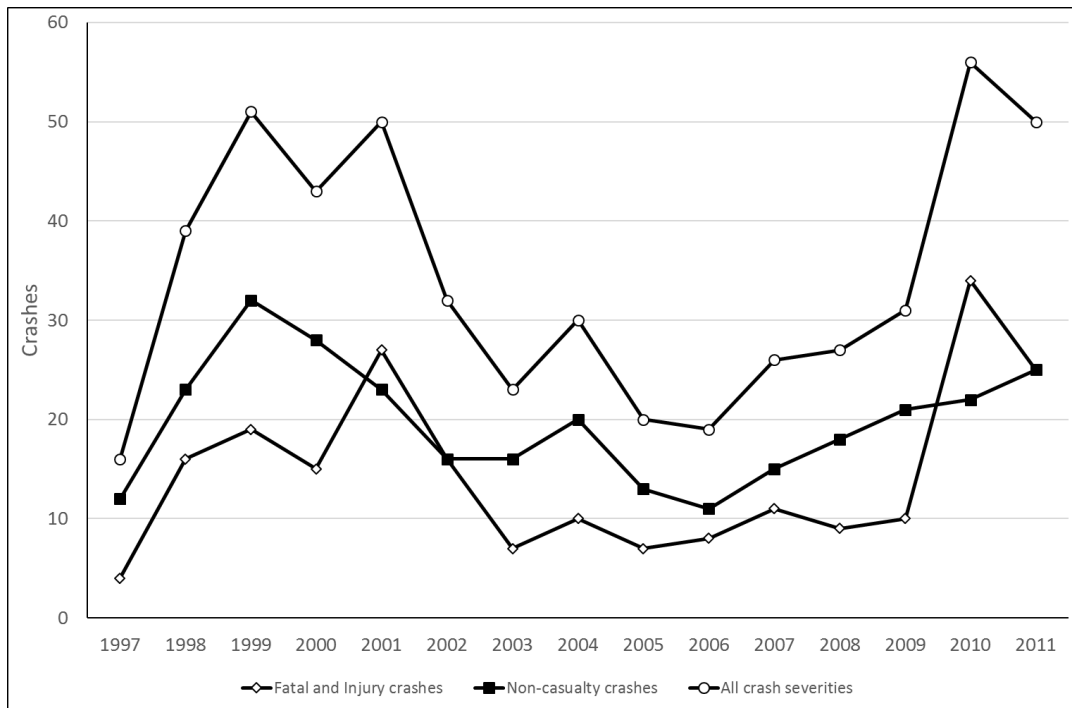
Figure 3.1 Crashes by severity in New South Wales where handheld phone use was a contributing factor, 1997 to 2011

3.2.2 REQUESTED CRASH DATA

Following the review of publicly available data sources, requests for tables counting the number of fatalities and people seriously injured in crashes involving distraction or inattention and mobile phone use in particular were sent to each data custodian in each jurisdiction.

As at writing, data on distraction and mobile phone use have been obtained from Queensland (Department of Transport and Main Roads, 2017b) and Tasmania (Department of State Growth, 2017). Data from Western Australia (Main Roads Western Australia, 2017) and data extracts from South Australia (Department of Planning Transport and Infrastructure, 2017) and the Australian Capital Territory (Transport Canberra and City Services Directorate, 2017) have also been provided, however, these datasets only record whether driver or rider inattention played a role in the crash. The VicRoads Crash Information System does not record contributing factors of crashes (Vic Roads, personal communication, 25 May 2017) and Victoria Police does not corporately record the contribution of mobile phones in crashes (Victoria Police, personal communication, 21 June 2017). The crash data from the Northern Territory does not record

distraction or inattention as a contributing factor (Department of Infrastructure Planning and Logistics, personal communication, 7 June 2017). CARRS-Q is still in communication with the New South Wales Centre for Road Safety. The NSW crash data extracts have been authorised, but have not yet been provided.

In Queensland between 2011 and 2015, there were 1 or 2 fatalities (0.5%) per year where distraction due to mobile phone use was a contributing factor. In 2016, there were 5 (2%) fatalities where mobile phone use was a contributing factor. From 2011 to 2016, between 9 and 21 (0.25%) people were hospitalised in crashes where mobile phone use was identified as a contributing factor.
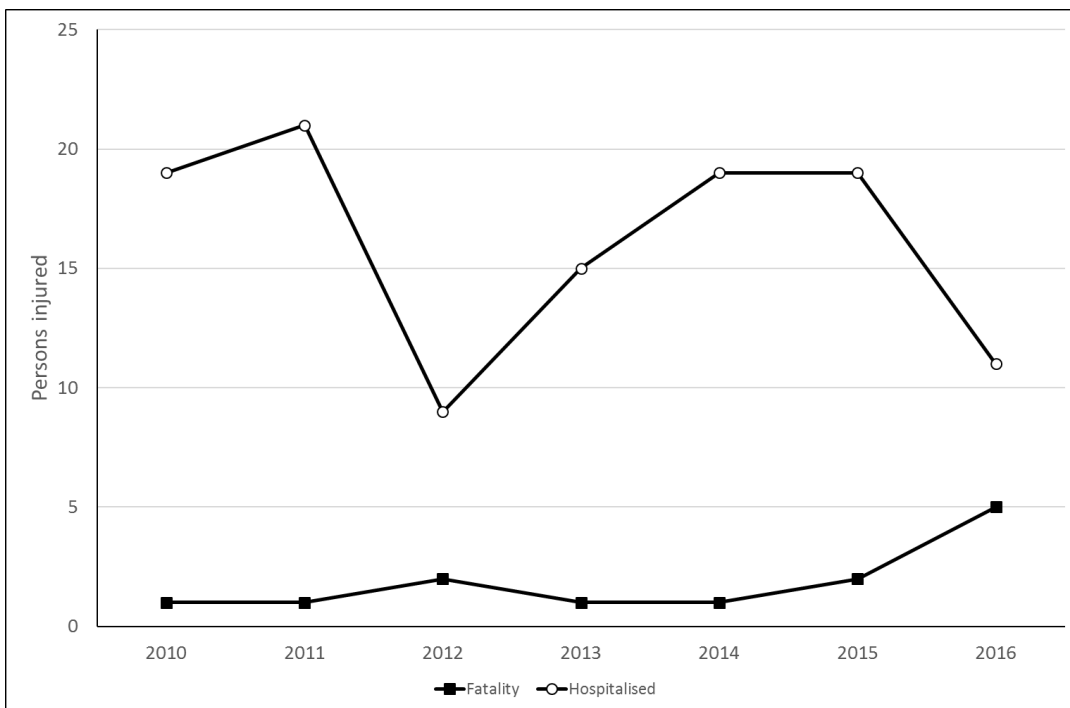
Figure 3.2 Number of fatalities and persons hospitalised in Queensland where handheld mobile phone use was a contributing factor in the crash, 2010 to 2016

In Tasmania, a total of 3 (1.7%) road traffic fatalities between 2012 and 2016 were as a result of crashes where distraction due to mobile phone use was a contributing factor. Over the same five year period, 5 (0.5%) of the people hospitalised in traffic crashes were injured in crashes where mobile phone use was a contributing factor.

The number of people killed and seriously injured in crashes Tasmania where mobile phone use was identified as a contributing factor are too low to establish whether there is a trend. However, in the Queensland there was statistically non-significant decreasing trend in the number of people killed and seriously injured in crashes where a mobile phone was a contributing factor.

3.2.3   INFRINGEMENT AND EXPIATION DATA

An additional potential source of information regarding the prevalence of mobile phone use are the number of infringements issued or expiations made for improper use of mobile phones while driving. Table 3.3 provides a time series of the number of infringements or expiations from 2011/12 to 2015/16 financial years and for the 2016/17 year to date. From 2011/12 to 2015/16, where full years of data are available, only Queensland appeared to have a statistically significant trend in the total number of mobile phone infringements per year. In Queensland, the figures suggest a decreasing trend in total infringement counts, with an average reduction of 2293 infringements per year. However, caution must be used when interpreting this data, as it is subject to the level of Police enforcement activities. They therefore, may not be a consistent measure of the prevalence of improper use of mobile phones while driving.

Table 3.3 Infringements or expiations issued for improper mobile phone use, 2011/12 to 2016/17

Jurisdiction	Infringement or expiation issued	2011/12	2012/13	2013/14	2014/15	2015/16	Year to date 2016/17*
New South Wales[a]	Learner or provisional driver	806	682	726	750	982	1684
	Open licence holders	41572	35923	33772	34620	37459	32587
	Total	42378	36605	34498	35370	38441	34271
Queensland[b]	Learner driver	1	2	5	11	3	1
	P1 provisional driver	19	27	27	40	32	36
	Open licence holders	29941	27584	27288	24559	19960	12028
	Total	29961	27613	27320	24610	19995	12065
South Australia[c]	Learner driver	11	14	11	14	8	5
	P1 provisional driver	411	571	522	479	293	177
	Open licence holders	8646	11994	12261	12819	11493	8960
	Total	9068	12579	12794	13312	11794	9142
Northern Territory[d]	Learner or provisional driver		14	5	2	15	10
	Open licence holders		936	781	479	527	414
	Total		950	786	481	542	424
Tasmania[e]	Using hand-held mobile phone	3241	2141	2914	3256	3273	-

*   Please note that data for the 2016/17 financial year is for a period of less than 12 months: New South Wales to April 2017, Queensland to February 2017, South Australia to March 2017 and Northern Territory not stated.

a.   NSW - Office of State Revenue (2017)
b.   Queensland - Department of Transport and Main Roads (2017a)
c.   South Australia - South Australia Police (2017a, 2017b, 2017c, 2017d, 2017e, 2017f)
d.   Northern Territory - Department of Infrastructure Planning and Logistics (2017)
e.   Tasmania - Department of Police and Emergency Management (2011, 2012, 2013, 2014, 2015); Department of Police Fire and Emergency Management (2016)

3.3   NATIONAL CORONIAL INFORMATION SYSTEM (NCIS)

A data query was sent to NCIS asking for tabular data on traffic and non-traffic fatalities where the mechanism of death was 'Distraction by Personal Use Item' and the object involved was 'Mobile Phone'.

NCIS personnel conducted a search of the database for records meeting these criteria and identified 36 motor vehicle incident cases, across all jurisdictions since July 2000 (National Coronial Information System, 2017). The NCIS noted that mechanism and object of injury are not consistently coded across jurisdictions, and suggested that the only way to identify relevant cases would be to conduct a manual review of all land transport injury cases in their database.

To test the feasibility of this suggestion, the NCIS conducted a manual review of 111 motor vehicle fatalities from January 2014. This review identified only one case where a mobile phone was implicated in the crash. The review found that the attached coronial findings and police narratives routinely mentioned a variety of contributing factors such as weather conditions, drug/alcohol intoxication, excessive speed or mechanical fault. However, potential mobile phone use was infrequently mentioned. There were a small number of fatalities where the police narrative indicated that the deceased's mobile phone had been examined to determine whether the phone had been in use at the approximate time of the crash.

From this review, the NCIS indicated that since mobile phone use in incident cases was not consistently coded in the database across jurisdictions and it was not frequently mentioned in the attached documents, further review of cases is unlikely to elicit additional information useful for this project (National Coronial Information System, personal communication, 30 May 2017).

4 REVIEW OF CURRENT RESEARCH ON RISK OF MOBILE PHONE/DEVICE USE

4.1 BACKGROUND AND SCOPE

Although car use has been in decline in Australian car-dependent cities (e.g. Brisbane metropolitan area (Li, Dodson, & Sipe, 2015), driving is still a common activity in the daily lives of millions of Australians. Driving as a transport behaviour has critical social and economic roles but also constitutes large risks for quality of life, including injury and death. During the 12 months ending April 2017, there were 1,235 road deaths registered in Australia (BITRE, 2017). Additionally, rates for people seriously injured in Australia due to a road vehicle traffic crash increased an average of 0.9% over the 10-year period from 2001 to 2010 (Henley & Harrison, 2016). Notable improvements in technologies such as cooperative intelligent transport systems and driving automation are expected to benefit road safety. However, estimates suggest that population-wide benefits are only likely to be observed in the long term (Dia, 2016) due to numerous challenges related to infrastructure investment (Clark, Parkhurst, & Ricci, 2016), public perception (Kyriakidis, Happee, & de Winter, 2015), and vehicle design policies (Smith, 2016). Until active safety technologies are completely accessible to all drivers, it will be necessary to understand current road safety issues to prevent road trauma.

Inadequate interactions between drivers and vehicles play a significant role on vehicle collisions, which may result in injury or fatalities (Petridou & Moustaki, 2000). Drivers alter their driving performance due to a wide range of factors, including fatigue, mobile phone use, mood, etc. Mobile phone distracted driving is recognised as one of the most important human factor issues in road safety worldwide (WHO, 2011). Conservative estimates suggest that distracted drivers are heavily overrepresented in road traffic crashes. In the US, mobile phone distraction is reported to contribute to about ten percent of road traffic crashes (NHTSA, 2017). The recent naturalistic study in the US, Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS), has reported that hand-held mobile phone interactions increase the odds of crash risk as much as 3.6 times (Dingus et al., 2016). A survey of 3706 drivers conducted in Australia reported that almost one in two Australian drivers aged between 18 and 24 years use a hand-held mobile phone while driving, nearly 60% of them send text messages, and about 20% of them read emails and use their phone for navigation (AAMI, 2012). Mobile phone distracted driving is likely to increase in future given the pervasiveness of this ubiquitous technology (Brace, Young, & Regan, 2007).

Most of the research on mobile phone distracted driving in the last 10 years has been concerned with tasks such as conversations and texting/browsing (Oviedo-Trespalacios, Haque, King, & Washington, 2016). Mobile phones today provide a wide range of functions, such as taking pictures, writing notes, making voice recordings, filming short videos, listening to music, among many others that can be performed while driving. Indeed, studies have found that drivers record themselves speaking to a camera (Hawkins & Filtness, 2015), playing games such as

Pokemon Go (Ayers et al., 2016), interacting with social media (Gauld, Lewis, White, & Watson, 2016), and playing/changing music while they were driving (Steinberger, Moeller, & Schroeter, 2016). Mobile phones are emerging technologies with frequent changes in software and hardware. The ongoing evolution requires the application of user-centred approaches to measure the impact of mobile phones on driving performance and crash risk. Therefore, in this review, when possible, behaviours were studied based on the type of interaction involved. For example, texting or internet usage involves visual, cognitive and physical demand, compared to listening to music which involves only cognitive demand, and hands free voice calls involve auditory and cognitive demand.

Different mobile phone tasks have distinct impacts on drivers. These generally depend on the type of interaction and user requirements, e.g. mobile phone conversations are usually associated with an increased cognitive workload (Oviedo-Trespalacios, Haque, King, & Washington, 2016), while texting and browsing on a mobile phone are usually associated with physical, visual and cognitive demands that may impair smoothness or proficiency in driving motion (Choi et al., 2013). Consequently, the risk of crash varies depending on the type of task performed by the driver, e.g. talking on a hand-held mobile phone increased crash risk by about 2.2 times while texting while driving was found to increase crash risk by about 6.1 times (Dingus, et al., 2016). There is, however, some dissenting evidence that argues that under certain circumstances (e.g. no traffic) some mobile phone tasks such as conversing do not increase crash risk (Young, 2017). Additionally, some studies have identified that in certain environmental conditions, mobile phone distraction might serve as a protective factor against collisions. Fitch, Hanowski, and Guo (2015) reported that hands-free conversations were associated with a reduced risk of crashes along merging ramps or near intersections. This phenomenon has been proposed as a result of self-regulatory strategies (also known as risk compensation behaviours) that drivers perform to manage the secondary task (Young, 2015).

4.2 PREVALENCE OF MOBILE PHONE USE WHILE DRIVING

Prevalence of mobile phone use while driving has been examined in terms of texting, having a conversation while holding the phone, and using the internet. Traditionally, self-reported measures have been used for assessing prevalence of mobile phone use while driving. The self-report methods have inherent limitations such as influence of social desirability or faulty memories. However, recent research suggests that self-report data could be consistent with actual police records in Australia (Ivers et al., 2009) and objective observed driving behaviour in driving simulators (Zhao et al., 2012). Objective measures have been applied to study the prevalence of mobile phone use while driving in observational and naturalistic designs. Observational studies involve the observation of drivers at selected intersections or midblock segments, whilst naturalistic studies involve the continuous observations of a group of drivers. Literature in these areas is reviewed next.

4.2.1 SELF-REPORTED ESTIMATES OF MOBILE PHONE USE WHILE DRIVING

The most comprehensive recent breakdown of self-reported mobile phone use while driving across Australian jurisdictions can be found in the report on the results of the 2013 Community Attitudes to Road Safety survey (Petroulias, 2014). The relevant table appears below (Table 4.1)

Table 4.1 Self-reported mobile phone use by jurisdiction, 2013 Community Attitudes Survey[a]

	Have mobile phone	Answer calls when driving	Make calls when driving	Read text when driving	Send text when driving	Use mobile phones when driving[b]
NSW	88	40*	34	26	17	47*
VIC	90	54	29	27	11*	60
QLD	91	55	27*	32	20	62
SA	88	44*	23*	21*	16	50*
WA	93	54	35	27	15	59
TAS	90	39*	20*	22*	7*	46*
NT	89	55	22*	21*	6*	57
ACT	96*	62	34	28	16	64

* Statistically significant at the 0.05 level

a. Petroulias (2014), excerpt from Table 6.2b, p. 68, based on 1058 landline phone interviews with active drivers

b. Have ever made or received calls or text messages

These figures indicate high levels of phone ownership and use; it is not possible to assess the difference between hand-free (legal for most drivers) and hand-held (illegal) use for calls, but reading and sending text (which are both illegal) were reported by about quarter and an eighth of respondents respectively. It can be seen that the patterns vary between jurisdictions, with Tasmania, the Northern Territory and South Australia being at the low end in most categories.

The most recent study available was conducted in South-East Queensland during 2016 by Oviedo-Trespalacios, Haque, King, and Washington (under review). A total of 484 drivers completed an on-line questionnaire studying four mobile phone-related behaviours where they: (i) Located and answered a ringing phone, (ii) Spoke on a hand-held phone, (iii) Texted or browsed on their phone, (iv) Looked at a hand-held phone while driving for more than 2 seconds. Of these respondents, 34.9% were males. With respect to age group, 49.8% were aged 17-25 years and 50.2% were aged 26-65 years. The average time with a valid licence was 3.33 years (SD = 0.13) for the 17-25 years old group, and 18.25 (SD = 0.72) for the 26-65 years old group. On the one hand, on a typical day, 45% of participants reported that they located/answered a ringing phone, and 28% spoke on a hand-held phone. To the extent that the data are comparable, these figures are consistent with Table 4.1, although this study looked at use in a "typical day" and estimated the amount of use per day. Drivers who located and answered a ringing phone did this task on an average 1.5 times per hour of driving, and the

average length of conversations among those who spoke on a hand-held phone was 9 minutes. On the other hand, on a typical day, 34% of participants reported that they texted or browsed and 39% looked continuously at their phone for more than 2 seconds. For every hour driving, participants reported engaging 3.5 times in texting and browsing and 3.9 times looking at their phone continuously for more than 2 seconds. In general, the most frequent interactions reported by drivers in Queensland involve heavy visual workload. While typical behaviours such as texting and calling were low, similar tasks in terms of interactions (i.e. located and answered a ringing phone, and looked at a hand-held phone while driving for more than 2 seconds) were highly prevalent.

Previous studies in Australia have confirmed a high prevalence of mobile phone use while driving. A New South Wales (NSW) study found, from a sample of 181 mature drivers (M = 36 years; SD = 12.8; 21% males), that 44% of drivers answered calls, 29% had hand-held conversations, 57% browsed in the phone, and 28% texted during the past week (Waddell & Wiener, 2014). These figures are similar to those in Table 4.1, with the exception of browsing, which was not asked about in the community attitude survey but was reported at high rates here. A study in Western Australia (WA) and NSW (McEvoy, Stevenson, & Woodward, 2006), using a sample of 1347 licensed drivers aged 18-65 years, showed that in the last trip (of 5 minutes or more duration), 9% reported mobile phone use, a figure not directly comparable to those above because a different counting base was used. In Victoria, a study of 295 drivers aged 18-83 years found that 35% of drivers engaged in hand-held conversations, 64.3% read text messages, and 55.4% sent text messages while driving (Young & Lenné, 2010), showing much higher rates of texting than presented in Table 4.1 for Victoria. A Queensland (QLD) study found that 33.4% of drivers answered a hand-held phone, 27.4% of drivers initiated a call on a hand-held phone, 26.3% of drivers read a text, and 18.9% of drivers sent a text at least once a day (White, Hyde, Walsh, & Watson, 2010). Compared with Table 4.1, this indicated much higher levels of texting and a lower amount of answering voice calls, although the question was asked about hand-held phones

The lack of comparability between these results points to a need to define the behavioural measures of interest, and the time frames and frequencies of usage that are relevant, in order to obtain data to allow comparison between jurisdictions and over time.

A large body of international research has investigated the prevalence of mobile phone use while driving. Regarding texting, 46.56% (n = 6168) of U.S. drivers (18-44 years) texted while driving in the previous 30 days (Qiao & Bell, 2016), 73.30% and 57.30% (n = 4964) of U.K. drivers read and sent text messages, respectively, (Benson, McLaughlin, & Giles, 2015), and 66.2% and 52.3% (n = 962) of New Zealand participants (16-80 years) reported reading and sending, respectively, at least 1–5 text messages while driving during a typical week (Hallett, Lambert, & Regan, 2012). Regarding talking on a mobile phone, 91% (n = 4964) of U.S. drivers (M = 21.8) phoned while driving at least some of the time (Hill, Styer, Fram, Merchant, & Eastman, 2015), and 60.4% (n = 962) of participants (16-80 years) reported conversing on their

cell phone while driving per week in New Zealand (Hallett, Lambert, & Regan, 2011). All these figures are comparable with the high end data found in the Australian research above.

4.2.2 OBSERVATIONAL AND NATURALISTIC ESTIMATES

The most recent observational study available was conducted at 61 sites in metropolitan Adelaide and rural regions within SA in 2009 by Wundersitz (2014a). Of the 11,524 observations registered, nearly 0.6% identified using hand-held phones. Earlier observational studies in Melbourne have shown hand-held mobile phone use prevalence of 2% (n = 17023) at 12 highway sites in 2002 (Taylor, Bennett, Carter, Garewal, & Barnstone, 2003), and 1.6% (n = 20207) at 12 highway sites in 2006 (Taylor, MacBean, Das, & Rosli, 2007). More recently in Melbourne, an observational study conducted by Young, Rudin-Brown, and Lenné (2010) revealed that 1.4% (n = 5813) of drivers were talking on a hand-held mobile phone, 1.5% of drivers were texting, 1.4% of drivers were talking by speaker or headset, and 0.2% of drivers were dialling/answering a mobile phone at three heavy-traffic intersection sites in 2009. No data for other states or territories in Australia was available.

Observational studies conducted in the U.S. found among 3265 drivers observed at intersections, a prevalence of 31.4% of drivers were talking and 16.6% texting or dialling on the phone (Huisingh, Griffin, & McGwin Jr, 2015). Other observational studies around the world have estimated that 3.4% of a total of 7168 drivers use mobile phones for hand-held interactions and hands-free conversations while driving in the U.K. (Sullman, Prat, & Tasci, 2014), 1.7% of a total of 6578 drivers in Spain use mobile phones for talking and texting (Prat, Planes, Gras, & Sullman, 2015), and 1.34% of a total of 9520 drivers in moving cars in New Zealand (Wilson, Thomson, Starkey, & Charlton, 2013).

In the U.S., the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS) mobile confirmed phone use is reported to interfere with the driving task almost one fifth of the driving time (Dingus, et al., 2016).

4.3 GENERAL FACTORS THAT INFLUENCE MOBILE PHONE USE WHILE DRIVING

Some groups of the population seem more susceptible to mobile phone distraction than others. Alarmingly, distracted driving, particularly the use of mobile phones while driving, is more prevalent among young drivers aged 18-24 years, a group that already had a higher crash risk before the advent of mobile phones. In Australia, Young et al. (2010) confirmed through an observational study that young drivers (<30 years) more frequently use hand-held mobiles than middle-aged and older drivers (30 years and more) while driving. This is in accordance with international studies, where at least one in two young drivers in U.S. and Canada have been found to use a mobile phone while driving (Tucker, Pek, Morrish, & Ruf, 2015). There may be gender differences within distracted drivers: recently in Victoria, males were observed to have a larger engagement in mobile phone distracted activities than females (Wundersitz, 2014b).

A recent study in Queensland determined predictors of mobile phone use for talking and texting/browsing on a typical day (Oviedo-Trespalacios, et al., Under Review). Drivers who have held a valid driving licence for less time and spend more time driving per day were more likely to report mobile phone use for talking and texting while driving. Additionally, having at least one traffic offence in the last three years was a predictor of actual self-reported usage of mobile phone while driving. Recidivism might play a role and brings new opportunities for developing targeted interventions for this high-risk group by imposing participation in an intervention program as part of the penalties. Attitudes and beliefs were predictors of mobile phone engagement on a typical day for talking and texting. Previous research has confirmed the role of attitudes and safety beliefs in the prediction of mobile phone distracted driving behaviour (Gauld, et al., 2016b; Walsh, White, Hyde, & Watson, 2008; Zhou, Yu, & Wang, 2016).

Engagement in task-management strategies was a predictor of mobile phone involvement on a typical day for talking and texting. Task-management strategies are the changes initiated by drivers to engage in mobile phone distraction. Scanning the environment more often was a consistent strategy in the models, indicating that the decision to engage in mobile phone use is closely related to the perception of potential hazards. Scanning for police officers was also significant in talking and texting/browsing tasks. The present findings seem to support other research studies in Queensland (White, et al., 2010), which report that infrequent distracted drivers were more likely to report that police presence and risk of an accident would prevent them from using their mobile phone while driving. Appropriate caution should be exercised in the interpretation of this finding because there is no guarantee that the drivers' judgement of a driving situation is adequate to minimise crash risk (Huth & Brusque, 2014; Kircher & Ahlstrom, 2016).

Several studies have used Theory of Planned Behaviour (TPB) constructs, and extended versions of it, to explain mobile phone distracted driving decisions in Australia (Gauld, Lewis, & White, 2014; Gauld, et al., 2016b; Nemme & White, 2010; Waddell & Wiener, 2014; White, et al., 2010) and internationally (Chen, Donmez, Hoekstra-Atwood, & Marulanda, 2016; Prat, Gras, Planes, González-Iglesias, & Sullman, 2015). The model consists of three standard constructs: Attitude, Subjective Norm (SN), and Perceived Behavioural Control (PBC), the strength of which determine the strength of one's intentions toward engaging in the behaviour, which are then regarded as proxies for whether people will actually engage in the behaviour (Lennon, Oviedo-Trespalacios, & Matthews, 2017). Among the behavioural beliefs, high intenders (i.e. a high intention to use a mobile phone while driving) were more likely to see 'sharing information' and 'using time effectively' as positive outcomes of concealed texting while driving than low intenders (Gauld, et al., 2014). In the case of SN, Nemme and White (2010) found that the more a person believes that their peers approve of and engage in behaviours such as texting while driving, the greater their intention to engage in these behaviours. In a recent NSW study, PBC has been found to be the strongest contributor to drivers' intentions to use hand-held mobile phones (Waddell & Wiener, 2014). Overall, results of the present study provide considerable support for the efficacy of the TPB model in

understanding mobile phone distracted driving. Other variables such as perceived crash risk has been less successful at explaining distracted driving (Walsh, et al., 2008).

Investigations have been conducted to identify the beliefs influencing young drivers (17 – 25 years) to initiate, monitor/read, and respond to social interactive technology (e.g., Facebook, email, texting) on smartphones, to target in public education messages (Gauld, Lewis, White, Fleiter, & Watson, 2017; Gauld, Lewis, White, & Watson, 2016a; Gauld, et al., 2016b). For example, Gauld et al. (2016a) found that young drivers reported that contact via mobile phone was important to them while driving, so they could keep up to date with friends' plans, particularly when a meeting was planned. Some drivers also referred to the pressure they felt from friends who expected a very quick reply and who would send continual communications until they received a response.

4.4 RELATIONSHIP BETWEEN MOBILE PHONE USE AND DRIVING PERFORMANCE

Two main approaches are utilised in the scientific literature to study driving performance of mobile phone distracted drivers: on-road and/or laboratory observations. On-road observations comprise naturalistic and quasi-naturalistic studies that allow for seeing the driver's behaviour, in uncontrolled or controlled environments, respectively. Laboratory observations have been consolidated in road safety research, as a low risk and economically feasible option for studying driving behaviours while controlling for different factors (Collet, Guillot, & Petit, 2010). Various authors have developed important safety evaluation methods based on naturalistic and simulated driving behaviour observations. Traditionally, driving simulators are considered the principal tool for road safety laboratory research. Driving simulators have been developed using advances in computer technology and nowadays are cheaper and safer than in-vehicle or on-road testing (Ariën et al., 2014). Nonetheless, with new technological developments in in-vehicle driving monitoring, naturalistic studies have increased their presence in the mobile phone distracted driving literature.

Generally, in simulator studies, it is possible to observe crashes. Although intuitively, the best option for studying crashes would be a controlled environment such as simulators, difficulties arise because crashes are rare events (Svensson & Hydén, 2006). For this reason, the use of surrogate safety measurements as a way of studying driving performance has been a frequent practice in the mobile phone distracted driving literature. These surrogate measures include: acceleration, headway distance, lane position, speed, among others. Yan, Abdel-Aty, Radwan, Wang, and Chilakapati (2008) validated a set of surrogate measures for evaluating safety in signalised intersections through the contrast of crash reports and simulator data. These surrogate measures included speed in different instances while approaching the intersection, acceleration, stop decision, and headway distance (for the case when the car is following another). As a result, previously accepted risky parameter levels of speed, acceleration, and headway were associated with high rear-end risk zones.

This section reviews research in mobile phone distracted driving and driving behaviour change from two perspectives: (1) Impaired driving behaviour, including changes in driving performance that are traditionally associated with higher crash risk. (2) Self-regulation, including potential safe behaviours that drivers perform to integrate the mobile phone tasks into driving.

4.4.1   DRIVING BEHAVIOUR CHANGE

Recent literature on mobile phone distracted driving has examined various driving performance metrics such as speed, acceleration, lane position, and headway distance (Oviedo-Trespalacios et al., 2016).

The speed selection of drivers has been reported to be influenced by various types of mobile phone tasks, including conversation (Becic et al., 2010, Metz et al., 2015, Yannis et al., 2010, Tractinsky et al., 2013, Reimer et al., 2011), holding a mobile phone (Christoph et al., 2013), navigation (Christoph et al., 2013), reading (Rudin-Brown et al., 2013), reaching for a mobile phone (Christoph et al., 2013), texting (McKeever et al., 2013, Thapa et al., 2014), answering by pressing the send button (Tractinsky et al., 2013), and dialling (Tractinsky et al., 2013). While a majority of studies reported a decrease in speed selection under mobile phone distracted driving (Oviedo-Trespalacios et al., 2017b, Oviedo-Trespalacios et al., 2017a, Oviedo-Trespalacios et al., 2015), some reported an increase in speed for mobile phone conversation (Garrison and Williams, 2013, Liu and Ou, 2011, Stavrinos et al., 2013), and texting (Young et al., 2014, Rudin-Brown et al., 2013). Speed variability has been reported to increase if the conversation includes emotional components (Dula et al., 2011). A study matching self-reported behaviour and observed driving performance found that drivers who reported frequent use of a mobile phone while driving changed speed more rapidly with faster throttle accelerations, and sudden non-directional accelerations (Zhao et al., 2013). Platten et al. (2013) reported that distracted drivers approaching hazardous situations decreased speed rapidly with higher decelerations.

Distracted drivers have been reported to have less lane deviation while conversing (Garrison and Williams, 2013, Reimer et al., 2014) but an increased deviation while texting (McKeever et al., 2013, Rudin-Brown et al., 2013) compared to non-distracted drivers. Many studies, however, have reported a negligible difference in lane position between the baseline and the distractive conditions of talking and texting (Cao and Liu, 2013, Irwin et al., 2015, Young et al., 2014). In terms of headway distance maintenance, distracted drivers have been reported to maintain a longer following distance (Bergen et al., 2013, Yannis et al., 2010) while talking and to have more gap variations (He et al., 2014) while texting. Pouyakian et al. (2013) reported that drivers answer mobile phone calls more frequently when headway distance is greater than 25 m.

Mobile phone use while driving impairs the interactions between driver and vehicle. Steering wheel corrections were higher among drivers distracted by a mobile phone (Zhao et al., 2013), particularly with conversations (Garrison and Williams, 2013) and texting (Owens et al., 2011).

The ability to maintain a constant speed decreases significantly when a driver is texting (Choi et al., 2013a); however, this result contradicts other research that reported a negligible effect of mobile phone conversations on speed maintenance (Cao and Liu, 2013, Reimer et al., 2012) or distraction due to drivers preparing to attend an incoming call (Holland and Rathod, 2013). The braking task has also been reported to be affected by mobile phone tasks. Distracted drivers brake aggressively when approaching an obstacle (e.g. pedestrian crossing) along the road (Haque and Washington, 2014a, Berg and Dessecker, 2013). Compared to hands-free driving, drivers conversing using a hand-held phone tend to brake more frequently (Zhao et al., 2013). Interestingly, there is a consensus that braking time of distracted drivers increases with conversing (Kim et al., 2013, Rossi et al., 2012, Benedetto et al., 2012, Berg and Dessecker, 2013, Long et al., 2012, Bergen et al., 2013), texting (Leung et al., 2012, He et al., 2014, Long et al., 2012), dialling (Platten et al., 2013), and ringing (Zajdel et al., 2013).

Eye behaviour (i.e., blink rate, gaze concentration, gaze position, etc.) has been utilised as a proxy for capture of critical information from the surrounding road traffic environment under distraction. Drivers distracted by mobile phone conversations have been reported to have an increased gaze concentration, implying less peripheral awareness and detection sensitivity (Reimer et al., 2012). In particular, mobile phone distractions lead to a decrease in vertical and horizontal glances (Briggs et al., 2011, Reimer et al., 2012). Mobile phone tasks such as reaching, answering, dialling, texting, and browsing were found to be associated with longer off-road glances (Simons-Morton et al., 2014), with texting tasks requiring more frequent and longer off-road glances (Owens et al., 2011, Reimer et al., 2014, Young et al., 2014, Tivesten and Dozza, 2014) and emotionally involving mobile phone conversations leading to a pattern of visual tunnelling with a decline in visual fixations (Lansdown and Stephens, 2013).

Mobile phone use while driving modifies the decisions made by drivers in certain traffic interactions. Drivers distracted by mobile phone conversations have been reported to take a longer time to detect a pedestrian at a zebra crossing (Haque and Washington, 2014b), indicating not only impaired peripheral scanning behaviour but also a slow information processing ability. Garrison and Williams (2013) noted that distracted drivers paid more attention to driving-relevant objects compared to less relevant objects like billboards, indicating a strategic decision by drivers to manage the human-environment interactions. Haque et al. (2016) reported that drivers conversing on a mobile phone while driving reduce their safety margins and manoeuvrability of the vehicle in complex traffic conditions such as roundabouts. Additionally, drivers distracted by mobile phone conversations committed more driving errors and road violations, e.g. road lanes excursions, speeding, red light running (Nabatilan et al., 2012). In contrast, Dula et al. (2011) and Platten et al. (2013) have not found any significant difference in the number of traffic light infractions for conversation tasks.

Interference is a two-way phenomenon in which both the driving task and the mobile phone task are perturbed. Becic et al. (2010) reported that performing dual tasks like driving while talking over a mobile phone influences both driving performance and conversation including quality loss in speech comprehension, language encoding and language production. Other

effects on conversation include loss of quality in speech production, complexity (Atchley et al., 2011) and rhythm (Maciej et al., 2011). Cao and Liu (2013) reported that concurrent vehicle lane keeping and speech comprehension tasks did not affect lane keeping performance but the performance of a comprehension task was reduced. Spence et al. (2013) reported a loss of accuracy in conversation when distracted drivers were assigned a demanding cognitive task. Driving task has also been reported to influence texting performance with an increase in accuracy errors (Alosco et al., 2012) and response times (He et al., 2014).

A large body of the literature focuses on performance differences between hand-held and hands-free conversations. Brace et al. (2007) and McCartt et al. (2006) concluded that hand-held dialling leads to less safe driving as well as faster but inaccurate dialling of mobile phones. Horrey and Wickens (2006) and Caird et al. (2008) showed that the impairment of driving performance for a hands-free phone conversation is equivalent to that experienced as the result of an in-vehicle conversation. Svenson and Patten (2005) argued that the position of the mobile phone in the car could interfere with the in-vehicle tasks and needs to be investigated. Haque and Washington (2014b) and Benedetto et al. (2012), however, did not find any significant difference in reaction times to unexpected events between hand-held and hands-free mode. The effects of other phone characteristics like the size and type of the mobile phone on driving performance are usually not available in the literature (McCartt et al., 2006).

4.4.2   SELF-REGULATION

Drivers initiate changes in driving to integrate the secondary task. While engaged in uninterrupted mobile phone conversations, drivers reduced their driving speed in similar driving conditions. This is confirmed by naturalistic studies (Fitch et al., 2014, Fitch et al., 2017), experimental investigations (Tractinsky et al., 2013, Horberry et al., 2006), and self-reported experiences (Young and Lenné, 2010, Huth and Brusque, 2014) corroborating that mobile phone distracted driving, and particularly engaging in conversation, results in drivers decreasing their driving speed. Reduced speed could offer safety advantages in terms of crash likelihood or injury severity. For instance, Aarts and Van Schagen (2006) found that crashes increase at an exponential rate with the speed increase of individual vehicles. Nonetheless, the potential negative consequences of this speed reduction of distracted drivers are that it could increase the risk of nose-to-tail crashes and congestion.

Under a complex driving environment with a narrower lane, high speed limit, and frequent presence of intersections and roadside buildings, drivers distracted by mobile phone conversations were reported to select a lower driving speed with higher variability and higher lateral acceleration (Liu and Ou, 2011). Demanding driving scenarios like driving along windy roads and driving in heavy traffic have been reported to influence driving speed and lane position variability of mobile phone distracted drivers (Tractinsky et al., 2013, Oviedo-Trespalacios et al., 2017b, Oviedo-Trespalacios et al., 2017a). Becic et al. (2010) reported that drivers under mobile phone distracted driving prioritize the driving task over the secondary task depending on the complexity (i.e., straight road segment or intersection) of the road traffic

environment. The speech production of the drivers engaged in mobile phone conversations has been reported to decrease when the difficulty of driving increased (Becic et al., 2010). Tractinsky et al. (2013) found that driving along windy roads and heavy traffic resulted in a delayed response to attend incoming calls; additionally, in complex situations drivers showed less willingness to initiate or accept incoming phone calls. Similarly, Atchley and Chan (2011) argued that drivers using the mobile phone may increase their vigilance even when driving in less stimulating environments.

Using as a basis the seminal work of Young and Regan (2013), this review considers tactical decisions of drivers to engage in mobile phone distracted driving. Tactical self-regulation corresponds to the decision that drivers make about when or where to engage in mobile phone distracted driving. Oviedo-Trespalacios et al. (Under Review-c) demonstrated that a driver's decisions to engage in multitasking can vary from location to location. While driving in a controlled environment, drivers showed a preference for engaging in mobile phone use at times when the vehicle was stopped, e.g. waiting at a signalised intersection (Oviedo-Trespalacios et al., Under Review-a). Confirming the existence of tactical self-regulation has important implications for police enforcement and road safety research. Knowing where drivers prefer to engage in unlawful mobile phone use could help to support and optimise police enforcement. Additionally, there is a need for making fair comparisons in the estimations of crash risk due to mobile phone distracted driving. The decision-making process of drivers should be included in risk assessment activities (e.g. to match baselines and mobile phone use while driving sequences on a scenario basis as suggested by Tivesten and Dozza (2014).

4.5   RELATIONSHIP BETWEEN MOBILE PHONE USE WHILE DRIVING AND CRASH RISK

In the context of mobile phone distracted driving, crash data is acknowledged as the key performance measure for safety in the traffic system (Oviedo-Trespalacios et al., 2016). The provision of ongoing and reliable crash data is a key component of evidence-based road safety practice. Crash data is usually provided by government-related entities; perhaps the most common source is crash reports (e.g. police or health-care providers). Generally, crash police or hospital data related to mobile phone distraction has a series of limitations: the under-reporting of low severity crashes, low occurrence of crashes linked to mobile phone use, and lack of behavioural detail preceding the crash. Therefore, it is reasonable to argue that crash data should not serve as a unique and standalone tool for informing evidence-led initiatives in mobile phone distracted driving. A common issue in the U.S. is that a large proportion of crashes that are reported to involve distraction do not have a specific behaviour or activity listed; rather they specify "distraction/inattention details unknown" (NHTSA, 2016).

There are alternatives for overcoming the limitations of police or hospital mobile phone distraction crash data: First, complement crash data with vehicle technologies (apps and devices) for driving monitoring (Singh, 2001) and, exceptionally, other external sources considered in police reports, such as cameras or witnesses. This is the rationale behind naturalistic studies whereby a group of drivers are monitored until a crash of interest is

registered. Second, in the case of a non-fatal injury, self-reported data, including questionnaires or interviews, could explain crash circumstances. Although self-reported data suffers from several drawbacks related with human factors such as memory or social desirability bias, recent research suggests that self-report data is fairly consistent with the actual police records in Australia (Ivers et al., 2009) and objective driving observations (Zhao et al., 2012).

4.5.1 POLICE AND HOSPITAL DATA RELATED TO CRASH RISK

Mobile phone distracted driving studies using police and hospital data are scarce worldwide. Based on crash reports in Australia (NSW), a study conducted 15 years ago by Lam (2002) showed that there was no significant increase in the risk of being killed or injured in a crash for drivers using a hand-held phone in most age groups, except 25–29 year-old drivers, when compared with those drivers who crashed without any distraction. The risk of car crash injury for 25–29 year-old drivers who used a hand-held phone was estimated to be 2.4 times higher than those not being distracted. Based on crash reports in the U.S., it is believed that distracted driving (included mobile phone use) caused nearly 3,477 fatalities in 2015 alone (NHTSA, 2017). A U.S. study of police crash reports reported that mobile phone distraction is estimated to have resulted in 18% of fatal crashes and 5% of injury crashes (Overton et al., 2014). A study targeting young drivers in the U.S. found that drivers had a higher likelihood of being severely injured if they were distracted by a cell phone (Neyens and Boyle, 2008). In Canada, Asbridge et al. (2013) reported that the odds of a culpable crash increase by 70% when the driver is using a mobile phone.

4.5.2 NATURALISTIC OBSERVATIONS RELATED TO CRASH RISK

Naturalistic driving studies are methods utilised for investigating driver behaviour and traffic safety in the roads. However, these methods have important limitations for the study of risk in mobile phone distracted driving: (i) the number of crashes observed in naturalistic driving studies is typically small, (ii) there is confounding bias arising from other driver behaviour errors (e.g. speeding), and (iii) the environment/conditions of a safety-critical event is uncontrolled (Young, 2017, Oviedo-Trespalacios et al., 2016). These limitations hinder the generalisability of the research findings to the population of distracted drivers.

Besides these technical challenges and academic debate, naturalistic studies have reported strong associations between crash risk and mobile phone use while driving. The most recent and largest naturalistic study in the U.S., Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS), gathered information from more than 3,500 drivers across a 3-year period (Dingus et al., 2016). Overall, the SHRP 2 NDS has reported that any hand-based mobile phone interactions increase crash risk odds by a factor of 3.6. An odds ratio value of 1.0 is considered equivalent to driving while not distracted. Table 4.2 shows the increases in the odds of a crash according to mobile phone tasks detected:

Table 4.2 Crash risk associated with mobile phone use

Observed distraction	Odds ratio (95% CI)
Mobile phone browse	2.7 (1.5 – 5.1)*
Mobile phone handheld dial	12.2 (5.6 – 26.4)*
Mobile phone reach	4.8 (2.7 – 8.4)*
Mobile phone handheld text	6.1 (4.5 – 8.2)*
Mobile phone handheld talk	2.2 (1.6 – 3.1)*
Mobile phone handheld total	3.6 (2.9 – 4.5)*

*indicates a difference at the .05 level of significance
Adapted from Dingus et al. (2016)

These results have been under discussion, but are not yet considered to be conclusive. Recently Young (2017) discusses potential confounding bias arising from driver behaviour errors and a mismatch in additional secondary task between the exposed and unexposed drivers. This means that usually drivers who crash while using their mobile phones were simultaneously engaging in other risky driving behaviours such as speeding. Since videos of driving while not distracted by the mobile phone also lacked the other risky driving behaviours observed in the crash, it is argued that they do not constitute a suitable comparison on which to determine the unique effect of mobile phone distraction.

An important finding reported in the SHRP 2 NDS is that young drivers (16 – 20 years old) and older drivers (65 – 98 years old) have higher crash risks while using a mobile phone (Guo et al., 2017).

Another important naturalistic study was conducted in the U.S. by Fitch et al. (2013). In this naturalistic study, a total of 204 drivers were monitored between February 2011 and November 2011. Crash risk was calculated using safety critical events that comprised crashes, near-crashes, and crash-relevant conflicts. The results are shown in Table 4.3:

No naturalistic study has been finalised to inform mobile phone distracted driving issues and particularities in Australia. At the moment, data from the first large-scale Australian Naturalistic Driving Study (NDS) (Regan et al., 2013) is under analysis. It is unclear when the data will be publicly available.

Table 4.3 Crash risk associated with mobile phone use

Observed distraction	Odds ratio (95% CI)
Mobile phone Visual-Manual Subtasks (i.e. text messaging/browsing, locate/answer, dial, push to begin/end use, and end handheld phone use)	1.73 (1.12 – 2.69)*

Mobile phone handheld talk	0.79 (0.43 – 1.44)
Mobile phone portable hands-free talk	0.73 (0.36 – 1.47)
Mobile phone integrated hands-free talk	0.71 (0.3 – 1.66)

*Indicates a difference at the .05 level of significance
Adapted from NHTSA (2016 and Fitch et al. (2013

Based on the recent Visual-Manual NHTSA Driver Distraction Guidelines for Portable and Aftermarket Devices (NHTSA, 2016) and a meta-analysis of naturalistic studies conducted by Simmons et al. (2016), two main findings have been consistent in the naturalistic driving literature:

(i)   Visual-manual tasks, such as texting and browsing, were associated with increased crash risk and safety-critical events (see Dingus et al. (2006), Dingus et al. (2006), Hickman et al. (2010), Hickman and Hanowski (2012), Simons-Morton et al. (2014), Simmons et al. (2016), Oviedo-Trespalacios et al. (2016), and Fitch et al. (2017), for some supportive literature) .

(ii)   Non-visual-manual tasks, such as conversing, were not associated with increased crash risk and safety-critical events (see Klauer et al. (2006), Olson et al. (2009) Hickman et al. (2010), Oviedo-Trespalacios et al. (2016), Young (2017), and Oviedo-Trespalacios et al. (2017) for some supportive literature). These results confirm that there are no differences in crash risk between hand-held and hands-free conversations (see Fitch et al. (2013), and Oviedo-Trespalacios et al. (2016) for supportive literature). Though speaking or listening to a hand-held device in isolation did not appear to increase safety-critical event risks (e.g. crashes), talking does require the driver to first locate, reach for and make a call on or answer the hand-held device. These task sub-components of hand-held mobile phone conversations could entail highly intensive visual, cognitive, and manual interactions (e.g. dialling or battery/duration monitoring) which increase crash risk.

An important consideration is that the most recent article published by Dingus et al. (2016) reported that talking could more than double crash risk in mobile phone distracted driving. There has been significant academic debate generated by these results, with the method of calculating the odds ratios being called into question. Since conversing on a phone at the time of a crash often coincides with other factors that contribute to crash occurrence, the contribution made by use of the phone is difficult to determine; one method of calculating the odds ratios ignores the impact of other factors, and indicates increased risk, while another (which is contested) takes the other factors into account and does not indicate increased risk from conversation alone. The debate has yet to be resolved, and has important policy implications for the management of cognitive distraction (see Atchley et al. (2017) and Strayer et al. (2003)).

While it is not completely clear why cognitive distraction (e.g. talking on a mobile phone) would not increase crash risk in naturalistic studies (bearing in mind the contrary findings of Dingus et al., 2016), recent research has suggested that the distraction observed in controlled studies of conversing on a mobile phone could be a result of not allowing participants to engage in natural behavioural adaptations such as self-regulation (Oviedo-Trespalacios et al., 2017).

4.5.3   EXPERIMENTAL OBSERVATIONS RELATED TO CRASH RISK

Experimental and/or naturalistic studies, on the other hand, are not suitable for estimating actual crash risk as crashes are rarely observed within the study design (Caird et al., 2008). Among the few studies that have discussed safety, mobile phone tasks like dialling (Tractinsky et al., 2013), and texting (Alosco et al., 2012, Kim et al., 2013, Stavrinos et al., 2013, Bendak, 2014) have been reported to increase the frequency of crashes.

4.5.4   SELF-REPORTED DATA RELATED TO CRASH RISK

A case crossover study in Australia using hospital data showed that drivers who use a mobile phone up to 10 minutes before a crash are associated with a fourfold increase in the likelihood of having a serious crash (McEvoy et al., 2005). In a study using drivers who attended hospital in Australia (WA), a distracting activity (not only mobile phone use) was cited in 57% of all rear-end collisions in which the driver hit the vehicle in front (McEvoy et al., 2007). Another case crossover study in Canada, using actual telephone activity of drivers reporting a crash, found that mobile phone conversations increase crash risk by a factor of four (Redelmeier and Tibshirani, 1997). In Norway, a study using self-reported data of drivers involved in accidents reported that the crash risk of using hand-held phones is higher than using hands-free technology (Backer-Grøndahl and Sagberg, 2011).

4.6   MOBILE PHONE USE WHILE DRIVING AND REGULATORY APPROACHES

Efforts to combat distracted driving today should involve system-wide stakeholders from community advocacy groups, mobile phone technology developers, car manufacturers, and researchers, among others. At first glance, a combination of a definitive mobile phone ban while driving and strong enforcement should be the most effective approach to address this problem. However, research worldwide showing a large prevalence of mobile phone distracted driving has confirmed that legislation and enforcement are not necessarily preventing mobile phone use while driving. As noted earlier, pioneers and advanced road safety systems with strong laws on distracted driving such as Australia and the USA have been unsuccessful in stopping these behaviours. The partial success of these strategies confirms the need for enhancing our understanding of the nature of the distraction problem.

4.6.1 LEGISLATION

Traditionally, legislation on distraction has focused too heavily on the role of the driver, while ignoring the responsibility of the wider road transport system (Young and Salmon, 2015, Parnell et al., 2017). This approach is lacking because mobile phone distraction is a complex problem that requires the unified and consistent action of multiple stakeholders from across the transport system (e.g. mobile phone manufacturers, app designers, vehicle manufacturers, etc.). System-wide legislation and interventions will allow more opportunities to prevent crashes and injuries.

The report "Mobile phone use: a growing problem of driver distraction" published by the World Health Organisation (WHO, 2011) showed that in many countries, legislation already plays an important role in addressing driver distraction behaviour (see Appendix B for some examples). For instance, European countries have general laws that target driving "without due care and attention". However, it seems that there is also an increasing trend towards development and adoption of more specific legislation relating to particular mobile phone tasks or population groups. In the U.S., many states explicitly prohibit talking, text-messaging or playing video games on hand-held mobile phones while driving. Additionally, a number of states, such as California, have passed laws banning or restricting young drivers (under the age of 18) from using mobile phones, or other types of mobile devices while driving (Zhou and Curry, 2009). Based on data from the National High Traffic Safety Administration (NHTSA) (2016) currently 46 states, District of Columbia (DC), Puerto Rico, Guam, and the U.S. Virgin Islands ban texting while driving for drivers of all ages. Fourteen states, DC, Puerto Rico, Guam, and the U.S. Virgin Islands ban hand-held mobile phone usage while driving. It is also important to mention that all states with device bans allow emergency calls, and some allow talking while stopped in traffic.

Generally, the effectiveness of legislation has been low if not virtually non-existent. The most recent literature review analysing a total of eleven peer-reviewed articles and reports from the U.S. on the impact of mobile phone restrictions for young drivers confirmed that nearly none of the restrictions evaluated before 2014 appear to have a long term effect on the prevalence of mobile phone use by novice drivers (Ehsani et al., 2016). Although some general studies in Washington DC, New York, and Connecticut have reported that hand-held bans could have long term effects (if effective enforcement is available), this could be because many drivers may have switched to hands-free devices (McCartt et al., 2010b). Recently, a U.S. study conducted by Rudisill and Zhu (2017) using the 2008–2013 National Occupant Protection Use Survey (NOPUS), concluded that universal bans of hand-held mobile phone use while driving were associated with markedly lower hand-held phone conversations across all drivers. However, mobile phone use was higher overall among females, younger age groups, and African American drivers; as such, these groups may benefit from directed interventional efforts. In New Zealand, an evaluation of the 2009 law that banned hand-held mobile phone use while driving showed evidence of some partial success in the on-road prevalence of mobile phone use. Similar results were documented in the U.K. by Johal et al. (2005).

A review of the research on the effects of driver mobile phone usage bans (particularly texting) found mixed results (McCartt et al., 2014). Policy evaluation of the effect of legislation prohibiting visual-manual interactions such as texting has been difficult. Among other issues, estimating the prevalence of texting interactions while driving is challenging because drivers usually hide the mobile phone through behavioural adaptions (e.g. texting with the phone in their lap) (Vera-López et al., 2013). Recently, these behavioural adaptations have been reported in Australia by Oviedo-Trespalacios et al. (In press). Nonetheless, the high prevalence of visual-manual mobile phone interactions reported in self-reported and observational on-road studies confirm that this is a persistent issue regardless of legislation. In Europe, Jamson (2013) documented that drivers in the most highly regulated country (Italy) report texting as frequently as those in countries with no legislation.

The impact that mobile phone bans has on reducing crash risk has been widely discussed. Some studies have found that driver mobile phone bans do not reduce collisions. For example, in the city of San Antonio (TX), after a prohibition from January 2015 of portable electronic devices (mobile phones, music players, electronic reading devices, computers, GPS or navigation systems, or portable gaming devices) while driving, no positive effect in reducing the number of accidents was found within the city (Roper, 2017). One reason that could explain why San Antonio's hands-free law has had no effect on the reduction of mobile-device related accidents might be that people are texting below eye-level or in their laps, to conceal their activity, making it much more dangerous to engage in, rather than texting with the device near eye level. Research elsewhere has demonstrated that these mobile phone positions are not optimal and increase the visual workload (see Wittmann et al. (2006) and Alconera et al. (2017)).

There are, however, some notable success stories. In California (U.S.), Kwon et al. (2014) reviewed the effect of the hand-held mobile phone ban in July 2008 using a large-scale traffic accident database. The results confirmed that the hand-held mobile phone law showed a primary effect on decline of collisions involving mobile phone distracted driving. Additionally, Ferdinand et al. (2014) found, using data in 2000 through 2010 in 48 U.S. states, that primarily enforced laws banning all drivers from texting were significantly associated with a 3% reduction in traffic fatalities in all age groups, and those banning only young drivers from texting had the greatest impact on reducing deaths among those aged 15 to 21 years. It is important to mention that most of the research agrees that there are large differences in the effect of the law between jurisdictions (Rocco and Sampaio, 2016). Altogether, it is important to remember that these studies based on crash data are unable to provide a causal link between the ban and fatalities.

In Australia, to the knowledge of the authors, no comprehensive evaluations have been conducted to assess the effectiveness of mobile phone distracted driving legislation.

4.6.2   ENFORCEMENT

Hand-held mobile phone bans require strong enforcement to have the desired effect on driver behaviour in the long term (McCartt and Hellinga, 2007, McCartt et al., 2010a). However,

research has shown that enforcing these laws is difficult. A comprehensive qualitative study with police officers found that barriers to enforcement in the U.S. include (Nevin et al. (2016)):

- **Societal factors:** (i) Distracted driving law is difficult to enforce because this is usually directed to specific tasks such as texting and drivers could be using their phone for utilitarian systems such as GPS; and (ii) mobile phones are technologies in constant evolution sometimes faster than policy cycles.
- **Organisational factors:** (i) Distracted driving has usually low prioritisation compared to other policing functions, (ii) lack of resources dedicated to distraction; and (iii) lack of clear policies regarding distracted driving among officers.
- **Interpersonal factors:** (i) Many drivers challenge officers during traffic stops; and (ii) communications between officers can influence enforcement motivations.
- **Individual factors:** (i) Officers identify with distracted drivers and distracted behaviour; (ii) detection of distracted drivers is difficult, and (iii) some officers believe that drivers can safely multi-task.

In the U.S., high-visibility enforcement programs targeting drivers who use hand-held mobile phones have been trialled successfully. Observed hand-held mobile phone use dropped nearly 33% in California and Delaware (NHTSA, 2016). The high-visibility operation in NSW, known as Operation Compliance, was highlighted by the World Health Organisation (WHO, 2011). Operation Compliance requires all police, regardless of duty type, to target specific traffic safety offences such as the use of mobile phones. To this end, resources are used to maximize effect – e.g. the use of motorcycle units to detect the use of hand-held phones by drivers – where the elevated position of the rider allows for the interior of the vehicle to be more clearly observed, and texting drivers to be detected. To the best of the authors' knowledge, no evaluation of the Operation Compliance has been conducted examining changes in mobile phone distracted driving prevalence.

In Queensland, the high self-reported prevalence of mobile phone use suggests that an enforcement oriented policy has not been able to prevent mobile phone distracted driving (Oviedo-Trespalacios et al., In press). For instance, drivers reported scanning the environment and covering the phone all the time with their hand to avoid police. The fact that drivers learned that covering the phone with their hand will help them avoid a police offence while driving must be incorporated in planning for road safety strategies. More research in behavioural adaptation is needed to overcome the limitations of today's interventions.

5 REVIEW OF CURRENT REGULATORY AND ENFORCEMENT PRACTICES

5.1 BACKGROUND

Australian State transport agencies and police agencies share responsibility for policy formulation and advice that is translated into regulatory frameworks for controlling the use of mobile phones and other mobile technologies by drivers. The regulatory framework also sets out penalties, while enforcement of the regulations is the responsibility of police. While there is a great deal of commonality between regulation and enforcement approaches across Australian States, there are also differences. Such differences are arguably more likely to be evident in an area of emerging concern, where State-specific political factors may influence the underlying policies applied to driver distraction by mobile phones and the form of the regulations that operationalise the policies, with flow-on effects on the way that police conduct enforcement. The purpose of this part of the project was to examine current regulatory and enforcement practices across Australia, to identify the policy goals being addressed, and to discern the degree of commonality in the policy goals. This was achieved through a review of publicly available policy documents and in the consultations with transport authorities and police.

5.2 AUSTRALIAN ROAD RULES REGULATION 300

The Australian Road Rules form the basis of most road law in Australia, although jurisdictions are able to choose whether or not they will adopt particular rules, and can add their own rules or modify the model rule. Jurisdictions also define their own offences and penalties based on the rule.

The relevant Australian Road Rule is Regulation 300 - Use of Mobile Phones (ARR 300), which states:

> *(1) The driver of a vehicle must not use a mobile phone while the vehicle is moving, or is stationary but not parked, unless—*
>
>> *(a) the phone is being used to make or receive an audio phone call and the body of the phone—*
>>
>>> *(i) is secured in a mounting affixed to the vehicle while being so used; or*
>>>
>>> *(ii) is not secured in a mounting affixed to the vehicle and is not being held by the driver, and the use of the phone does not require the driver, at any time while using it, to press any thing on the body of the phone or to otherwise manipulate any part of the body of the phone; or*

(ab) the phone is being used as a driver's aid and—

> *(i) the body of the phone is secured in a mounting affixed to the vehicle while being so used;*

and

> *(ii) the use of the phone does not require the driver, at any time while using it, to press any thing on the body of the phone or otherwise to manipulate any part of the body of the phone; or*

(b) the vehicle is an emergency vehicle or a police vehicle; or

(c) the driver is exempt from this rule under another law of this jurisdiction.

ARR 300 then notes that certain terms are defined elsewhere and gives examples of driver's aids: closed-circuit television security cameras; dispatch systems; navigational or intelligent highway and vehicle system equipment; rearview screens; ticket-issuing machines; and vehicle monitoring devices.

Since the aim of allowing hands-free phone use is to address the manipulation and direction-of-gaze issues associated with hand-held phones, ARR 300 then outlines what requirements must be met:

> *(2) For the purposes of this rule, a mobile phone is secured in a mounting affixed to the vehicle if, and only if—*

> *(a) the mounting is commercially designed and manufactured for that purpose; and*

> *(b) the mobile phone is secured in the mounting, and the mounting is affixed to the vehicle, in the manner intended by the manufacturer.*

> *(3) For the purposes of this rule, a driver does not use a phone to receive a text message, video message, email or similar communication if—*

> *(a) the communication is received automatically by the phone; and*

> *(b) on and after receipt, the communication itself (rather than any indication that the communication has been received) does not become automatically visible on the screen of the phone.*

> *(4) In this rule—*

"affixed to", in relation to a vehicle, includes forming part of the vehicle;

"audio phone call" does not include an email, text message, video call, video message or other similar communication;

"body", in relation to a mobile phone, means the part of the phone that contains the majority of the phone's mechanisms;

"held" includes held by, or resting on, any part of the driver's body, but does not include held in a pocket of the driver's clothing or in a pouch worn by the driver;

"mobile phone" does not include a CB radio or any other two-way radio;

"use", in relation to a mobile phone, includes any of the following actions by a driver—

>*(a) holding the body of the phone in her or his hand (whether or not engaged in a phone call), except while in the process of giving the body of the phone to a passenger in the vehicle;*

>*(b) entering or placing, other than by the use of voice, anything into the phone, or sending or looking at anything that is in the phone;*

>*(c) turning the phone on or off;*

>*(d) operating any other function of the phone.*

What is evident in the level of detail and specification required is the need to adapt the legislation to an increasing array of options presented by communications technologies.

The penalties to be applied to breaches of ARR 300 are set by individual jursidictions, which can also exempt drivers (or particular kinds of drivers in particular circumstances) from the rule. In the Australian Road Rules itself, there are general exemptions from any of the rules for drivers of police vehicles and emergency vehicles, depending on the needs of the circumstances, appropriate care being taken, and use of flashlights/alarm/siren.

5.3 JURISDICTION REGULATORY REQUIREMENTS

A search was performed on the public information supplied via websites of transport agencies regarding laws about mobile phone use and the penalties applied. Where available, information pertaining to other mobile or nomadic technology was included. This information was confirmed or supplemented with information from interviews with transport and policing agency representatives.

Table 5.1 summarises the information on the legal requirements in relation to ARR 300, and the defined offences and penalties, where available. It also includes comments provided during interviews relevant to potential legislative change.

Table 5.1 Legislation and penalties for mobile phone use while driving

	Fully licensed car drivers	**Other groups**	**Comments arising from interviews**
ACT	ARR 300, defines two offences: • Drive using hand-held mobile phone - $416 and 3 demerit points • Drive using mobile phone for messaging, social networking, mobile application or accessing the internet - $511 and 4 demerit points	Apparently no differences	N/A
NSW	ARR 300 $325 and 3 demerit points Higher fine for use in school zones: $433 and 3 demerit points Double demerit points on public holidays	Complete ban for P1/2 (P2 since Dec 2016)	Emerging issue of integration of mobile phones with VDU, e.g. Apple CarPlay: P drivers who want to use legal functions (e.g. music) may only be able to do so through the phone interface
NT	ARR 300 $250 and 3 demerit points	Complete ban for P1/2	Total ban rejected due to remote/regional needs
Qld	ARR 300 $365 and 3 demerit points Double demerit points for second or subsequent offence within 1 year	Complete ban for P1	People low on points tend to challenge to extend their time
SA	ARR 300 $320 and 3 demerit points	Complete ban for P1	Drivers do not understand the legislation: think it's legal to use a hand-held when stopped in traffic
Tas	ARR 300 $300 and 3 demerit points	No differences	Possibly penalties are not high enough Currently reviewing graduated licensing Monetary incentives likely to work better, e.g. through insurance
Vic	ARR 300	Complete ban for P1/2	Due to high noncompliance among young people, examining

	$466 and 4 demerit points		if there are ways of allowing some use with particular kinds of driver aid
			Provide specific advice on smartwatches
			Emerging issue of technology allowing phones to sync to car and show Facebook etc
WA	ARR 300, offences specified: - Using a hand held mobile phone whilst driving - Creating, sending or looking at a text message, video message, email or similar communication whilst driving $400 and 3 demerit points	No differences	Public feedback is that penalties should be increased

5.3.1   SIMILARITIES BETWEEN JURISDICTIONS

It is clear that all jurisdictions base their legislation on ARR 300, and comments made during the interviews with transport and police agencies frequently referred to it. This implies that a coordinated approach to legislation in this area has a high chance of success.

5.3.2   DIFFERENCES BETWEEN JURISDICTIONS

Given the universal use of ARR 300, the differences in the details of its application between jurisdictions were greater than might have been expected.

5.3.2.1   Specification of offences

Most jurisdictions specify a single offence for mobile phone use, however ACT, NSW and WA specify more than one.

NSW sets a larger fine for use of a mobile phone in a school zone.

WA specifies two offences, with texting, video messages and email being added to the generic offence of "using a mobile phone while driving". While the different offences recognise the different tasks that can be performed using a mobile phone, as well as the overlap with ARR 299 (dealing with visual display units, or VDUs), there is no difference in penalties and it could be considered that the additional offence is adequately covered by "using a mobile phone while driving".

In the ACT an additional offence is also specified – "drive using mobile phone for messaging, social networking, mobile application or accessing the internet" – but it has a higher fine and an additional demerit point. This has the advantage of taking into account the greater risk associated with non-conversing mobile phone tasks that draw attention away from the road for more prolonged periods. There is potentially some value in adopting this approach, and Queensland has indicated an interest in exploring the hierarchy of risks associated with different kinds of mobile phone use.

As an aside, Victoria provides information about the penalties for using a smartwatch while driving, but this does not involve the creation of a separate offence. Prepared by VicRoads in response to inquiries from the public, the information explains how the provisions of ARR 299 and 300 apply to the use of smartwatches, which in any case operate via their connection with a mobile phone.

5.3.2.2   Fines and demerit points/double demerit points

Across Australia, fines for mobile phone use (at the lower level for jurisdictions with more than one offence) vary between $250 and $466, and the number of demerit points varies between 3 and 4. Double demerit points are assigned in some States, either on public holidays or (in Queensland) for second and subsequent offences within a year. While a number of considerations are taken into account in setting penalties, especially consistency across a jurisdiction's traffic penalties, the variation in the monetary penalty in particular seems high. Similarly, double demerit points are applied to achieve greater deterrence under certain circumstances that are presumed to be high risk, but for mobile phone use there is a lack of consistency.

5.3.2.3   Young drivers

In some jurisdictions P1 and P2 drivers are completely banned from any form of mobile phone use, in Queensland and SA the complete ban applies only to P1 drivers, and in the remainder P1 and P2 drivers are treated in the same way as fully licensed drivers. It is worth noting that the restrictions on P1/2 drivers fall under Graduated Driver Licensing (GDL) policy rather than policy on driver distraction alone. GDL involves a mix of constraints on young driver exposure to risk, and it is arguable that it is the overall balance of risk exposure that is more important than risk in one area (i.e. mobile phone use) alone. However it is also desirable to pursue a consistent policy line of distracted driving, and young drivers are simultaneously the group most likely to regularly use a mobile phone, and the group with the highest crash risk.

5.4   ENFORCEMENT PRACTICES

Table 5.2 summarises the information provided by police agencies, and to some extent by transport agencies, on the enforcement of mobile phone legislation. Only the Victoria Police

did not respond, however information on enforcement in Victoria was provided by other interviewees.

Table 5.2 Enforcement practices for mobile phone use while driving

	Main enforcement method	**Other methods**	**Comments**
ACT	Observation by car and motorcycle police	Trialling unmarked motorcycles with uniformed police	Difficulty detecting texting
NSW	Motorcycle police with helmet cameras, also working on congestion – one squad CBD, another at Parramatta, occasionally use in rural areas	Looked at camera detection but requires an operator as cannot detect mobile phone use automatically Sometimes use spotter from high vantage point	Enforcement backed up with campaigns e.g. Get Your Hand Off It Emerging issues: use of phones increases, railway crossing and stop sign violations, use of navigation systems creates problems if vehicles are directed to unsuitable roads
NT	Visual observation by police cars and motorcycles, latter most successful	Trialled cameras but not successful	Difficulty detecting texting
Qld	Observation and marked and unmarked cars and motorcycles	Sometimes use observers. Wear body cams, footage can be used as evidence if contested, which is rare.	Typically not dedicated mobile phone enforcement, done as part of general duties
SA	Motorcycle police with Go-pro cameras, footage can be used, but rarely needed	Observers on high vantage pint calling to team located down the road	Run campaigns on inattention a couple of times a year Officers have discretion to write a caution
Tas	Motorcycles, marked and unmarked cars	Spotters at large Hobart roundabout	Focus on fatal five, have infringement targets for mobile phone use
Vic	Two police, one in a position where they can see into cars	Considering camera detection system	Have investigated use of metadata to prove phone in use when offence observed
WA	Motorcycle police Plain motorcycle, uniformed police	Two-person team with bridge mounted camera; one km range, spots mobile phone	Category A offences (fatal five) need to comprise 90% of infringements detected Trial of cameras and also

	Helmet mounted cameras Camera footage is legal evidence	and seat belt use Use mapping to assist enforcement targeting	"beacon" system – alarm transmission when vehicle crashes, use of phone recorded

5.4.1   PREFERRED ENFORCEMENT PRACTICE – MOTORCYCLE POLICE

The primary challenge for enforcement is the need to observe motorists using a mobile phone illegally. When the legislation was originally enacted, the dominant use of hand-held mobile phones was for voice calls, which is relatively easy to detect from a car. However the widespread current use of mobile phones for texting and social media means that they can be held out of direct view, on the driver's lap or by the door. Motorcycle police are positioned at a higher eye level and able to go close to vehicles to look in, so it is not surprising that this form of enforcement is the most popular.

In some cases, such as the NSW squads in the Sydney CBD and Parramatta, enforcement is undertaken by sole motorcycle police, while in other cases it is undertaken by two police, one of whom spots drivers using mobile phones and notifies the motorcycle police officer who pulls the driver over. Because of the potential risks, sole operation is more easily undertaken when drivers are stationary at traffic lights, while a two person operation means that the motorcycle police officer does not need to ascertain whether the driver of a moving vehicle is using a phone as this has already been determined by the spotter. If there was a move to place less importance on mobile phone use while stationary (which is not seriously proposed by agencies but has some support among the public), single officer operations would become more difficult and the more resource-intensive two officer operation would be more appropriate, subject to technology solutions discussed below.

5.4.2   USE OF CAMERAS

Cameras are used routinely in some jurisdictions and occasionally in others. The Australian legal system places a high level of trust in the word of a police officer, so the need for camera evidence of mobile phone use apart from the officer's statement is probably unnecessary in the majority of cases, and drivers accept the penalty. In some jurisdictions this is all that police rely on, while in others there are varying degrees of use of cameras, which have different levels of evidentiary standing. In WA, for example, motorcycle police have helmet cameras and the footage taken can be used as evidence. In other jurisdictions the standing of photographic evidence is unclear. Some motorcycle police have helmet cameras, and cameras can also be used by police car occupants. Cameras may also be positioned on suitable vantage points, such as overpasses, however they usually need an operator to be present to determine that an offence has been committed, so that a police officer can pull over the vehicle.

Unlike speed camera and red light camera offences, there is no specific camera-detected mobile phone offence with owner onus legislation to allow for automatic camera operation. The

potential for more widespread use of cameras is being examined in Victoria and Western Australia, using a system developed by the company Parking Strategy. Two uncommissioned surveys have been undertaken by Parking Strategy in Sydney and Melbourne, where they report (Parking Strategy, 2017):

- Sydney: 418 infringements over 12 hours (about one every 103 seconds), with 4.1% of motorists observed using a mobile phone
- Melbourne on the M2 Motorway: 56 infringements were observed in 21 minutes (one every 21 seconds)

A commissioned trial by Parking Strategy is about to be undertaken in Western Australia. Contact was made with the company, who agreed to the citation of the figures above (from a proposal to VicRoads). While the camera shots still need to be checked manually to confirm mobile phone use, the company is hopeful that image processing algorithms can be developed to allow better automatic detection. If this could be achieved, it could form the basis of an automated enforcement approach, however it is understood that there are considerable challenges involved in developing a successful algorithm.

5.4.3 ENFORCEMENT PRIORITY

The enforcement of mobile phone use relative to other offences is approached in different ways. Some jurisdictions (notable WA and Tasmania) reported that, because driving while distracted is one of the Fatal Five driver behaviours, it has a higher priority for enforcement than offences outside the Fatal Five. In WA the Fatal Five offences are defined as Category A offences, and 90% of infringements detected need to fall into this category. In Tasmania, specific targets for mobile phone infringements are implemented, though this may be at a regional level only.

In Sydney, the CBD motorcycle squad that undertakes a large proportion of mobile phone enforcement was not established for this purpose, but as a means of addressing congestion in the CBD resulting from the light rail construction being undertaken. While the nature of the CBD traffic control task lends itself well to mobile phone enforcement, the main objective of the squad is to facilitate traffic movement. The policy question that arises is whether such an "incidental" focus on mobile phone enforcement is adequate.

Overall, in the larger jurisdictions, the detection of mobile phone infringements does not appear to have kept pace with population increases, and is therefore even further behind the rate of uptake and use of mobile phone-based applications by drivers. Several police interviewees felt that their enforcement efforts had not made a difference to levels of use, and that the problem needed a technological solution rather than an enforcement solution.

5.5   COMMON POLICY GOALS ACROSS JURISDICTIONS

Commonality of the use of ARR 300 can be seen, though the States are not uniform in how novice drivers are addressed and there are variations in the severity of penalties. The interviews also identified some emerging issues and policy directions that are being considered by jurisdictions.

5.5.1   EMERGING ISSUES AND POLICY DIRECTIONS

There is a shared view that the efforts to reduce mobile phone use while driving through legislation and enforcement have been of limited success, and may only have slowed a tide of increasing use. There were two main themes underlying the comments made: technological and social.

5.5.1.1   Technological issues

In several interviews the issue of technological change was mentioned as both a challenge and an opportunity. The introduction of greater interactivity between devices, through applications such as Apple CarPlay, challenges the current assumptions about the functionality of mobile phones. Since the phone is also a source of music, a potential navigation aid and collision warning device, "using a mobile phone" covers a wider range of activities than is envisaged in ARR 300. For P1/2 drivers in jurisdictions where all phone use is banned for these license classes, the automatic connection of the phone for music is therefore illegal. The driver aid features of a phone, which in theory should benefit the driver, are similarly illegal. Amending ARR 300 to address these issues and to anticipate future technological change seems both necessary and hard to achieve.

On the other hand, in several interviews it was stated that technology offers an answer to the dangers of mobile phone use while driving that enforcement alone cannot address. It was less clear what shape such an answer would take; interviewees were often aware of voluntary blocking software and were doubtful about its value, while the impact of complete blocking was considered to involve risks, e.g. one police interviewee remarked that the delay between a crash in a rural area and the arrival of emergency services has been greatly reduced by the use of mobile phones.

5.5.1.2   Social issues

Several of the interviews raised the point that, among young people in particular, the use of a mobile phone as a form of social connection is of primary importance, while tasks like driving are less crucial. There are different ways of expressing this, with the most extreme being inversion of the vehicle control/mobile phone use relationship, such that the demands of driving are seen to be a distraction from the need to maintain contact with important others. Another perspective is to problematize mobile phone use among young people as a form of addiction. Alternatively, a societal development perspective taken by some interviewees is that the shift

to a different form of social contact though technology has happened too rapidly for society to have developed behavioural protocols around what kinds of use are appropriate and to what level. To address this issue, the evolution of such protocols and their inclusion in the socialisation of children (at home and in school) is seen to be a long term means of establishing a social framework that can be utilised to justify legislation, support compliance and legitimise enforcement.

These perspectives have varying implications, and there is no clear direction at this stage. As there are similar issues being experienced in other areas, for example mental health among young people in relation to social media use, it is likely some consensus will emerge. However this is not likely to provide guidance in the short term.

5.5.2 NATIONAL LEADERSHIP AND AN EVIDENCE-BASED APPROACH

As noted above, all jurisdictions have recourse to the Australian Road Rules, and all are members of the Austroads Road Safety Taskforce, which has identified mobile phone use (and distracted driving in general) as a significant policy issue. In the interviews it was noted that ARR 300 is under review and there was a clear sense among transport agency interviewees of a commitment to a national approach. In general, police agency interviewees considered the policy issues to be the province of the relevant transport agency in their jurisdiction. The interview period overlapped with an Austroads Road Safety Taskforce meeting, and contacts interviewed after the meeting mentioned the discussions that had taken place, giving the impression that the Taskforce provides a useful forum for exploring issues and challenges. However, the federal structure of Australian government means that the transport agencies in the States and Territories have more influence on transport policy than the Department of Infrastructure and Regional Development and Austroads itself is a peak body for State and Territory (and New Zealand) road authorities, so that national leadership in this area has to proceed through consensus.

There is also a strong emphasis among the jurisdictions, in both transport agencies and police agencies, on an evidence-based approach to policy on driving while distracted by mobile phones and other devices. The lack of comprehensive and reliable crash data, and the challenge of ever-changing technology, present challenges to an evidence-based approach. The literature review noted that naturalistic driving studies are beginning to provide better insights into the crash risks associated with distracted driving, and some jurisdictions have expressed interest in exploring the implications of this research (notably Queensland and Victoria). However, the literature review also pointed out that the interpretation of the naturalistic driving study data is disputed, and that the dispute concerns an issue directly relevant to policy – whether it is risky to have a mobile phone conversation on a hands-free phone. This implies that it will be difficult to gain a clear policy direction through national consensus without first resolving the questions surrounding the evidence. As most of this evidence is being collected and interpreted in the United States, the ability to move forward in Australia is limited.

Consideration of these points suggests that, in the short/medium term, the best way to work towards a nationally agreed policy direction is to:

- Consult researchers with relevant expertise to determine the evidence base on which policy can be developed
- Investigate means of collecting valid, reliable and comprehensive data on mobile phone involvement in road crashes
- Explore enforcement options that can be implemented by all jurisdictions
- Explore technology options that balance the costs and benefits of reducing or blocking connectivity of mobile phones in vehicles

In the longer term, the social context of mobile phone use needs to be explored and addressed, though this would take place in a broader context and draw on social education approaches.

6 SCOPE FOR EXISTING AND NEW TECHNOLOGICAL APPROACHES

6.1 EXISTING TECHNOLOGICAL APPROACHES TO REDUCING THE RISK OF MOBILE PHONE USE

6.1.1 WORKLOAD DETECTION AND ALERTING

A basic approach to distraction is to alert drivers if they need to devote more attention to the road. However, this approach relies on a means of measuring workload in the first place, then developing devices that can use these measurements to trigger alerts.

6.1.1.1 Measuring workload

The main focus on workload measurement has been on cognitive workload, although visual factors are taken into account as well. Workload can be measured at the physiological level using an electroencephalograph (EEG), electro-oculography (EOG), eye gaze monitoring, visual occlusion measurement, and heart rate monitoring (Mehler, Reimer & Coughlin, 2012). Cognitive distraction may be inferred from various metrics including strong gaze concentration to the road centre, reduction in lane-keeping variance, and/or an increase in small (usually below 2°) steering wheel reversals.

6.1.1.2 Distraction alerts

These in-vehicle systems utilise workload measurements to warn drivers if they are judged to be visually and/or cognitively distracted by interaction with a mobile phone or some other source of distraction. Hence, they may reduce the risk of mobile phone use by reminding drivers that they are distracted and helping them to re-orient their attention back to activities critical for safe driving.

Two types exist:

Visual Distraction Alerts – warn the driver if they are judged to be glancing away from the road for too long, or too often, and help the driver to re-focus visual attention to the roadway. Eye glance and head-rotation metrics are commonly used to gauge the level of driver visual distraction. Alerts may include flashing lights, icons, tones, seat vibrations and voice messages.

Cognitive Distraction Alerts – warn the driver if judged to be paying excessive attention to internal thoughts or auditory content (e.g. day dreaming). Flashing lights on both sides of the windscreen may be used to remind drivers to scan the road environment (particularly the peripheries) if they are having a mobile phone conversation and gaze concentration is judged to be too high.

The benefits of these systems are mixed. Donmez, Boyle, & Lee (2007), for example, found that visual distraction alerts increased visual attention to the forward roadway. Others, however,

have reported contradictory findings (e.g. Lee et al. 2013) or have reported that drivers perceive alerts to be overly obtrusive and annoying (e.g. Roberts, Ghazizadeh, & Lee 2012).

Distraction alerting systems are available in some production vehicles currently on the market, and are mainly used in fleet vehicles.

6.1.2 WORKLOAD MANAGERS IN-VEHICLE

A Workload Manager (WM) is a system that assesses continuously the difficulty of driving and regulates the flow of information that could interfere with driving to drivers (Green, 2004). Workload managers may thus reduce the risk of mobile phone use by reducing driver exposure to mobile phone information and functions at times at which exposure is most likely to compromise the performance of activities critical for safe driving. Workload managers have been built into some production vehicles currently on the market.

The functions of WMs can be categorised into three primary groups: Information Rescheduling, Function Lockout, and Adaptation of Information Format (Engstrom & Victor 2009).

Information Rescheduling - ensures that the driver receives information only when it is needed and when s/he is able to receive it safely (e.g. by delaying an incoming text message until the driver passes through an intersection).

Function Lockout - involves the entire disabling of a function or sub-function when driving is judged to be difficult. (e.g. text messaging functionality on smartphone is disabled while driving over a certain speed).

Adaptation of Information Format - involves changing the way information is presented, not just its timing, based on driving demand and context (e.g. text message is read aloud to the driver so s/he does not have to read it on a smartphone display).

WM functions, such as functional lockouts, have been found to reduce driver workload (e.g. Wood & Hurwitz 2005) as well as reduce impairments in driving performance (Donmez, Boyle, & Lee 2006) associated with secondary task performance.

Self-regulation support technologies - involves advising drivers of when it is safe to use their phone through context-aware technologies. Recent research has highlighted self-regulation as an alternative for safe mobile phone use while driving (Oviedo-Trespalacios et al., 2016; Oviedo-Trespalacios et al., 2017a; Oviedo-Trespalacios et al., 2017b).

Gamification – The term gamification refers to the use of game design, game playing techniques and game mechanisms to engage users and motivate positive behaviour. Gamified systems can be embedded in mobile phone devices to support driving functions while avoiding distraction (Vaezipour, 2015; Vaezipour et al, 2015; Orfilia et al., 2016; Vaezipour et al, 2016; Vaezipour et al, 2017). Distraction can be prevented using ambient devices feedback and altruistic motivations.

6.1.3   WORKLOAD MANAGERS: APPLICATIONS ON MOBILE PHONES

Some Workload Manager-like applications have also been developed for mobile phones:

- AT&T Drive Mode (Information Rescheduling) – this app silences all phone notifications when travelling over 25 km/hr. The app is self-enabled (http://www.att.com/gen/press-room?pid=23185)
- Cellcontrol (Function Lockout) – is a device installed under the dashboard that communicates with an app on the phone which prevents children from gaining access to text messaging, email and camera functionality while driving. This application cannot be disabled by the child. The device is designed for parents (https://www.cellcontrol.com/)
- Live2Txt (Function lockout) - a self-enabled app that blocks the phone from receiving texts and calls (http://www.getlive2txt.com/)
- Drivemode (Adaptation of Information Format) – a self-enabled app that allows text messages, received while driving, to be read aloud by a voice on the phone with the aim of keeping the driver's eyes on road (https://drivemode.com/).
- Drivesafe.ly (Adaptation of Information Format) - Similar to Drivemode. Reads text messages and emails aloud while driving. This app is self-enabled. (http://www.drivesafe.ly/)

No data on the effectiveness nor the acceptance of these systems is known to the authors, although (as noted in section 6.4) there is some recent research from a fleet experiment in South Australia that indicates a problem with acceptance.

6.2   NEW AND POTENTIALLY EMERGING TECHNOLOGIES THAT HAVE PROMISE

6.2.1   TECHNOLOGIES TO SUPPORT POLICE ENFORCEMENT OF DISTRACTION LAWS

ComSonics, based in Virginia, USA, has developed a radar gun-type device, which is capable monitoring, scanning, and identifying radio signals associated with cellphone use. It is reportedly capable of detecting unique radio frequencies emitted by cellphones when text messages are sent (Forster, 2014). It is not known if the device has yet been deployed in the US, or elsewhere. As at 2014, the device was reportedly close to production (https://www.digitaltrends.com/cars/step-away-iphone-virginia-company-developing-radar-gun-help-catch-texting-drivers/).

Norfolk County Council in the UK and the firm Westotec have trialled a device that detects whether a mobile phone is being used in a moving car. Mobile Phone Detection System (MPDS) is a portable technology that is able to tell if a mobile phone is being used in a moving vehicle, regardless of whether they are conversing or receiving/sending a text message. A roadside

sensor monitors oncoming vehicles and sends information to a sign upstream which flashes when mobile phone use has been detected in the vehicle. The technology was not aimed originally at issuing infringements for illegal mobile phone use; but, rather, to remind drivers of distraction laws (Rayner, 2015). However, the technology has since been modified to turn it into a speed-camera style automatic fine collector. If a mobile phone is detected in a moving vehicle, a photo is taken which is then used to determine if the driver was the person on board using the phone (http://road.cc/content/news/142406-speed-camera-style-mobile-phone-detectors-could-spot-drivers-talking-wheel-and).

We are not aware of any published studies that have evaluated the effectiveness of these technologies.

6.2.2   TECHNOLOGIES THAT AIM TO KEEP DRIVERS' EYES ON THE ROAD

Windscreen Head-Up Displays (HUDs) project information onto the vehicle windscreen in line with the driver's forward line of sight. Windscreen HUDs are associated with a number of driving performance benefits compared with conventional, or head-down, displays (Briziarelli & Allen, 1989; Sojourner & Antin, 1990; Horrey, Wickens & Alexander, 2003; Liu, 2003; Liu & Wen, 2004; Ablaßmeier et al., 2007. Generally, they yield fewer decrements in driving performance and shorter gazes away from the forward roadway.

The benefits of windscreen HUDS may be diminished, however, if too much information is presented on the HUD.

6.3   EVOLVING TECHNOLOGIES THAT CAN CONTRIBUTE TO DRIVER DISTRACTION

6.3.1   SMARTWATCHES

Smartwatches can be used to perform many of the same functions as a smartphone. The screen through which a driver interacts with the device is, however, much smaller than that of a smartphone, which may be more visually distracting.

One study demonstrates this. Giang, Shanti, Chen, Zhou, & Donmez (2015) find that drivers are more likely to glance at notifications on a smartwatch than on a smartphone and that they displayed more impaired brake response times when using a smartwatch than when using a smartphone.

6.3.2   HEAD-MOUNTED DISPLAYS

Head-mounted displays project information in the driver's forward field of view onto a wearable display (e.g. Google Glass)

Google Glass comprises a small, monocular, transparent display mounted on a framework like a standard pair of glasses (Young et al. 2016). Google Glass has been investigated in five known

studies. Of these, four focus on the impact of voice-texting on driving performance (Sawyer et al.,2014; Tippey et al., 2014; He et al., 2015; Young et al., 2016); the remaining one looks at use of Google Glass for entering destination input by voice into a navigation system (Beckers et al., 2014).

Generally, it is found that, compared to manual texting, voice texting using Google Glass results in better lane keeping performance. However, compared to baseline driving (without Google Glass), voice texting using Google Glass results in more missed event detections, increased reaction time to road events (e.g. lead car braking), and more variable lane keeping.

6.3.3 FITNESS-TRACKING DEVICES

Wearable fitness-tracking devices are used to monitor an individual's physical activity (e.g. heart rate, steps taken). Generally they are worn on the wrist, like a conventional watch. Some devices, such as *Fitbit Surge*, can be wirelessly connected to a smartphone and notify the user when a call or text message has been received on the smartphone through a vibration transmitted through the device. Visual information relating to the call/text, such as the caller's name, or even a text message, can be displayed on the device.

We are not currently aware of any published material that has assessed the distraction potential of this technology.

6.4 RECOMMENDED TECHNOLOGICAL APPROACHES

It is clear from the comments above on new and existing technological approaches that there is a lack of research data on which to base best practice. This is not confined to distraction by mobile phones, but applies to the issue of distracted driving more generally. In an effort to address this shortcoming, an EU project consulted with experts to develop consensus on "good practice" approaches to distracted driving (TRL, TNO & Rapp Trans, 2015). Although the report was published two years ago, it remains relevant because the study adopted a highly structured approach based on the characteristics of approaches to distraction rather than focusing on particular products. The assessment of good practice was applied not only to technological approaches to distraction, but also to public education, driver licensing and research. The technology-based approaches covered workload managers and phone blocking systems, in addition to warning systems for collisions and drowsiness, and regulatory approaches such as certification of apps and devices and HMI guidelines to ensure product standardisation. These approaches were assessed in terms of their impact on distracted driving, their costs and benefits, and the barriers to, opportunities for, their deployment.

Overall, of all approaches to distracted driving (both technological and non-technological), workload managers considered to be the least effective approach, followed by certification and then by phone blocking technology. The most effective approach was a technological one – collision warning systems. In the context of mobile phone distracted driving this is an

intervention which does not prevent distraction, but alerts drivers who may be distracted of an imminent collision (or risk thereof, such as through lane deviation). Looking at the scores assigned by the experts consulted, the low rating of workload managers and phone blockers was primarily due to their assessment as having low user acceptance. Workload managers and phone blockers were also considered relatively less easy to deploy, although phone blockers were considered to be as cost-effective as collision warning systems.

It is worth noting that workload managers and phone blockers were not rated as highly on maturity of technology as collision warning devices; as two years have elapsed since the report, more recent research was sought, and a South Australian study focused on fleet vehicles was identified (Ponte, Baldock & Thompson, 2016). In a fleet setting it would be reasonable to expect a greater chance of success and acceptance of phone blocking, however the researchers found that the participants had more negative attitudes to phone blocking after the trial than before it, as a result of problems with the two technologies trialled: one involving software on the phone, and the other having both phone software and pairing the phone with external Bluetooth hardware. The problems experienced included: blocking did not work; blocking occurred when it should not have (after journey or on weekends); difficulty overriding the blocking when necessary; and blocking of passengers phones. These experiences suggest that phone blocking technology still requires further development.

An alternative approach to phone blocking is to encourage voluntary use of the various apps that are appearing, provided by manufacturers (e.g. Android, Apple), developed privately (e.g. LifeSaver, DriveSafe Mode) and either provided or supported by telecommunications companies (e.g. Telstra's Drive Mode, Vodafone's provision of links to blocking programs). Often these apps are aimed at parents to impose in a non-voluntary way on their teen children as drivers, however a recent review found that teenagers try to bypass such restrictions and recommends embedding blocking technologies into broader behavioural approaches, such as incentives provided by parents or insurers (Delgado, Wanner & McDonald, 2016).

Taken together, the findings outlined above suggest that: phone blocking technology requires further development to improve its performance and win user acceptance; workload managers may have promise in the future, but are at a less advanced stage of development than phone blocking technology; and that collision warning devices have the greatest potential, even though address distraction as it occurs rather than preventing it.

7 NOMADIC DEVICES AND IN-CAR SYSTEMS

Pervasive computing and nomadic devices are becoming more common as part of digital environments that sense, adapt, and respond to human needs. The advances in such connected devices as part of the development of the Internet of Things (IoT) are increasingly being seen in cars, either integrated into the vehicle operating system or as a standalone system. Nomadic devices such as smartphones have not been designed with car use and safety in mind. Multiple new devices may compete for a driver's attention and therefore pose driver distraction problems while driving. To avoid this, the integration of nomadic devices in vehicles would ideally present a distraction-free interface, and consider safety, functionality and usability.
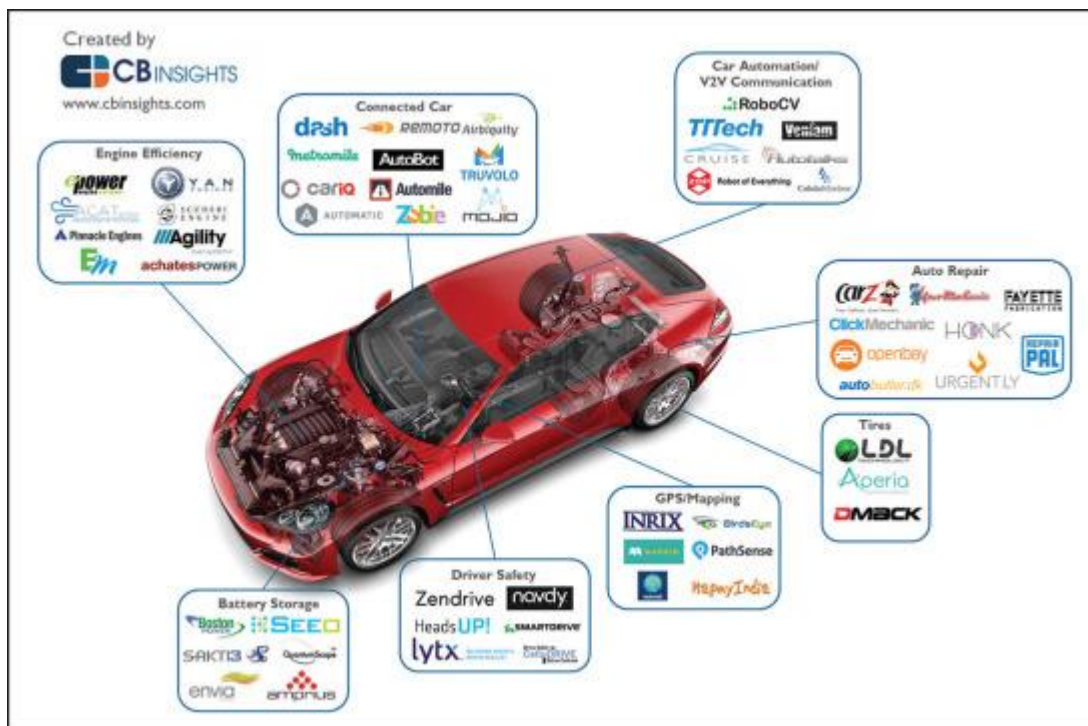
Figure 7.1 Cars have become highly complex with many interconnected systems
Source: CBInsights, www.cbinsights.com.

7.1 APPLE CARPLAY AND ANDROID AUTO

Apple CarPlay and Android Auto allow a smartphone (iPhone or Android phone, respectively) to be connected to the vehicle, such that some of its features can be hosted by the human-machine interface (HMI). These systems usually work through an on-board touch screen in the vehicle (usually the vehicle navigation system) and support navigation, phone calls, and messaging.

Displays in the vehicle are not always necessary. Apple's Siri Eyes Free, for example, enables drivers to use many Apple CarPlay features through voice commands without the need for an in-vehicle touch screen.

Many new connected vehicles include support for both Apple CarPlay and Android Auto, and older cars can be upgraded to use them with aftermarket double-DIN entertainment consoles (e.g. Pioneer AVH-4100NEX).

We are not aware of any published material that has evaluated specifically Apple CarPlay and Android Auto software. However, there is preliminary research on integrated hands-free mobile phone functionality (e.g. conversing and composing text messages) which can be hosted by these products. This is discussed below.

7.2   INTEGRATED HANDS-FREE MOBILE PHONE CONVERSATIONS

Integrated hands-free mobile phone (IHF) conversation involves wireless connectivity between the vehicle's built-in hardware and the mobile phone, typically through Bluetooth; that is, short-range radio waves that have a maximum reach of approximately 10m. Essentially, this connectivity serves two primary functions:

- Allows phone functionality and content to be accessed through the vehicle hardware itself (e.g. accessing/reading mobile phone text messages on the IVIS screen)
- Allows the driver to use the mobile phone hands-free (i.e. compose a text message using voice activation, in which the car /microphone speakers process the spoken words, compose a text message, and relay this message back to the mobile phone to send).

Six known studies have examined the link between integrated hands-free mobile phone (IHF) conversations and driving performance and safety risk.

Overall, the results of the studies reveal that driver interactions with IHF, for example to initiate a conversation or end a call using voice input, tend to be associated with fewer decrements in driving performance compared with visual-manual mobile phone interactions. Specifically, drivers tend to look away from the roadway less often, and for less time (e.g. Mehler et al. 2016), and have faster reaction times to road events (Maciej & Vollrath 2009) with IHF (and voice input) compared to visual-manual mobile phone interactions.

However, IHF often does not completely eliminate the need to manually operate a mobile phone or the IVIS to undertake a phone-related task. Many integrated or fixed systems still allow, and sometimes require, visual-manual interactions. For example, Fitch et al. (2013) found that, even though the IHF conversations themselves didn't take eyes off the road any more than baseline driving, behaviours such as beginning/answering the call, as well as ending it, increased eyes-off-road time by around 40%.

Two NDSs examined the link between IHF conversations and safety (Young & Schreiner 2009; Fitch et al. 2015). Both studies suggest that IHF conversations actually *reduce* the risk of having a safety critical event compared to baseline driving (i.e. driving while not engaged in an IHF conversation). The reasons for these findings are not properly understood by the research community.

7.3   TEXT MESSAGING USING IVS

Two studies have explored the impact of IHF mobile phone text messaging on driving performance. During such interactions, the driver typically voices a message which is then processed by the vehicle microphone/speakers and converted to text (i.e. speech-to-text technology). This message is wirelessly relayed to the mobile phone as a text message ready to be sent (or is sent).

Compared to manual, or conventional, text messaging, using IHF is associated with fewer driving decrements such as less and shorter glances away from the roadway, reduced steering wheel position variance and less rapid steering corrections (Owens, McLaughlin, & Sudweeks, 2011).

However, when compared to baseline driving, IHF interactions are associated with poorer driving performance, delayed reaction time to critical road events and a greater number (and length) of glances away from the roadway (Owens, McLaughlin, & Sudweeks 2011; Coleman et al. 2016).

Thus, even though the biomechanical requirements of composing a text message are reduced with the use of IHF, the cognitive component of this interaction remains (e.g. thinking about what to communicate, how to communicate it etc.). This cognitive demand may, in turn, impact on the ability of the driver to detect hazards in the forward roadway (e.g. Strayer, Drews & Johnston 2003), and in the periphery due to visual tunnelling effects (Recarte & Nunes 2003). This may account for the performance decrements associated with voice interactions when compared with baseline driving.

8 DISCUSSION

The problem of mobile phone distraction while driving is one of many manifestations of digital disruption, where technological change is challenging social arrangements and the ability of governments to regulate public activities. In the area of driving, one of the major ways that this digital disruption is expressed is by a recasting of the driving task as a distraction from the social need to remain in contact via social media and phone conversations, whereas the customary approach has been to view driving as the preeminent task and phone use as the distraction. This recasting of the driving/communicating relationship (among young people in particular) has taken place in the context of a dramatic increase in the range and uptake of communication technologies and applications.

Until recently, the main form of evidence for the crash risk associated with mobile phone use came from laboratory or simulator studies, and occasional hospital-based studies that used forms of case-control methodology. Crash data has always been lacking because of the difficulties involved in determining whether a phone was being used at the time of the crash. This was evident in the data accessed for this project, where there were very few crashes where mobile phone use was identified as a contributing factor. However, recent reports from naturalistic driving studies, mostly in the United States, are beginning to address this gap. In general, data from naturalistic studies shows a high prevalence of driving while distracted, and significant increases in crash risk when a mobile phone is being used in hand-held mode, while texting, reading emails and browsing. Unfortunately it is not clear whether conversation alone increases crash risk because there is a debate about the validity of the methods used to calculate the odds ratios that have been generated from the naturalistic data. This is an area where future research is needed, as the risk associated with conversing is relevant to the consideration of appropriate regulations on mobile phone use.

In addition to seeking some kind of resolution of the debate over the naturalistic crash data, it would be worth addressing the collection of crash data in some way. For example, there has been previous discussion of the mandatory installation of a microchip known as a "controlled area network (CAN) bus" that would have a buffer that contains the record of vehicle operation information immediately before an event such as a crash. Under the Australian Design Rules, new buses and trucks are required to have a CAN bus fitted for other data logging purposes, and it is understood that most new cars are fitted with them. There are already CAN bus products on the market that have Wi-Fi and Bluetooth capability. If the CAN bus was able to record mobile phone use (including an identifying code to ascertain which phone it was) this would provide both better data and assistance to police in identifying the contribution of distraction to the crash. In the short term it would also be worthwhile further exploring the data available in the National Coronial Information System, perhaps through a text mining approach, i.e. an algorithm to automatically read the text information in coronial records and extract information on mobile phone use. While fatalities are relatively small in number, the circumstances of the crashes are better researched and documented than non-fatal crashes.

Regulatory frameworks in Australia are based on ARR 300, but there are variations by jurisdiction that are worth examining further, in terms of consistency of approach (defined offences, penalty levels) and justification (related to the range of risk levels identified for different forms of distraction by mobile phones in naturalistic studies). As there is an overlap between policy approaches, for example the mobile phone restrictions imposed in Graduated Driver Licensing schemes, this would involve consultation with a broader range of stakeholders.

The police and some transport agencies have doubts about the effectiveness of enforcement as a way of reducing mobile phone use. While automated enforcement using cameras would address this problem, this requires the development of an image processing algorithm that can successfully identify mobile phone use by drivers, which is considered (at the least) a difficult task. Further research development of such an algorithm would be of benefit in determining the value of this approach. The possibility of self-enforcement through apps may be worth following up, though interviewees were not optimistic about the chances of success. Technological enforcement approaches involving blocking have negative implications, however there are emerging technologies that may be able to measure workload and control the driver's access to communication in accordance with workload, although as noted in section 6 these technologies still lack maturity and public acceptance.

From a government and policy perspective, the need for a national consensus among jurisdictions and an evidence-based approach to policy should shape the approach taken. In the short/medium term, taking into account the points raised above, this would involve:

- Consulting researchers with relevant expertise to determine the evidence base on which policy can be developed, including a resolution of the debate on the validity of naturalistic driving study crash risk estimates

- Investigating means of collecting valid, reliable and comprehensive data on mobile phone involvement in road crashes, such as wifi and Bluetooth-enabled CNN bus microchips that record mobile phone use in the vehicle

- Exploring enforcement options that can be implemented by all jurisdictions, including the possibility of automated enforcement by cameras, provided a successful detection algorithm can be developed within a reasonable timeframe

- Exploring technology options that balance the costs and benefits of reducing or blocking connectivity of mobile phones in vehicles

In addition, the broader effects of digital disruption on society, and especially the social functioning of young people, have relevance to the use of mobile phones while driving. In the longer term, the social context of mobile phone use needs to be explored and addressed, with the aim of establishing a social framework that enables young people to interact with social media in less harmful ways. Such a framework could be utilised to justify legislation, support compliance and legitimise enforcement.

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APPENDIX A INTERVIEW SCHEDULE

LEGISLATION AND ENFORCEMENT

My understanding of your current regulations is that (*read summary of information collected on this*):
Is this a reasonable summary?
Is this an adequate system (prompt for problematic cases that have occurred)
Are there changes planned or regulation issues that are under discussion?

I would also like to talk about the way the legislation is enforced; from information we have collected so far, we understand that your current practices are (*read summary of information collected on this*):
Is this a reasonably accurate description?
What kinds of difficulty have been experienced and how have they been addressed?
Are you considering other options for enforcement?

CRASH DATA

Are sources of distraction and inattention, and specifically the use of mobile phones and devices routinely considered as potential contributing factors of a crash?

What threshold of evidence is needed to determine that mobile phone/device use contributed to the crash as opposed to whether it was (strongly) suspected?

What barriers have police officers experienced in determining whether mobile phone/device use was a contributory factor of the crash?

Do the notes and detailed reports of investigations record that mobile phone/device use was considered but could not be confirmed at the required evidentiary threshold?

If the detailed reports of the crash investigation record that mobile phone/device use was confirmed as a contributing factor are there limitations in the crash databases that may result in under reporting its role? (prompt for possibilities)

APPENDIX B SUMMARY OF DRIVER DISTRACTION LAWS ACROSS DIFFERENT JURISDICTIONS (ADAPTED FROM WHO REPORT, 2011)

Table B.1 Driver distraction laws in New Zealand

While driving a vehicle, a driver must not – (a) use a mobile phone to make, receive, or terminate a telephone call; or (b) use a mobile phone to create, send, or read a text message; or (c) use a mobile phone to create, send, or read an email; or (d) use a mobile phone to create, send, or view a video message; or (e) use a mobile phone to communicate in a way similar to a way described in any of paragraphs (b) to (d); or (f) use a mobile phone in a way other than a way described in any of paragraphs (a) to (e). (1A) Subclause (1) is overridden by subclauses (2) to (7). (2) An enforcement officer may, while driving a vehicle, use a mobile phone to make, receive, or terminate a telephone call if the officer is making, receiving, or terminating the call in the execution of the officer's duty. (3) A driver may, while driving a vehicle, use a mobile phone if— (a) the driver is using the phone to make a 111 or *555 call; and (b) it is unsafe or impracticable for the driver to stop and park the vehicle to make the call. (4) A driver may, while driving a vehicle, use a mobile phone to make, receive, or terminate a telephone call if the phone does not require the driver to hold or manipulate it to make, receive, or terminate the call. (5) *[Revoked]* (6) A driver may, while driving a vehicle, use a mobile phone to make, receive, or terminate a telephone call if the vehicle has stopped for a reason other than the normal starting and stopping of vehicles in a flow of traffic. (7) A driver may, while driving a vehicle, use a mobile phone in a way described in subclause (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.   *A mobile phone is defined as —* (a) includes a portable electronic device whose functions include being a telephone: (b) does not include a CB radio: (c) does not include any other kind of two-way radio: (d) does not include an earpiece or mouthpiece that is connected, physically or otherwise, to a mobile phone to allow a driver to use the phone without holding or manipulating it
Visual display units
2.5(1)   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 the motor vehicle from his or her normal driving position while the motor vehicle is in motion. 2.5(2)   *Subclause 2.5(1)* does not apply if: • (a)   the television screen is fitted in the motor vehicle only for the purpose of assisting the driver to reverse safely, by showing a clear picture of the area directly behind the motor vehicle; or   • (b)   the motor vehicle is a passenger service vehicle and the provisions of *Land Transport Rule: Passenger Service Vehicles 1999* are complied with; or   • (c)   the screen is fitted as original equipment by the vehicle manufacturer and is designed so that only information relating to the navigation, safe operation and control of the motor vehicle can be displayed on the screen while the motor vehicle is in motion; or   (d)   the screen is only capable of displaying text and any change to the text on the screen is controlled manually by the driver.

Table B.2 Driver distraction laws UK – mobile phones

(1) No person shall drive a motor vehicle on a road if he is using—
    (a) a hand-held mobile telephone; or
    (b) a hand-held device of a kind specified in paragraph (4).
(2) No person shall cause or permit any other person to drive a motor vehicle on a road while that other person is using—
    (a) a hand-held mobile telephone; or
    (b) a hand-held device of a kind specified in paragraph (4).
(3) No person shall supervise a holder of a provisional license if the person supervising is using—
    (a) a hand-held mobile telephone; or
    (b) a hand-held device of a kind specified in paragraph (4),
    at a time when the provisional license holder is driving a motor vehicle on a road.
(4) A device referred to in paragraphs (1)(b), (2)(b) and (3)(b) is a device, other than a two-way radio, which performs an interactive communication function by transmitting and receiving data.
(5) A person does not contravene a provision of this regulation if, at the time of the alleged contravention—
    (a)he is using the telephone or other device to call the police, fire, ambulance or other emergency service on 112 or 999;
    (b) he is acting in response to a genuine emergency; and
    (c) it is unsafe or impracticable for him to cease driving in order to make the call (or, in the case of an alleged contravention of paragraph (3)(b), for the provisional licence holder to cease driving while the call was being made).
(6) For the purposes of this regulation—
    (a) a mobile telephone or other device is to be treated as hand-held if it is, or must be, held at some point during the course of making or receiving a call or performing any other interactive communication function;
    (b) a person supervises the holder of a provisional licence if he does so pursuant to a condition imposed on that licence holder prescribed under section 97(3)(a) of the Road Traffic Act 1988 (grant of provisional licence);
    (c)"interactive communication function" includes the following:
        (i)sending or receiving oral or written messages;
        (ii)sending or receiving facsimile documents;
        (iii)sending or receiving still or moving images; and
        (iv)providing access to the internet;
    (d) "two-way radio" means any wireless telegraphy apparatus which is designed or adapted—
        (i) for the purpose of transmitting and receiving spoken messages; and
        (ii) to operate on any frequency other than 880 MHz to 915 MHz, 925 MHz to 960 MHz, 1710 MHz to 1785 MHz, 1805 MHz to 1880 MHz, 1900 MHz to 1980 MHz or 2110 MHz to 2170 MHz; and
      (a)   "wireless telegraphy" has the same meaning as in section 19(1) of the Wireless Telegraphy Act 1949(**2**)."

Table B.3 Driver distraction laws UK – visual display units

(1)   No person shall driver, or cause or permit to be driven, a motor vehicle on a road, if the driver is in such a position as to be able to see, whether directly or by reflection, a television receiving apparatus or other cinematographic apparatus used to display anything other than information –

    (a)   About the state of the vehicle or its equipment;

    (b)   About the location of the vehicle and the road on which it is located;

    (c)   To assist the driver see the road adjacent to the vehicle; or

    (d)   To assist the driver to reach his destination.

(2)   In this regulation "television receiving apparatus" means any cathode ray tube carried on a vehicle and on which there can be displayed an image derived from a television broadcast, a recording or a camera or computer.

Table B.4 Driver distraction laws U.S.

State	Hand-held cell phone ban	All cell phone ban		Text messaging ban	Video screen restriction (Yes/No)
		School bus drivers	Novice drivers		
Alabama	None	None	16 or 17 w/ license <6 months	All drivers	Y
Alaska	None	None	None	All drivers	Y
Arizona	None	Yes	None	None	Y
Arkansas	Only drivers 18-20 years old	Yes	<18	All drivers	N
California	Yes	Yes	<18	All drivers	Y
Colorado	None		<18	All drivers	N
Connecticut	Yes	Yes	<18	All drivers	Y
Delaware	Yes	Yes	Learner or intermediate license holders only	All drivers	N
D.C.	Yes	Yes	Learners permit only	All drivers	Y
Florida	None	None	None	All drivers	Y
Georgia	None	Yes	<18	All drivers	N
Hawaii	Yes	None	<18	All drivers	N
Idaho	None	None	None	All drivers	N
Illinois	Yes	Yes	<19	All drivers	N
Indiana	None	None	<21 (effective 7/15)	All drivers	Y
Iowa	None	None	Restricted or intermediate license holder only	All drivers	N
Kansas	None	None	Learner or intermediate license holders only	All drivers	N
Kentucky	None	Yes	<18	All drivers	N
Louisiana	Learner or intermediate license holders only	Yes	1st year of license or <18	All drivers	Y
Maine	None	None	Learner or intermediate license holders only	All drivers	Y
Maryland	Yes	None	<18	All drivers	Y
Massachusetts	None	Yes	<18	All drivers	Y
Michigan	None	Yes	Level 1 or 2 license holder only	All drivers	Y
Minnesota	None	Yes	<18 w/ learner or provisional license	All drivers	Y
Mississippi	None	Yes	None	All drivers	N
Missouri	None	None	None	Only drivers 21 years of age or less	N
Montana	None	None	None	None	N

State	Hand-held cell phone ban	All cell phone ban		Text messaging ban	Video screen restriction (Yes/No)
		School bus drivers	Novice drivers		
Nebraska	None	None	<18 w/ learner or intermediate license	All drivers	Y
Nevada	Yes	None	None	All drivers	Y
New Hampshire	Yes	None	<18	All drivers	Y
New Jersey	Yes	Yes	Permit or provisional license only	All drivers	Y
New Mexico	In state vehicles only	None	Learner or provisional license only	All drivers	Y
New York	Yes	None	None	All drivers	Y
North Carolina	None	Yes	<18	All drivers	Y
North Dakota	None	None	<18	All drivers	N
Ohio	None	None	<18	All drivers	N
Oklahoma	Learner or intermediate license holders only	None	None	All drivers (effective 11/15)	Y
Oregon	Yes	None	<18	All drivers	Y
Pennsylvania	None	None	None	All drivers	Y
Rhode Island	None	Yes	<18	All drivers	Y
South Carolina	None	None	None	All drivers	Y
South Dakota	None	None	Learner or intermediate license holders only	All drivers	Y
Tennessee	None	Yes	Learner or intermediate license holders only	All drivers	Y
Texas	None	Yes when w/ passenger 17 years or younger	<18	Only when (a) w/ a passenger 17 or younger, and (b) driver is younger than 18 years	Y
Utah	None	Yes	<18	All drivers	Y
Vermont	Yes	None	<18	All drivers	Y
Virginia	None	Yes	<18	All drivers	Y
Washington	Yes	None	Learner or intermediate license holders only	All drivers	Y
West Virginia	Yes	None	<18 w/ learner or intermediate license	All drivers	Y
Wisconsin	None	None	Learner or intermediate license holders only	All drivers	Y
Wyoming	None	None	None	All drivers	Y