Use of in-vehicle technologies to assist with and encourage safe and efficient driving behaviour

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An important note for the reader

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Abbreviations and acronyms

ACC	Autonomous Cruise Control
ADDW	Advanced Driver Distraction Warning
AEB	Autonomous Emergency Braking
AIS	Alcohol Interlock System
ANCAP	Australasian New Car Assessment Program
BSM	Blind Spot Monitoring
CAS	Crash Analysis System
DDAW	Driver Drowsiness and Attention Warning
DMS	Driver Monitoring System
eRUC	Electronic Road User Charges
ESC	Electronic Stability Control
EWD/EL	Electronic Work Diary/Logbook
FCW	Forward Collision Warning
FMT	Fleet Management Telematics
GPS	Global Positioning System
HGV	Heavy Goods Vehicle
ISA	Intelligent Speed Assist/Adaptation
JNCAP	Japan New Car Assessment Program
LCV	Light Commercial Vehicle
LDW	Lane Departure Warning
LKA	Lane Keep Assist
LKS	Lane Keep Support
MIAMI	Motor Industry Association Incorporated
MITO	Motor Industry Training Organisation
MVR	Motor Vehicle Register
R&D	Research & Development
RCW	Rear Collision Warning
SUV	Sports Utility Vehicle
VRU	Vulnerable Road User

Contents

Executive summary **9**

Abstract **11**

1 Introduction **12**

1.1 Background and objectives 12
1.2 Choice of technologies for consideration 12
1.3 About this report 14
1.4 Context 14

2 Literature review: effectiveness of vehicle technologies **15**

2.1 Summary of method 15
2.2 Findings 15
2.2.1 Effectiveness estimates 16
2.2.2 The evidence on behaviour change 22
2.3 Summary 27

3 Stakeholder insights into implementation and use of in-vehicle technologies **29**

3.1 Participant recruitment 29
3.2 Pre-interview survey 29
3.3 Interviews 30
3.4 Analysis 30
3.5 Results 30
3.5.1 Decisions to buy or retrofit vehicles with in-vehicle technologies 30
3.5.2 How drivers are trained 32
3.5.3 The barriers and enablers specific to individual technologies 32
3.5.4 What enables the uptake of in-vehicle technologies? 37
3.5.5 What barriers are there to the uptake of in-vehicle technologies? 39
3.5.6 Other technologies that have been fitted to vehicles 41
3.6 Summary 41

4 Analysis of vehicle fleet characteristics in New Zealand **43**

4.1 Datasets 43
4.2 Results for factory-fitted technology 44
4.2.1 Vehicle registration data 45
4.2.2 Summary of results 51
4.2.3 Estimating prevalence for new vehicles imported into New Zealand 52
4.2.4 Estimating prevalence for the entire light passenger vehicle fleet 57
4.3 Results for retrofitted technology 59

5 Analysis of crash data and potential crash savings **61**

5.1 Method 61
5.1.1 Target population and effectiveness estimate 61
5.1.2 Autonomous Emergency Braking 65
5.1.3 Forward Collision Warning 65
5.1.4 Lane Keep Assist 66
5.1.5 Lane Departure Warning 66

5.1.6 Intelligent Speed Assist 66
5.1.7 Rear Collision Warning 66
5.1.8 Driver Monitoring Systems 66
5.1.9 Fleet Management Telematics 66
5.1.10 Alcohol Interlock Systems 67
5.1.11 Electronic Work Diaries/Logbooks 67
5.1.12 Blind Spot Monitoring 67
5.1.13 Under-reporting factors 67
5.1.14 Fitment rate 68
5.1.15 Social cost 69
5.2 Results 69
5.2.1 Target population and effectiveness of technology 70
5.2.2 Casualties saved and fitment rate 73
5.2.3 Social cost savings 76

6 Roadmap development 79
6.1 Roadmap development workshop method 79
6.1.1 Participant selection and invitation 79
6.1.2 Overview of workshop 79
6.2 Outcomes 80
6.2.1 Explanation of roadmaps 80
6.2.2 Technology Group 1: Autonomous Emergency Braking, Lane Keep Assist and Intelligent Speed Assist 81
6.2.3 Technology Group 2: Blind Spot Monitoring and Rear Collision Warning 85
6.2.4 Technology Group 3: Fleet Management Telematics and Electronic Work Diaries/Logbooks 88
6.2.5 Technology Group 4: Driver Monitoring Systems and Alcohol Interlock Systems 90

7 Discussion 95
7.1 Fleet characteristics and implications 95
7.2 Factory-fitted technologies with general application 95
7.2.1 Current prevalence and trend 95
7.2.2 Potential crash and cost savings 95
7.3 Retrofitted technologies that mainly benefit commercial fleets 96
7.4 Other technologies 96
7.5 Impacts on efficiency 96
7.6 Risks of reliance on advanced driver assistance systems 97
7.7 Increasing uptake 97
7.7.1 General public 97
7.7.2 Commercial fleet settings 97
7.7.3 Social considerations 97
7.8 Roadmaps and recommendations 98
7.9 Further research 100

References 102

Appendix A: Literature review method 106

Appendix B: Participant information sheet 108

Appendix C: Pre-interview survey **109**
Appendix D: Topic guide **123**
Appendix E: Target populations from CAS data **129**
Appendix F: List of non-compliance factors **131**
Appendix G: Workshop logic models **132**

Executive summary

This project investigated the best ways to increase the uptake of in-vehicle technologies that promote safe and efficient driving behaviour in New Zealand. We conducted a literature review to examine the evidence linking in-vehicle technologies to safety and efficiency improvements and then estimated the extent to which such technologies were likely to deliver cost-effective improvements in New Zealand. We also investigated the barriers and enablers related to the uptake of these technologies in commercial fleets. Finally, roadmaps and tips for prioritisation were developed, based on logic models and stakeholder insights gathered in a co-creation workshop.

The New Zealand motor vehicle fleet consists of a combination of new and used imported vehicles; we found that 59% of all the registered vehicles in New Zealand that had been manufactured between 2008 and 2020 were new imports and 36% were used imports. Light passenger vehicles made up 60% of the New Zealand fleet, and these vehicle types were more likely to be used imports than other vehicle types (49% of these light passenger vehicles were used imports, mostly coming from Japan). Only 15% of light passenger vehicles in New Zealand were 5 years old or less. This is relevant because most of the technologies considered in this report have only been installed in a significant portion of new vehicles in the last three to five years. Thus, even though the analysis found that Autonomous Emergency Braking (AEB) was installed in 91% of *new* light passenger vehicles that were manufactured in 2020, it was present in only 9% of all light passenger vehicles registered in New Zealand at the time of this research.

We considered five types of factory-fitted technologies: AEB, Lane Keep Support systems (LKSs), Blind Spot Monitoring (BSM), Rear Collision Warning (RCW) and Intelligent Speed Assist (ISA). At the time of this analysis, the prevalence of these technologies in light passenger vehicles in New Zealand was around 9% for AEB, BSM and LKS, 14% for RCW and < 1% for ISA. Installation of AEB and LKS had increased rapidly in new vehicles in the last five years of the study's time frame, and our analysis found that they were installed in 91% and 87% (respectively) of new cars and vans sold in New Zealand in 2020. RCW and BSM had increased less quickly, and were installed in 69% and 63% (respectively) of new cars and vans sold here in 2020. ISA was installed in only 12% of new light passenger vehicles sold here in the same year.

We also investigated a selection of retrofitted technologies, including Driver Monitoring Systems (DMSs), Electronic Work Diaries/Logbooks (EWDs/ELs), Alcohol Interlock Systems (AIS) and Fleet Management Telematics (FMT). It was difficult to estimate the prevalence of these systems accurately, as no New Zealand database systematically collects this data. Our best estimate from the published literature and stakeholder interviews was that approximately 25% of commercial fleets in New Zealand at the time of this research had some form of FMT. Our crash analysis indicated that FMT and EWDs/ELs had a significant potential to reduce crash involvements among commercial vehicles if implemented and managed well.

Among the technologies for which it was possible to calculate casualty crash reductions, the technology that would produce the greatest savings in casualty crashes and associated social costs was LKS. If it had been installed in all light passenger vehicles between 2016 and 2020, we estimated that the savings would have been close to $2 billion. The technology with the second-greatest savings would have been AEB, at $420 million (including pedestrian and cyclist protection), followed by AIS ($401 million) and Advanced Driver Distraction Warning ($349 million).

Globally, research has identified disbenefits associated with reliance on advanced driver assistance systems. These have included passive fatigue (fatigue from lack of engagement in the driving task, resulting in lack of orientation to the driving task and slower response to safety-critical events); skill atrophy; and challenges for the training and education of drivers. The casualty-crash-savings estimates noted above took into consideration these kinds of disbenefits. However, good management of these would maximise the benefits accrued from adopting safety technologies.

Our stakeholder consultation found options for increasing the uptake of technologies in private vehicles, as follows:

- Promote the existing sources of information on the benefits of in-vehicle technologies (eg Australasian New Car Assessment Program, *My Car Does What?*).
- Provide clear information on the costs and benefits of the technologies.
- Encourage faster turnover of old vehicles and purchase of newer used vehicles through incentives such as tax breaks.
- Consider mandating the technologies in both new and used imports, once the prevalence is high enough.

For commercial vehicles, the options were as follows:

- Ensure government contracts require the most effective technologies.
- Provide incentives, such as tax breaks, to encourage uptake.
- Encourage/support bulk buying of vehicles for fleets, to achieve discounts.
- Highlight the health and safety imperative for purchasing the safest vehicles possible for fleets.
- Encourage fleet managers to purchase vehicles with optional safety technologies already installed.

We presented these results in a roadmap co-creation workshop, which ultimately led to the following recommendations for Waka Kotahi:

1. Set up the working groups and advisory groups outlined in this report, with clear terms of reference and governance, to coordinate the work effectively.
2. Consider monitoring and evaluation early in each roadmap, to enable effective monitoring and evaluation of any interventions, and to inform any business cases or regulatory impact statements. Consider reforms to current data collection processes to improve monitoring.
3. Engage early with stakeholders and work with the communications group for each technology to:
    a. understand industry and community needs, knowledge, attitudes and behaviours (to inform the communications needs and the approaches and channels of communication that would be most effective)
    b. ensure that clear and relevant information is made available to industry and private buyers of new and used cars regarding the costs and benefits of the technology, as well as how to keep it in working condition
    c. communicate clearly about plans to mandate the technology, to enable industry to plan and encourage early adoption.
4. Based on the factors above, we suggest prioritising the work as follows:
    a. Work towards mandating LKA and AEB in new vehicles.
    b. Also consider mandating BSM and RCW.
    c. Create a small working group to consider ISA feasibility issues, and strategies to overcome any obstacles.

d. Work towards mandating EWDs/ELs, which improve compliance with fatigue laws and may enable greater uptake of FMT.

e. Promote awareness of the benefits of DMSs in both private and commercial vehicles, monitor their prevalence in the New Zealand fleet to inform later decisions about mandating them, and ascertain whether concerns about variance in reliability, dependent on driver race and sex, are valid.

f. Investigate alternatives to AIS that could detect the impairing effects of a broader range of psychoactive substances in a less intrusive way and monitor advancements in those technologies with a view to promoting their use when they come to market.

g. Engage with relevant bodies to ensure the repair and maintenance skills for advanced driver assistance technologies are being taught in automotive courses, and consider a warrant-of-fitness test for safety-critical technologies.

h. Commission research to inform better guidance for commercial fleets on how to get the best safety and efficiency outcomes from FMT.

Further to the recommendations above, it would be worth building on the current work to (1) calculate the estimated social cost savings from in-vehicle safety technologies as a proportion of the total New Zealand social costs of crashes over time and (2) quantify the regulatory costs associated with implementing these recommendations. This would help to prioritise actions appropriately to increase the uptake of in-vehicle safety technologies in future road safety strategies by making it possible to compare the costs and benefits of these interventions with other interventions across the Safe System pillars and over time.

Abstract

This report provides recommendations on how to increase the uptake of in-vehicle technologies to increase safe and efficient driving behaviour in New Zealand. It includes (through the literature review) an overview of the evidence linking specific in-vehicle technologies to safety and efficiency behaviour improvements and the extent to which such technologies could deliver cost-effective improvements in New Zealand (informed by both the data analysis and stakeholder interviews). It also provides insights (gained from stakeholder interviews) into the barriers and enablers related to the uptake of technologies, to inform decisions regarding the best mechanisms for increasing the use of these technologies in New Zealand. Finally, roadmaps and tips for prioritisation for individual technologies are provided, based on logic models and stakeholder insights that were gathered in a co-creation workshop.

1 Introduction

1.1 Background and objectives

In-vehicle technologies that support driving that is safer and more efficient are becoming increasingly available. Research has previously identified that greater uptake of some key safety technologies, such as Autonomous Emergency Braking (AEB) and Electronic Stability Control (ESC), could result in significant crash savings in New Zealand (Keall & Newstead, 2020. Similarly, technologies that support efficient driving (eg by influencing drivers' choice of speed and acceleration or by routing that is more efficient) could mitigate the negative impacts of road transport on the environment.

The New Zealand Government aims to capitalise on advancements in vehicle technologies to reduce road trauma and emissions from transport. This is captured in:

- *New Zealand's Road Safety Strategy 2020–2030 – Road to Zero*, which includes focus areas such as improving vehicle safety, road user choices and work-related road safety
- *Toitū Te Taiao,* the Waka Kotahi NZ Transport Agency sustainability action plan, which aims to minimise the negative impacts of the transport system on the environment through its 'safe, clean and efficient vehicles' workstream.

To achieve these aims, it is necessary to understand which technologies will provide the greatest benefits in the New Zealand context, and how best to achieve increased uptake of these. This project therefore seeks to provide an understanding of:

- the evidence linking in-vehicle technologies to safety and efficiency behaviour improvements
- the extent to which such technologies are likely to deliver cost-effective improvements specifically in New Zealand, resulting in a list of 'best-fit' technologies for the country
- the best mechanisms for increasing the use of these technologies in New Zealand, including which regulations from other jurisdictions to prioritise and which technologies to prioritise for 'retrofitting' to older vehicles and fleets in New Zealand.

The factors that influence the effectiveness and uptake of safety and efficiency technologies in commercial fleets are less understood than those relating to private vehicles. Light and heavy commercial vehicles are subject to a wider range of telematics-based technologies than light passenger vehicles, and they are driven further and have higher fleet turnover. In addition, new vehicles from commercial purchases make their way into the local used-vehicle market more quickly than privately purchased vehicles. There is a significant amount of research available about what motivates individuals to choose and use advanced driver assistance systems in private vehicles, and Waka Kotahi has already commissioned a research project into this. Therefore, we focused more on commercial fleets, to address this gap in knowledge.

1.2 Choice of technologies for consideration

The list of technologies considered in this project are shown in Table 1.1. The choice of technologies under consideration was partly guided by the Waka Kotahi Request for Proposals, which listed possible technologies such as 'alcohol interlock systems, breathalyser interlock systems and commercial vehicle Electronic Logbooks (ELs), fleet management programmes and advanced driver assist technologies such as autonomous emergency braking and lane departure warning'. Input from the project steering group and from TRL's in-house experts' knowledge of in-vehicle technologies on the market was also used. In addition, we drew on the expertise of those who developed the General Safety Regulations legislation that has been adopted in Europe.

Table 1.1 Technologies and definitions

Technology	Definition	Typical installation
Autonomous (or automated) Emergency Braking (AEB)	Uses sensors to detect the presence of a potential hazard in front of the vehicle and, where the driver has not done so in time, to apply the brakes to avoid a collision or to mitigate its severity. Forward Collision Warning (FCW) is often included as part of this feature.	Factory-fitted.
Forward Collision Warning (FCW)	The vehicle automatically provides an audio-visual warning in response to the detection of a likely collision, to alert the driver. Often bundled with AEB. Some include pedestrian warning systems.	Factory-fitted.
Lane Departure Warning/Lane Keep Assist (LDW/LKA)	Uses sensors to detect the position of the vehicle in its lane and warns the driver if the course of the vehicle is gradually veering out of its lane and/or provides corrective directional control, through steering action or application of brakes on one side of vehicle. Less sophisticated (generally older) systems are likely to provide a warning only.	Factory-fitted.
Intelligent Speed Assist/Adaptation (ISA)	Uses digital map data and/or visual data from a camera to identify the local speed limit, warns the driver if the limit is being exceeded and, at the driver's discretion, can limit the vehicle speed accordingly.	Depends on the type. Adaptation types cannot be retrofitted.
Rear Collision Warning (RCW)	Camera/audio system that alerts the driver of objects that are to the rear of the vehicle. Typically designed to assist with reversing manoeuvres.	Usually factory-fitted but can be retrofitted.
Driver Monitoring System (DMS)	Monitors the status of driver alertness and attention to the driving task, and warns the driver if they are impaired. Systems detect status either directly (eg by eye-monitoring sensors) or indirectly by identifying driving style behaviours that are characteristic of an impaired driver.	Retrofitted and beginning to be factory-fitted in some models by some manufacturers.
Fleet Management Telematics (FMT)	Allows the sending, receiving and storing of information relating to the vehicle via telecommunication devices (information may include location, speed, idling status, fuel consumption and driver inputs to controls such as accelerator and steering). This information can be used for fleet management purposes such as providing safer-driving feedback advice and creating ELs and maintenance schedules.	Retrofitted.
Alcohol Interlock System (AIS)	Automatic control system that is designed to prevent driving with excess alcohol by requiring the driver to blow into an in-car breathalyser before starting the ignition. The AIS can be set at different levels and limits.	Retrofitted.
Electronic Work Diary/Electronic Logbook (EWD/EL)	A means of automating monitoring of (heavy-) vehicle driving hours. May also monitor other aspects relating to driving safety.	Retrofitted.
Blind Spot Monitoring (BSM)	Provides an audio/visual warning when objects (generally other vehicles or vulnerable road users [VRUs]) are close to or within vehicle blind spots.	Factory-fitted.

1.3 About this report

The project progressed in two stages: (1) information gathering and analysis and (2) roadmap development.

The earlier interim report provided results on stage 1, including:

- a literature review on the effectiveness of vehicle technologies in supporting safe and efficient driving behaviour (Chapter 2 of this final report)
- stakeholder insights into the barriers and enablers related to the implementation and effective use of in-vehicle technologies (Chapter 3)
- analysis of the current prevalence and trends in uptake of key technologies (Chapter 4)
- analysis of the potential crash savings from increased uptake of key technologies (Chapter 5).

This final report adds detail on the development of roadmaps and recommendations to help inform future strategies for increasing the uptake of in-vehicle technologies that promote safe and efficient driving behaviour (Chapters 6 and 7).

1.4 Context

The results described in this report, including the potential effectiveness of technologies and strategies to increase uptake of in-vehicle technologies, will need to be considered with reference to known relevant features of the local context in New Zealand, including:

- the relatively small population (around 5 million), rural spread and low population density, leading to lack of alternative transport choices (except in major urban centres), which in turn contributes to greater car ownership rates and high average vehicle kilometres
- no local manufacturing of vehicles, resulting in reliance on imported vehicles – approximately 36% of all vehicle imports are used vehicles, predominantly from Japan
- small population and lack of local manufacturing, leading to less opportunity to influence manufacturer decisions regarding technology.

2 Literature review: effectiveness of vehicle technologies

The aim of the literature review was to review the published scientific literature on in-vehicle technologies that assist with and encourage safe and efficient driving behaviour. Relevant research findings were drawn out from the literature to highlight how effective such technologies could be in this area. Where possible, this included extracting estimates of effectiveness for the different technologies within appropriate contexts.

The findings from the literature review, as well as the effectiveness estimates, built upon previous work that Seidl et al. completed for the European Commission, *In depth cost-effectiveness analysis of the identified measures and features regarding the way forward for EU vehicle Safety* (European Commission report CPR2411). Seidl et al. (2017) was a large-scale literature review and stakeholder consultation on a list of vehicle safety technologies (including most of those that were covered within this current review). The purpose of their work was to identify the likely effectiveness and cost of implementation of the various technologies. Their 2018 work analysed the overall cost-effectiveness of different packages of measures tailored from the list of technologies covered in their previous work. The main output of this was a list of effectiveness estimates (ie potential future casualty reductions) of each technology in relation to corresponding target populations. We used these effectiveness estimates in the calculation of estimated casualty savings that are presented in Section 5.1 of this report. The Seidl et al. work acted as the ideal starting point for this current review, which drew on research conducted since their work and aimed to focus on the New Zealand context.

2.1 Summary of method

Relevant search terms (see the detailed list in 7.9Appendix A:) were used to search several research databases (Google Scholar, ScienceDirect, TRID). Multiple searches were conducted within each database through an iterative process, wherein each search term was tested individually and with others to identify which terms generated the most relevant results. Boolean operators, wildcard characters and filters were also used to refine the search output to only the most relevant results.

The literature identified through this search process was then entered into a spreadsheet. Literature that was clearly irrelevant (eg not at all related to the focus of the current review, not a journal paper, no human behaviour being tested), based on the title, was removed at this stage, leaving 55 papers. The abstracts of these papers were then reviewed and scored according to the inclusion criteria: relevance and quality. In this context, ‘relevance’ referred to how much a study directly evaluated the impact of the specific in-vehicle technologies under investigation, while ‘quality’ referred to scientific robustness of the study methodology. Thirty-four papers scored high enough to justify being taken forward for full-text review.

This literature was reviewed in full, with the findings recorded systematically in the review spreadsheet. Each individual text was presented in a row, with summaries of research goals, methods and findings detailed in columns. Conclusions relating to the current research were drawn from each reference where possible.

2.2 Findings

This section presents the main findings relating to the objectives of the literature review. First, sources that provided effectiveness estimates are discussed in relation to those provided in Seidl et al. (2018). This is followed by a detailed discussion of evidence on behaviour change outcomes for each of the in-vehicle technologies under investigation.

In this context, effectiveness is defined as the net change in the variables of interest (ie changes in casualty crashes or fuel efficiency). Effectiveness estimates, and how they were combined with technology prevalence estimates and used to estimate potential crash savings in the New Zealand context, are discussed in further detail in Chapter 5.

2.2.1 Effectiveness estimates

Twelve of the 34 papers that underwent full-text review provided estimates on the effectiveness of systems being investigated in our research. At least one effectiveness estimate was found on the following systems: AEB, FCW, ISA, LKA and DMS. These papers and associated estimates are summarised in Table 2.1. Note that the estimates provided in this table predominantly cover safety outcomes from crash studies. Few papers that were identified within this review addressed driving efficiency outcomes. Only one paper (Tulusan et al., 2012) provided effectiveness estimates focusing on efficiency outcomes. This paper is included within Table 2.1; however, this does represent an area where further evidence is required.

The estimates drawn from this literature review were not very consistent with those provided by Seidl et al. (2018). This is likely because different studies have taken different approaches to how they conduct their analyses, how they categorise and present their estimates, and the different populations targeted within each study. For example, in the case of DMS, Seidl et al. (2018) targeted vehicle collisions from a European dataset of casualties where drowsiness or significant distraction was a contributory factor. Their estimates were then broken down by fatal, serious- and slight-injury collision reductions; whether these were either mitigated or avoided; and by vehicle category. This is not comparable to the approach taken by Fitzharris et al. (2017), who targeted fatigue events within a commercial truck fleet in Australia, simply noting the level of reduction in these events with and without supervisory feedback.

It is also important to highlight that some of the reviewed studies considered injury categories or severity. The severity of injuries depends on the vehicle occupant safety systems that are in place; that is, vehicles that are more modern would be expected to – on average – reduce the severity of injuries. As vehicle models were not considered within the reviewed studies, it could not be assumed that the presented figures reflected current estimates of vehicle safety.

In addition, some studies (eg Camden et al., 2019; Perez et al., 2020) provided estimates based on a collection of advanced driver assistance systems, including those under investigation in this research. It is not always clear how effective the specific systems were when considered on their own, separate from other active safety systems or a company's own fleet risk management strategies. Also, many of the cited studies lacked control groups. This means that even where technologies were considered on their own and not as part of a wider package of systems, the conclusions were limited. Furthermore, it is not clear how applicable the estimates provided here are to the New Zealand context. A range of different countries are represented here, some of which have driving environments that are very different from the one in New Zealand.

A final critique (described in more detail in the next section of this paper) is that negative behavioural adaptation effects were also observed in the use of some of these in-vehicle safety technologies. These could have been naturally accounted for in the net effects on crashes for those studies that examined effects on crashes in Table 2.1, but the longer-term effects may not have been accounted for.

In short, the estimates provided here suggest that the systems covered have a demonstrable effect on improving safety outcomes – or in the case of Tulusan et al. (2012), fuel efficiency. However, the stated limitations need to be borne in mind when considering how these findings can be applied within the context of New Zealand.

Table 2.1 Effectiveness estimates drawn from the literature review, including summaries of the studies' approaches

System	Source	Summary of approach	Target population	Country	Estimated effectiveness
AEB	Camden et al. (2019)	Case study of 9 commercial motor vehicle fleets in the US. The various carriers considered in the investigation were consolidated on the specific safety systems they had installed in their fleets and the subsequent impact this had on safety outcomes. Analysis was conducted to generate a matrix of the carriers' successful safety strategies.	Commercial motor vehicle fleets in the US.	US	Different case study fleets demonstrated different levels of effectiveness: • Carrier A experienced a 56% crash reduction with AEB. • Carrier B experienced a 31.7% crash reduction from full suite of collision-mitigation technologies (including AEB and LKA). • Carrier C experienced a 75% crash reduction with telematics devices and AEB. • Carrier G experienced a 66.3% crash reduction in 1 year following the introduction of On-board Safety Monitoring and AEB.
	Kovaceva et al. (2020)	Crash data from the German In-Depth Accident Study (GIDAS) and Community Dataset on Accidents on the Roads in Europe (CARE) was used to develop a safety benefit assessment framework, which was used to estimate the impact of AEB systems, taking into account effectiveness and market penetration.	Fatal collisions involving passenger cars and VRUs in Germany.	Germany	At 82% market penetration and user acceptance levels, using an AEB system could prevent 5–6% of all cyclist fatalities and 10–12% of car-to-cyclist fatalities, and 3–4% of all pedestrian fatalities and 5–6% of car-to-pedestrian fatalities in the EU.
	Stark et al. (2019)	German accident data was used to create a simulation framework that could predict which collisions could be addressed or avoided by a combination of advanced driver assistance systems, including AEB, LKA and Autonomous Cruise Control (ACC).	Vehicle accidents on rural roads or motorways in Germany with at least one severely or fatally injured person.	Germany	12% of all the cases of people killed or seriously injured in extra-urban scenarios documented within the sample dataset could have been prevented by a mix of ACC, AEB and Lane Keep Support systems (LKSs).

System	Source	Summary of approach	Target population	Country	Estimated effectiveness
	Tan et al. (2020)	2008–2017 data on road traffic accidents in China was modelled to predict the likely impact of using AEB on reducing the numbers of people who were killed or seriously injured.	Total fatalities and injuries in Chinese road traffic collisions.	China	AEB system was predicted to reduce fatalities caused by road traffic collisions in China in 2030 by 3–8%; the associated injury reduction was 3–5%.
	Chajmowicz et al. (2019)	Car-to-cyclist accident data was used to build curves for fatal, severe and slight injury risk as a function of impact speed. The simulation tool was then used to compute the likely injury reduction had the vehicle been fitted with AEB.	French frontal car-to-cyclist accidents resulting in fatal, serious or slight injuries.	France	A high-end AEB system (ie one with a wider sensor angle) was the most effective at reducing car-to-cyclist fatalities and injuries: • fatalities – 59% reduction • severe injury – 54% reduction • slight injury – 42% reduction.
	Logan et al. (2017)	Real-world in-depth crash data collected in Victoria and New South Wales between 2000 and 2013 for the Australian National Crash In-Depth Study was used to estimate the safety benefits of automated driver systems (including AEB, FCW and LKA).	Crashes that led to at least one vehicle occupant being hospitalised.	Australia	55% reduction in serious injuries.
	Cicchino (2017)	Regression analyses were used to compare rates of police-reported crashes across 22 US states during 2010–2014 between passenger vehicles with stand-alone FCW or AEB systems.	Police-reported front-to-rear crashes in vehicles where an AEB system was offered as an optional feature and information on the presence or absence of the system on individual vehicles was available.	US	43% reduction in front-to-rear crash rates, and 45% reduction in front-to-rear *injury* crash rates.

System	Source	Summary of approach	Target population	Country	Estimated effectiveness
FCW	Perez et al. (2020)	All automotive accidents within an oilfield service company during 2017 were analysed to identify the nature of the incidents, with driving performance data being used to identify scenarios in which focused solutions could have been useful in reducing the number of incidents.	All automotive accidents within an international truck fleet. Specific focus on head-on collisions and rollovers.	International (no details on specific countries covered)	The implementation of a FCW system could have resulted in a 19% reduction of incidents in 2017. A 17% reduction in automotive accidents was observed within the sample company's accident rates when comparing 2017 and 2019 accident rates, following the introduction of an assortment of advanced driver assistance systems (including FCW and LKA).
	Logan et al. (2017)	Real-world in-depth crash data collected in Victoria and New South Wales between 2000 and 2013 for the Australian National Crash In-Depth Study was used to estimate the safety benefits of automated driver systems (including AEB, FCW and LKA).	Crashes that led to at least one vehicle occupant being hospitalised.	Australia	56% reduction in serious injuries.
	Cicchino (2017)	Regression analyses were used to compare rates of police-reported crashes across 22 US states during 2010–2014 between passenger vehicles with stand-alone FCW or AEB systems.	Police-reported front-to-rear crashes in vehicles in which the FCW system was offered as an optional feature and information on the presence or absence of the system on individual vehicles was available.	US	27% reduction in front-to-rear crash rates, and 20% reduction in front-to-rear *injury* crash rates.
ISA	Doecke & Ponte (2017)	2013 US crash data was used to model the impact that limiting ISA had on impact speed and subsequent injury severity, with the associated estimate calculated by summing the change in injury probabilities in individual crashes and comparing that with the total of the original injuries.	Serious, slight and non-injury crashes in the US, including: • rear-end • head-on • hit fixed object.	US	Limiting ISA system showed: • 62% reduction in serious-injury crashes • 27% reduction in moderate-injury crashes • 22% of crashes would have been avoided altogether.

System	Source	Summary of approach	Target population	Country	Estimated effectiveness
	Doecke et al. (2021)	2013 Australian crash data was used to model the impact that limiting, supportive and advisory ISA had on impact speed and subsequent injury severity, with the associated estimate calculated by summing the change in injury probabilities in individual crashes and comparing that with the total of the original injuries.	Fatal and serious-injury crashes in Australia, including: • rear-end • head-on • hit fixed object • pedestrian.	Australia	Estimated serious-injury reductions differed by ISA system: • limiting ISA – 17.6% • supportive ISA – 8.1–12.3% • advisory ISA – 5.1–9%.
	Tulusan et al. (2012)	50 corporate car drivers (25 control, 25 experimental) used the DriveGain smartphone application over a period of 8 weeks. The app collected data from over 800 journeys on factors such as average speed, gear changes, acceleration and braking. Changes in driving behaviours were compared over time.	Corporate car drivers in Switzerland.	Switzerland	A 3.23% improvement in fuel efficiency.
LKA	Perez et al. (2020)	All automotive accidents within an oilfield service company during 2017 were analysed to identify the nature of the incidents, with driving performance data used to identify scenarios in which focused solutions could have been useful in reducing the number of incidents.	All automotive accidents within an international truck fleet. Specific focus on head-on collisions and rollovers.	International (no details on specific countries covered)	The implementation of an LKA system could have resulted in a 2% reduction of incidents in 2017. An 17% reduction in automotive accidents was observed within the sample company's accident rates when comparing 2017 and 2019 accident rates, following the introduction of an assortment of advanced driver assistance systems.
	Logan et al. (2017)	Real-world in-depth crash data collected in Victoria and New South Wales between 2000 and 2013 for the Australian National Crash In-Depth Study was used to estimate the safety benefits of automated driver systems (including AEB, FCW and LKA).	Crashes that led to at least one vehicle occupant being hospitalised.	Australia	33% reduction in serious injuries.

System	Source	Summary of approach	Target population	Country	Estimated effectiveness
DMS	Fitzharris et al. (2017)	Retrospective analysis of real-time fatigue-event data collected between 2011 and 2015 from a DMS fitted within a commercial vehicle fleet was conducted, comparing fatigue-related incidents before and after fitment.	Fatigue-related incidents in Australian truck fleet.	Australia	Fatigue alerts reduced the incidence of fatigue events by 66.2%. With additional feedback via the driver’s employer, this increased to a 94.4% reduction from the baseline rate.

2.2.2 The evidence on behaviour change

Beyond the effectiveness estimates discussed in the previous section, most of the studies identified during our literature review highlighted the effects that in-vehicle technologies had on behaviour change outcomes. In many cases, this evidence was drawn from laboratory-based experiments (eg driving simulator studies) and provided useful insights on the effects of in-vehicle safety systems on behaviour – both positive and negative. The following subsections cover the evidence that was found for each of the in-vehicle technologies under investigation. Note that AEB systems are not covered in this section, as all identified studies on AEB provided effectiveness estimates as part of their conclusions, and so were covered in the previous section.

2.2.2.1 Collision Warning Systems

This literature review identified several simulator studies that investigated different collision warning systems. Ali et al. (2020) used a heads-up display system that displayed information (eg current speed limit, distance to car in front, safety-critical messages) on a screen directly in the eye-line of the driver in the simulated environment, mimicking real-world systems of this type that display such information on a screen inside the vehicle. Auditory alerts were also used alongside safety-critical messages, such as when individuals were exceeding the speed limit or moving dangerously close to the leading vehicle. The system therefore provided both collision warning and ISA functions. Participants were required to complete a simulated drive through a range of different environments while managing different traffic scenarios. Their performance was then compared driving with and without the driving assistance system. Drivers were found to comply with the driving aid, maintaining larger spaces between themselves and the leading vehicle. A similar finding was observed in Zhu et al.’s (2020) three-year real-world trial of an audio-visual FCW system, providing evidence of the effect of such systems on close-following behaviours and the associated collision risk.

The simulator studies documented in Large et al. (2019) and Merenda et al. (2017) had very similar designs, both of them assessing the effect of a collision warning system on safety outcomes, as well as driver acceptance and attitude towards the system. The specific systems used in these studies provided either auditory, visual or audio-visual alerts when a pedestrian was identified as walking in front of the forward path of the driver’s vehicle. In both studies, the participants drove through a simple simulated urban environment that was populated by pedestrians – some of which would walk onto the road, triggering the warning system. Driver performance was then measured and compared across the different alert types. The findings from these studies showed that audio-visual alerts produced the earliest braking, with earlier warnings being received more favourably by participants, as this allowed the greatest time to react to the situation. Furthermore, based on data collected through eye-tracking devices used in these studies, it was concluded that participants were able to react to the collision warnings before they had visually identified where the collision risk was.

Similar findings were shown in studies by Calvi et al. (2020) and Winkler et al. (2018), though the systems that these studies used differed. Calvi et al. (2020) featured heads-up display-based visual alerts like those seen in Ali et al.’s (2020) study, while Winkler et al. (2018) featured a two-stage warning system that provided both an early warning and then an urgent warning if the situation became more safety-critical. An additional finding from Winkler et al.’s (2018) investigation was that their collision warning system had no negative distracting effects on the driver.

Though the evidence detailed thus far on collision warning systems has been largely positive, Reinmueller et al. (2020) identified a negative behavioural adaptation effect associated with a collision warning system. They found from a simulator study that drivers spent more time with their eyes off the road, as they became reliant on the warnings provided by the collision warning system. However, it is important to emphasise that this effect was observed in an adaptive system that could provide earlier warnings based on the driver's level of distraction. This was an advanced system, incorporating features of a DMS that went beyond the capabilities of most collision warning systems that are typically fitted within vehicles. This negative adaptation effect may not be as pronounced in non-adaptive warning systems, though this is an area that requires further investigation and evidence.

A simulator study by Yue et al. (2021) provided one example of evidence on this matter, finding positive adaptation effects. In specific pre-crash scenarios (including intersections and freeways), the drivers could pre-empt alerts provided by the collision warning system if they had already perceived enough safety-critical cues. This might suggest that collision warning systems can help train people in better hazard perception skills, by conditioning them to recognise stimuli that trigger the warning system. Again, this is an area that would benefit from further study.

Theofilatos et al. (2017) completed an evidence review based on the SafetyCube project, which aimed to quantify risks and measures associated with drivers, vehicles and infrastructure, to develop a road safety decision support system. They reviewed five studies (four of which were simulator-based) that evaluated the effect of collision warning systems on road safety outcomes (eg reaction time, speed), concluding that such systems have a mixed impact on road safety, as they argued that simulator experiments could not be taken to represent 'real' road safety outcomes. Their conclusion emphasises a need to investigate the applicability of such findings to real-world environments. This could be done through conducting duplicate studies within real-world and simulated environments, to understand whether the simulator approach to investigating in-vehicle safety technologies is valid.

Woodrooffe (2019) conducted a survey of 1,010 drivers across seven different truck fleets, as well as interviews with key representatives from each of the companies involved. Their aim was to assess in-vehicle safety technologies and management practices, and their impact on overall safety performance. FCW systems were rated as 'highly effective' in improving safety, a consensus drawn from the collected data. While it is not clear exactly what is meant by 'highly effective', this finding seemed to represent a positive perception of the technology from the relevant stakeholders, possibly built from observing an improvement in safety following their introduction (although in itself, this would not be a reliable indicator of effectiveness).

The research covered within this section has addressed only FCW systems, not RCW systems. When conducting the literature search, using the terms 'rear', 'collision' and 'warning system' (or reasonably synonymous alternatives) alongside each other typically generated results on rear-end collisions. This is likely because rear-end collisions make up a significant proportion of road accidents and are thus a greater focus of research when compared with RCW systems. This may highlight a need to generate and promote more research on these systems.

2.2.2.2 Lane Keep Assist

Several service providers investigated in Camden et al.'s (2019) case study reported that LKA systems contributed significantly to improved safety outcomes. Where truck fleets within this study showed improvements in crash reduction, it was unclear how much of this improvement could be attributed to the LKA system and how much to other fitted safety systems (eg AEB). However, feedback from the people who were consulted in their study made strong recommendations for such systems. Recent systems that had lower rates of false-positive alerts were received particularly positively by the fleet drivers. A similar finding was reported in Woodrooffe's (2019) study, detailed in the previous section.

Benloucif et al. (2019) evaluated two different LKA systems: one provided continuous haptic feedback to the driver, based on their position within the road, and the other adjusted the level of haptic feedback depending on the driver's distraction level (ie adaptive LKA). The intention of this latter system, which incorporated elements of driver monitoring, was to determine whether it improved on the former system's lane-keeping performance by adjusting the level of control offered in situations where the driver was fatigued or distracted, rather than providing 'overwhelming assistance'. In other words, this system would take a greater level of control in maintaining an appropriate lane position when the driver's state was impaired. These two systems were tested within a simulator study wherein participants completed a series of drives with and without both systems. During each drive, the participants were also required to complete a secondary task, to simulate distraction. Under normal driving conditions, both systems yielded similar results – the drivers could maintain better positioning in the centre of the lane. However, during the distraction task, the adaptive system demonstrated a greater ability in helping the driver to maintain a better position. As with other simulator studies discussed in this report, it is not clear whether such findings can be extrapolated to real-world driving scenarios. This concern needs to be borne in mind when interpreting Benloucif et al.'s (2019) findings, as their simulated environment was of a low fidelity and did not account for factors such as traffic.

Miller and Boyle (2019) evaluated the effects of an automated LKA system on driving performance within a set of simulated driving environments. Participants were required to complete eight drives within a simulator over a week-long period, with the LKA system being activated for half of the drives. This was to investigate the effect on driving performance of removing the LKA system once participants had been exposed to it. The system was programmed as a lane-centring system, providing force feedback to keep the vehicle in the lane whenever it crossed the lane boundaries. While the LKA system used in this study resulted in reduced variation in drivers' lane position, when the system was no longer activated there was a significant increase in drivers' lateral deviation. This would suggest that drivers develop a reliance on such systems to keep them appropriately positioned within the road. This kind of negative behavioural adaptation is similar to that which was observed in Reinmueller et al.'s (2020) study on an adaptive forward collision system. This point would benefit from further supporting evidence; however, it may still be worth considering when investing in automated LKA technology.

2.2.2.3 Intelligent Speed Assist

Ali et al. (2020) and Starkey et al. (2020) both conducted simulator studies examining the effects of different ISA systems on driver behaviour. Ali et al.'s (2020) study was detailed in Section 2.2.2.1 as they investigated multiple systems simultaneously. Regarding the ISA function of their heads-up display warning system, their participants showed a high level of compliance with the provided information, adjusting their speed in response to speed limit exceedance warnings. Frequency of speed limit exceedance was also found to be lower when the system was available, likely because drivers were able to adapt their behaviour appropriately based on the provided information.

A similar approach to Ali et al. (2020) was taken in Starkey et al.'s (2020) study, with drivers required to drive through a range of simulated environments and traffic scenarios while their speed limit compliance was assessed. However, their ISA system only provided information of the current speed limit via a smartphone application mounted on the centre console of the vehicle. Two versions of this system were tested: one was a manual system where the driver had to select the correct speed limit for the environment, while the other was a passive system that automatically set the correct speed limit without the need for driver input. This was intended to assess the distractive effects of the different systems. Two alert types were also created: audio-visual, which alerted the driver when they were exceeding the speed limit by displaying a flashing speed limit rondel with an accompanying beeping noise; and visual-only, which displayed only the flashing rondel. Similar to Ali et al.'s (2020) findings, the ISA system used here had good results regarding compliance with speed choice. Starkey et al. (2020) found no significant differences between the different versions of the system, both of them resulting in improved compliance compared with the baseline condition. Furthermore, they found no evidence to suggest that the ISA system distracted drivers or led to any negative driving-related outcomes.

Vaezipour et al. (2018, 2019) also conducted two simulator studies of their own, looking at how in-vehicle ISA could improve driving efficiency. The system they chose provided different advisory messages triggered by specific traffic events (eg speed limit changes) and feedback messages triggered by driver behaviours (eg acceleration, exceeding the speed limit). Green and red LED lights also indicated appropriate and inappropriate behaviours. The findings from these studies showed that providing drivers with such information could reduce fuel consumption and speeding behaviours, as well as promote smoother acceleration and deceleration. These experiments provided some initial evidence that ISA systems could improve driving efficiency outcomes, backing up Tulusan et al.'s (2012) study showing fuel savings in fleets.

The simulator studies discussed here offer some evidence on the positive effects that advisory ISA systems can have on speed limit compliance. It is always necessary to question how applicable simulator findings are to real-world conditions. For example, it is possible that under the laboratory conditions of the simulator study, participants may alter their behaviour in response to alerts regarding their speeding behaviours in order to be perceived more favourably by the experimenter. Under private solo-driving conditions in the real world, drivers may opt to ignore such warnings.

However, Theofilatos et al.'s (2017) review provided evidence from six different observational and field studies examining the effectiveness of ISA systems on road safety in real-world driving contexts. The reviewed studies included longitudinal trials of ISA systems in different European countries (including Sweden, the Netherlands, Hungary and Spain) and showed a good level of consistency in their outcomes. They concluded from their review that such systems have an overall positive effect in reducing vehicles' mean speed, instances of drivers exceeding the speed limit, and crash frequency. Overall, their evidence indicated a positive effect of ISA systems in both simulated and real-world driving environments.

2.2.2.4 Driver Monitoring Systems

Further to the work by Fitzharris et al. (2017) that was detailed in Section 2.2.1, one other study covering DMSs was found in this literature review. Bell et al. (2017) evaluated the effect of in-vehicle monitoring systems on risky driving behaviours within commercial fleets. Specifically, they set out to compare the effect of immediate in-cab alerts against supervisory coaching on specific risky behaviours, which included distracted driving. Their study utilised truck fleets from the oil and gas industry across 20 sites in 12 states of the US. Data was collected over four study periods between April 2012 and July 2014, following the implementation of a camera-based monitoring system. The system was triggered when the driver engaged in any of the targeted risky driving behaviours, and instant feedback was given to the driver through a light within the vehicle cab to denote the level of risk (green light for safe, yellow or red for risky events). Depending on the study period, different groups of drivers would receive no feedback, feedback only, or feedback plus coaching.

Comparing the likelihood of engaging in risky driving behaviours between the control and experimental conditions, no significant reduction was found with the in-cab alert-only system. Bell et al. (2017) speculated that had they considered manoeuvre-related behaviours instead of risky behaviours, the in-cab alert system may have been more effective. Furthermore, it was possible that the design of the alert system was not the most effective at encouraging behaviour change. However, the findings from this study showed that when the in-cab alert system was paired with supervisory coaching, the likelihood of drivers engaging in risky driving behaviours was significantly reduced. This finding begins to highlight that there is an important role for feedback and training in improving commercial fleet driver road safety that cannot be addressed by in-vehicle technology alone. This idea has been supported by a review by Huang et al. (2018) and Pyta et al. (2020), who found that coaching and training programmes could improve the effects of in-vehicle feedback systems, as well as reduce the potential of a deterioration in the effects of in-vehicle safety systems over time.

2.2.2.5 Fleet Management Telematics

Little evidence was found in this literature review regarding the effectiveness of 'fleet management' telematics systems in reducing crashes – an observation that has been made in previous research (Grayson & Helman, 2011). Telematics systems that do not necessarily monitor driving behaviour directly are designed to collect data from fleet vehicles (eg sensor and vehicle engine data), to allow fleet operators to manage their fleets better. It is not always feasible or efficient for fleet operators to monitor live feeds of incoming telematics data at all times, particularly in large fleets. Instead, telematics data is often used to identify vehicle maintenance needs and analyse events that occurred prior to an incident. This could explain why there appears to be little existing evidence on the impact of such systems on safety and efficiency outcomes.

This literature review identified two papers that considered how telematics systems could be utilised to improve driving efficiency outcomes. De Oliveira et al. (2019) completed an analysis of safety and efficiency outcomes within a fleet of 33 juice haulage trucks in Brazil. Their study involved a stepped process of undisclosed and conscious periods of monitoring driver telematics data, both with and without driver training and feedback. Safety and efficiency outcomes were found to improve when drivers were conscious of being monitored. In particular, drivers were found to spend more time driving within the speed limit. These improvements were greatest when accompanied by feedback and training from supervisors, though a drop was observed when feedback was removed. This would suggest that telematics system monitoring can be effective, though it is most effective when paired with appropriate feedback and training in response to undesirable behaviours. De Oliveira et al.'s (2019) study did not provide any details on the nature of the training or feedback that was given, so it would be necessary to conduct further investigation into understanding what constitutes effective feedback in this context.

Mane et al. (2021) developed a framework to determine and understand the key driving behaviours that influence fuel consumption in heavy-duty vehicle fleets. Specifically, telematics data collected over a 10-month period from a fleet of 22 trucks within a timber haulage company in Ireland was analysed to identify inefficient driving behaviours. Average speed, idling, stops, and harsh braking and accelerations were identified as behaviours that had a negative impact on fuel consumption. The authors proposed that a targeted incentive scheme could be used within this company to address these undesirable behaviours and improve fuel consumption.

2.2.2.6 Alcohol Interlock Systems

At the time of this literature review, evidence on the effectiveness of AISs within a commercial fleet context was limited, as studies on this technology have typically focused on drunk-driving offenders. AISs are usually only fitted to vehicles in programmes for rehabilitating repeat offenders and are not common within commercial fleets.

Theofilatos et al. (2017) reviewed two field experiments of AISs within commercial vehicle fleets. Their review suggested that these could have positive effects on road safety. However, they ultimately concluded that the studies did not indicate the effects that AISs could have on accident rates. They also noted that the reliability of AIS breath tests within a commercial fleet context was unknown, unlike when the same devices were used in drink-driving offender programmes and regularly calibrated and checked for tampering.

The conclusions drawn from Theofilatos et al.'s (2017) review demonstrated a need for better understanding of the impact that AISs could have within commercial vehicle fleets. Moreover, it would be worth considering whether there is significant risk within commercial fleets of collisions caused by alcohol impairment to justify investing in this technology in this context.

2.2.2.7 Electronic Work Diaries/Logbooks

This literature review identified only one study that considered EWDs/ELs. Woodrooffe's (2019) study, which has been detailed in Section 2.2.2.1, surveyed truck fleet drivers and fleet safety executives on how they rated different in-vehicle technologies in terms of safety, acceptance and satisfaction. EWDs/ELs were rated as being a 'highly effective' safety technology and they scored high acceptance and satisfaction ratings from the fleet drivers.

Woodrooffe's (2019) study also provided evidence showing that fleets that had a greater number of fitted safety technologies had greater safety scores (based on incidents of unsafe driving behaviour, hours of service and vehicle maintenance). Unfortunately, it was not clear exactly what role EWDs/ELs played in achieving these safety scores specifically (except through a general contribution to an increased focus on safety culture). Further investigation into how this specific technology could improve commercial fleet safety and efficiency would be beneficial, particularly within the context of New Zealand.

2.2.2.8 Blind Spot Monitoring

Cicchino (2018) investigated the impacts of BSM systems on the rate of police-reported lane-change collisions in the US. Analyses were conducted using data collected from 26 states between 2009 and 2015, allowing for a comparison of lane-change crash rates between vehicles with BSM and those without. The study was limited to vehicles in which BSM systems were offered as an optional extra, as this allowed the author to identify which vehicles had a BSM system fitted. The results from this study suggested that BSM systems had a modest effect on reducing lane-change collisions. However, it was noted that systems that automatically took action in safety-critical situations (eg active lane keeping) were more effective than systems that only warned the driver of potential collision risks.

It is worth noting that Cicchino's (2018) approach did not define the *activation rates* of such systems, only whether the systems had been fitted. As it was assumed that the systems were turned on in all cases, their reported effect could have been greater than their actual effect. However, evidence from Reagan et al. (2018) found that BSM systems were activated in 99% of vehicles that had the system fitted. Although the target vehicles investigated in these two studies may have been different, Reagan et al.'s study did offer some support for Cicchino's reported effect size.

The work by Cicchino (2018) was the only study identified in this review that specifically targeted BSM systems, with Reagan et al. (2018) providing some supplementary support for their finding.

2.3 Summary

This review has provided evidence from a selection of scientific literature on the assorted in-vehicle safety technologies under current investigation. The various effectiveness estimates provided in Section 2.2.1 have suggested that systems such as AEB, ISA, collision warnings and LKA could significantly reduce the rates of vehicle collisions and related injuries. Furthermore, Section 2.2.2 has highlighted findings that demonstrated how such systems could positively influence driver behaviours and associated safety outcomes.

The limitations of this review need to be highlighted, as these affect how well this evidence can be considered within the context of the current work. Limitations of how well the identified effectiveness estimates can be applied within this context were detailed earlier, at the end of Section 2.2.1. In addition, any possible negative behavioural adaptation relating to these technologies (as identified within Section 2.2.2) will naturally be considered in the net effects of the technologies on crashes. However, behavioural adaptation is not well understood and many studies are narrow in their approach, failing to truly track behaviour over time. Thus, caution should be used when considering these figures. Furthermore, most of the evidence discussed here was not drawn from research within commercial vehicle fleets. Many studies, particularly the range of simulator studies, were undertaken with opportunity samples of licensed drivers. Commercial fleet drivers are professional drivers who can be trained differently and to a more advanced level than most other drivers. It is possible that they may have different responses to such systems when compared with the average driver. Therefore, the findings provided by the research discussed here may not be wholly applicable to the commercial fleet context that this work is currently targeting with respect to some of the technologies under investigation (specifically, retrofitted technologies such as FMT and DMSs).

In addition, there was a notable lack of evidence regarding some of the technologies that are under investigation here, such as RCW systems and AISs (apart from in the offender population). This means there are notable gaps remaining in this evidence review. This point should not be taken wholly as a negative, as these gaps represent opportunities for future studies in this area.

3 Stakeholder insights into implementation and use of in-vehicle technologies

To understand the barriers to implementing these technologies in New Zealand, and therefore likely drops in the potential effectiveness of them, we undertook interviews with end-users of the technologies (identified in the literature review) and with experienced industry experts.

3.1 Participant recruitment

In collaboration with Waka Kotahi, a range of potential experts and end-users were identified. An introductory email was sent, including an information sheet (see Appendix B) and a pre-interview survey (see Appendix C). Nineteen participants responded to the invitation email and 16 of them were interviewed. Since the focus of the interviews was on the implementation of technologies, the participants were selected based on the level of experience they had with the use of these technologies, where possible. Industry groups included stakeholders with an understanding of the New Zealand context, such as fleet operator associations and industry advocates. A breakdown of participants in terms of their group types and their locations is provided in Table 3.1.

Table 3.1 Overview of participant group types and location

Number of interviewees	Organisation type	Location
2	In-vehicle technology provider	Australia, New Zealand
1	Insurer	New Zealand
5	Industry group	New Zealand
2	Regulator	New Zealand
2	Light commercial fleet	New Zealand
3	Heavy goods vehicles (HGVs)	New Zealand
1	Commercial fleet, mixed	New Zealand

TRL's research ethics process was followed, with the project being granted permission to proceed on the basis that participants provided informed consent to take part, were informed that they could withdraw their participation if they wished, and that all topics discussed were relevant to their professional competence or experience.

One of the limitations of this study is that the sample of participants was based on self-selection. This means that commercial fleet organisations that place a high value on safety culture and adherence to regulations may be over-represented in the sample. The interviewees from fleets tended to be from bigger companies, which may have more resources, and therefore the responses cannot be generalised across fleet operators.

3.2 Pre-interview survey

An online pre-interview survey (see Appendix C) was conducted to collect some background information about each participant's organisation and experiences with in-vehicle technologies. It also included questions about consent, availability and contact information. This information supported the recruitment of participants from a wide range of organisation types and experiences.

3.3 Interviews

A semi-structured topic guide (see Appendix D) was developed for the interviews, which were conducted using a virtual platform (Microsoft Teams) and recorded and transcribed with the consent of the participant. Each interview took between 45 minutes to an hour. All data was fully anonymised (eg references to organisation names were removed from transcripts) before analysis, to ensure that identifying information could not be linked to participants.

The interviews focused on how technologies were implemented into commercial fleets and other settings, barriers and enablers related to implementation, how technologies were being used, and broad lessons learned.

3.4 Analysis

An internal workshop was used to identify high-level themes across the interviews. Each of the interviewers contributed to a discussion about the barriers and enablers identified through their interviews. These responses were integrated and structured to provide high-level groupings. The transcripts of the interviews were then used to provide detailed information on each discussion point. Due to the limited scope of the task, no in-depth analysis of the transcripts was done; the purpose was to make sure that high-level barriers and opportunities were collected, so these could be fed into the roadmap later.

3.5 Results

3.5.1 Decisions to buy or retrofit vehicles with in-vehicle technologies

Throughout this section when discussing specific findings and themes, we present quotes that illustrate the theme or finding in the text:

> *"Like this."*

A breakdown of the uptake of in-vehicle technologies reported by participants from commercial fleets can be seen in Table 3.2. The following trends were seen:

- AEB, FCW, LDW/LKA and ISA were in fleets where HGV turnover was high, with the fleet typically replaced every three to seven years. These technologies had been integrated into the vehicles by the manufacturer.
- Both younger and older fleets had some technologies, such as EWDs/ELs, DMS and FMT mainly retrofitted. However, there was some variation in the combinations of these across the fleets.
- One participant represented a fleet of owner-drivers. The vehicles in this fleet tended to be older and did not have any of these technologies incorporated by the manufacturer. However, they had retrofitted DMS, FMT and EWDs/ELs.
- One of the lighter commercial fleets for the construction industry bought vehicles with a five-star ANCAP rating, and they did not use any other technologies in their vehicles. Their typical fleet turnover rate was around three years. The other light commercial vehicle (LCV) fleet consisted mainly of owner-driver vans and sports utility vehicles (SUVs) with a three-star ANCAP rating, and was represented in the interview by a membership association. These vehicles mainly operated on rural roads and some of them had EWDs/ELs and Global Positioning System (GPS) tracking fitted.

Table 3.2 The uptake of in-vehicle technologies as reported by participants, including whether the technologies were retrofitted (R) or factory-fitted (F)

Fleet type	AEB	FCW	LDW/LKA	ISA	DMS	FMT	AIS	EWD/EL	BSM	RCW	Pedestrian Warning System
HGVs	F	F	F	F	F	R			F		
HGVs, LCVs, trailers	F	F	F	F	R	R		R			
HGVs					R	R		R			
HGVs	F	F	F		F, R	F, R			F	F	
LCVs	F	F	F	F							
LCVs								R			

The safety of drivers was reported as being a key factor in the decision-making process for the majority of fleet operators. One operator, representing owner-drivers, reported that safety was not the primary concern for their drivers; they were focused on doing the job easily, quickly and cheaply. Three operators stated that client requirements played a significant role in their decision-making process. Of these three operators, two responded to their clients' requirements for increased operational safety as a leverage to win tenders and they decided to use vehicles with technologies, both factory-fitted and retrofitted. The third operator decided not to retrofit vehicles with telematics due to the concerns of their clients around privacy when using their vehicles.

Additionally, the ability of fleet operators to negotiate savings on technologies was reported as being important. For instance, two participants were able to receive discounts through their membership of an organisation that negotiated technology discounts on their behalf. Due to the costs involved in buying, retrofitting, maintaining and providing services (eg producing data reports and alert management), management buy-in was stated by all fleet operators as being a key component to the uptake of in-vehicle technologies:

> *"It's very expensive this stuff, so if you haven't got their buy-in from the top then that's not going to happen and the truth is that has to be viewed as an investment because you don't buy the stuff, install it and then start making more money, that's just not how it works, unfortunately … if you haven't got their buy-in you're stuffed." (P11, fleet)*

> *"It [management buy-in] is 100% important … it's one of those elements that's an asset-rich piece of equipment for an organisation, therefore a senior management buyer is essentially going to be the decision maker." (P10, fleet)*

The fleet operators who were dependent on contracts from clients reported that they could not charge their customers more if they had in-vehicle technologies installed, nor if they had an excellent safety record. These operators felt the strongest about the need to see a cost–benefit analysis and more transparency regarding the safety records of different commercial fleets within the industry, to reap the benefits that technologies could provide.

The impact that client requirements had on deciding which technologies to retrofit could not be overstated. For one HGV operator, technologies acted as an enabler, providing evidence of their adherence to regulations and used as leverage to win tenders:

> *"There's definitely a cost involved with it [technologies] but we are at a point now that it is working for us and we are able to tender for contracts based on our systems that we've got. It used to be a bit of a bonus for our clients that we had all this stuff but now, they're coming to us because we've got this fitted to the vehicles." (P11, fleet)*

For another operator, the concerns of their staff and clients around privacy meant that they had decided not to fit GPS-enabled technologies to their vehicles:

> *"[FMT and DMS were] seen as an invasion of people's privacy, but also that they were being monitored too closely. That's obviously not the intention of that technology for those of us that were advocates for the technology, but those that were not advocates for the technology were a loud minority." (P10, fleet)*

3.5.2 How drivers are trained

The majority of fleet operators explained that their drivers were trained in the use of new technologies when they were introduced or during induction when a driver joined their company:

> *"Usually if the vehicle is new, then there's an induction process for that vehicle. Or if the employee is new, then there's an induction to the vehicle." (P10, fleet)*

All the participants reported that the use of the technologies was mandatory, with drivers told not to tamper with devices. One participant found that initially, even when the company told new drivers to use these devices and to drive within the guidelines, the drivers still felt that the company actually wanted them to maximise profits even if that meant not adhering to the rules. This operator found that with time and in discussion with managers, the drivers became more compliant with the safety culture, leading to a real reduction in overspeeding and improvements in fuel efficiency.

3.5.3 The barriers and enablers specific to individual technologies

3.5.3.1 Autonomous/Automated Emergency Braking and Forward Collision Warning systems

Since AEB and FCW technology is factory-fitted, it was only reported as being used by fleet operators who had bought new five-star ANCAP-rated vehicles. HGV fleet operators that used these technologies also tended to report buying high-end European or Japanese vehicles with these already fitted, and that their fleets tended to have a three- to seven-year turnover. Since both AEB and FCW are required for a five-star ANCAP rating, these technologies were reported as becoming more prevalent in fleets.

3.5.3.2 Lane Departure Warning/Lane Keep Assist and Intelligent Speed Assist

Several participants reported characteristics of the topology and infrastructure of New Zealand that meant that LDW/LKA and ISA technologies were not supported, or did not function on occasion. The following issues were raised:

- Not all roads have defined or maintained white lines for the LDW/LKA systems to track. (One participant used the term ‘trunk road’ when describing this but because of the lack of clear definitions that apply to all countries for such terms, we have used the more general term ‘road’ here.)
- Narrow or winding roads tend to lead to numerous false LDWs.
- Some parts of the country have patchy GPS cover, compromising ISA.

LDW/LKA false alarms were reported as being distracting, leading to driver frustration. Interestingly, even though all the fleet operators interviewed stated that any technologies that were fitted had to be used by their drivers at all times, when asked directly, one participant said they allowed their drivers to turn off the LDW system when it became too distracting. This shows the importance of technologies being able to function reliably within their intended environment.

Several participants noted that there was already a reluctance to include these technologies in vehicles due to the additional costs to the operator. If operators were to invest in technologies, they needed to be able to use the functionalities of these on New Zealand roads. Therefore, the road infrastructure must match the requirements of the individual systems to support uptake. Several participants felt that this would require drive and input from the government in terms of investing in the development and upkeep of the road infrastructure.

3.5.3.3 Driver Monitoring Systems and Fleet Management Telematics

All the fleet operators that had DMSs in their vehicles also had FMT. Most participants felt that the use of DMSs and FMT would tend to be met with resistance from drivers, who would feel that their driving would be scrutinised. This understanding was supported by the interviews with fleet operators that had introduced (or tried to introduce) these systems. Several fleet operators reported that management had to put a lot of effort into educating drivers on:

- what data outputs were produced
- how the data outputs were accessed and the format of these outputs
- who had access to specific data outputs
- with reference to each specific type of data output, how this could potentially affect the drivers.

Several fleet operators stated that even with the delivery of detailed information about the use of outputs from DMSs and FMT, some drivers still did not feel comfortable with having their driving behaviour monitored. However, most operators that had FMT installed in their fleets reported an improvement in the safe and efficient driving behaviour of their drivers, particularly for:

- **harsh braking and cornering** – several participants reported improved efficiencies in terms of reduced tyre wear, maintenance costs and fuel consumption
- **overspeeds** – three of the four operators reported a reduction in overspeed events and an improvement in drivers monitoring their speed and reacting to alerts, but at the cost of the amount of goods that could be delivered within a tight time frame (one operator said that an average reduction of 3 km/hour would require them to increase their fleet by 2% to meet their delivery quotas, meaning they tended to set the overspeed alert by 3 km/hour above national speed limits, rather than at the speed limit).

One operator reported:

> *“The sheer fact that the drivers have to concentrate on driving the vehicle so that they don’t get the overspeed and they do get the good scores with the Scania system gives us real confidence that they’re concentrating on the task of driving the vehicle instead of just staring out the window. That’s anecdotal, right, I couldn’t give you any figures but we’re 100% confident that the technology that we’ve got has made us safer …. A side effect with all of the stuff though is that a lot of times it improves our efficiency.” (P11, fleet)*

Conversely, one operator said there was no real impact on safety outcomes or efficiencies for their LCV fleet:

> *"No [there has been no safety impact], but I also probably wouldn’t expect [it] either. Because one of the difficulties in this space is that if it is preventing harm, you will never know about it because there’s nothing to report …. They are shared pooled vehicles, so trying to understand efficiencies would be a very difficult thing to do in the way our organisation works.” (P10, fleet)*

Having trialled these technologies, and due to the concerns of their customers regarding privacy, this operator had decided not to install DMSs or FMT in their vehicles.

FMT was also reported to have a positive impact on the ability of operators to maintain and service their fleets. One operator reported that it significantly reduced the administration costs for calculating when a vehicle required maintenance and servicing, as well as electronic Road User Charges (eRUC) charges. It was also reported to reduce the costs of penalties incurred during vehicle inspections.

Different types of DMSs were used to monitor the alertness of drivers. Some systems worked in combination with telematics data, while others were stand-alone systems. Several participants reported that **fatigue monitoring** had helped to identify issues with specific drivers (eg sleeping disorders) that would otherwise have gone undetected. Fatigue monitoring tended to be mentioned in relation to not only saving the driver’s life but also that of other road users.

One industry group participant reported that the introduction of fatigue monitoring had had an impact on both customers and fleet companies:

> *“I’ve actually seen them [supply chain] go from not giving a damn to that being the norm or becoming the norm … because they started seeing the value [financial] and there was a little bit more pressure in that department.” (P13, industry group)*

One company that used a driver-facing camera system found that in a few cases, the drivers were not aware that they had experienced a severe fatigue event (where the event had been escalated to management because the driver had not reacted to the in-vehicle alert within a set period) and they believed it was a false alarm. Showing the driver the in-cab footage of the event tended to lead to greater acceptance of the technology and compliance with future alerts.

Two participants reported that their companies dealt with fatigue-related events on a one-to-one basis, with the driver and fleet manager discussing a fatigue event confidentially and agreeing on strategies to help mitigate against this happening in the future. One of these participants said this approach was taken because they wanted their drivers to respond to the initial in-vehicle alert and take a break, rather than being concerned about the potential for sanctions. For both these participants, fatigue-monitoring data was not included in incentives for drivers.

However, some participants also stated that concerns around fatigue tended to be related to factors outside the workplace and that it was difficult, as an employer, to know how to address these within the workplace. This was supported by the response of one industry group participant:

> *“Managing fitness for work is more about what happens outside of the truck than in the truck, you know? It’s the driver getting good sleep and what happens at home. I know there’s been a big ramp up in e-logbooks, and personally I’m a supporter of it, [but] I think it’s far from a silver bullet.” (P9, industry group)*

The importance of having a driver feedback system that supports and manages driving behaviour together with coaching could not be overstated. All participants that had a DMS installed in their fleets had an incentive system associated with positive driver behaviour. This was often in terms of driver league tables, prizes or bonuses. One participant mentioned that the league tables had a temporary impact. Another said that driver behaviour changed over time and the new behaviour became the norm; they had been unable to operate the incentive system for five months, but contrary to some findings in the literature, they did not see a degradation in driver behaviour. This supported the observation made by one of the industry group participants that for a technology to be accepted, it had to be shown to either be beneficial to the individual or mitigate a cost.

Two companies had outward-facing cameras to capture on-road events and the managers reported that it had merit in terms of protecting drivers. Firstly, within the company, it provided additional information that helped drivers to explain events, such as harsh braking or cornering. Secondly, it acted as evidence in cases where the driver or the company was subject to an incident investigation, thus expediting the process and getting drivers back onto the road more quickly. One participant stated that they only provided camera evidence to the authorities with the driver’s consent and that this was an important aspect of encouraging drivers to accept the use of this technology.

In New Zealand, road user charges (for fuel not taxed at source) can be managed electronically (eRUC). These services are provided by a third party. This third party offers a range of driver assistance benefits through its in-cab platforms, and those using the eRUC capability usually sign up for the additional features. According to one industry group participant, operators preferred a package option from providers because of the high cost of data transmission in New Zealand, due to there being only two data companies, Spark and Vodafone.

3.5.3.4 Blind Spot Monitoring

Only two of the five fleet operators had BSM. This had been fitted by the manufacturer to their vehicles as part of an integrated package. One other participant reported that they had considered retrofitting BSM and RCW systems to their HGV fleet, but after an analysis of their few incidents of collisions, they felt that these systems would not have had an impact on the outcomes of these incidents. According to one participant, BSM systems could not be made mandatory or regulated for, due to the lack of an international definition for this technology.

3.5.3.5 Electronic Logbooks/Electronic Work Diaries

Electronic or paper-based logbooks are compulsory for certain categories of HGV drivers to monitor driver hours and their breaks (eg type of vehicle, distance travelled). According to one industry group participant, about 20% of the HGV fleet in New Zealand does 80% of the long-distance driving; within this fleet, about 40% of them are fitted with EWDs/ELs.

Four of the six fleet operators reported using EWDs/ELs in their fleets. Two industry group participants observed that EWDs/ELs (retrofitted) had not proved attractive in the New Zealand context but were becoming more prevalent, mainly due to some high-profile prosecutions of accidents associated with non-compliance with the work-time directive:

> *"It is felt that since work-time provisions are under scrutiny by Waka Kotahi, that electronic logbooks may help to preserve the current work-time provisions. Both companies and drivers have resisted logbooks and it depends on where they sit in the market and how economically vulnerable they think they will be to a change. However, they provide economic and safety benefits, since it is easier to maintain your driver status and when to take a rest." (P6, industry group)*

According to several industry group participants, both companies and drivers have resisted using EWDs/ELs. One participant said:

> *"Companies can … be resistant, but that depends where they sit on the market, how economically vulnerable they think they will be to a change like electronic logbooks … the logbook one provides a safety benefit, but it's a lot easier to maintain your driver status, knowing where his rests should be, if you're using electronic logbooks." (P6, industry group)*

Industry group participants reported that using EWDs/ELs could be a sensitive issue, since some companies wanted their drivers to drive longer hours than those stipulated by the work-time rules. This was especially true for smaller companies with very small profit margins. One industry group participant reported that the responsibility for compliance to work-time rules tended to be on the driver, and that some companies specifically hired owner-operators so that they were not liable if rules were broken.

Barriers to installing EWDs/ELs included the following:

- Privacy concerns: One of the fleet companies stated that they had considered the use of EWDs/ELs, but due to the privacy concerns of their clients, they had decided not to retrofit this technology.
- Unclear legal status: One HGV operator stated that their company was waiting for clarification in the law regarding ELs before committing to the expenditure. As some of their drivers also drove for other companies on their days off, the operator needed to know whether the law would be applied to the individual or to the truck, before selecting the type of technology to introduce.[1]
- Intrusiveness: One fleet operator said they had considered fitting their LCVs with EWDs/ELs and telematics devices, but their customers had felt that the devices were too intrusive. (However, the other LCV fleet representative reported that their drivers found EWDs/ELs and GPS tracking invaluable when they had to prove the status of the deliveries that they made.)

Enablers for the uptake of EWDs/ELs included the following:

- When they are integrated with other driver aid technologies, they are viewed as being more acceptable.
- If they were mandated it would increase the potential for more-complicated systems to be added.
- They provide evidence that the driver has complied with the work-time directive and they make it easier to maintain driver status.
- They make it easier for the driver to know when to take a break.

[1] The Worktime & Logbook 2007 Rule is 'driver-centric'. It relates to recording the drivers' worktime – whether driving or not. Therefore, it would not be applied to the vehicles. The definition of worktime captures more than 'driving'; it also includes secondary employment (which may not be transport related), which means the rule cannot be applied at the truck/fleet-only level, as this would capture only a portion of worktime. Most of the approved logbooks at present allow for multiple forms of mobile devices to be used, in conjunction with tablets affixed in vehicles. This allows the driver to record and access worktime records outside of certain vehicles or for worktime that does not involve a vehicle.

3.5.3.6 Alcohol Interlock Systems

None of the fleet operators had AISs installed. One participant reported that they had considered retrofitting AISs to their fleet. The AIS version they considered would have locked the ignition for a 24-hour period after detecting alcohol in the driver, which would not be practical because different drivers used the same truck in a 24-hour period. Instead, the company had an alcohol-testing programme in place for their drivers.

3.5.4 What enables the uptake of in-vehicle technologies?

3.5.4.1 Cost–benefit analysis

A recurring theme was the need to provide clear and transparent evidence that the use of in-vehicle technologies could make a real difference, in terms of both safety outcomes and vehicle efficiencies. Technologies must therefore be shown to provide the driver or operator with a proven long-term benefit, such as making their lives easier or saving them money.

According to one participant, the justifications of the benefits of some technologies were sometimes questionable. Therefore, it was important to improve users' understanding of the technologies and to provide a way to prioritise the technologies according to their impact on safety and efficiencies:

> *"It's just the tension in the marketplace that will dictate which technology is the best. The electronic devices … provide an economic benefit." (P6, industry group)*

Several participants suggested the use of case studies to deliver a clear and accurate cost–benefit analysis for specific in-vehicle technologies:

> *"I'd say the biggest barrier, and it sort of overarches everything, comes down to a willingness to pay …. I think some really good evidence-based case studies or, even if it wasn't a case study, a broader look at the true cost–benefit would be interesting and could help too. … there are a number of factors but 'give me a compelling reason to change' is probably one of the biggest drivers in change. So, I think if it's really, really crystal clear what the benefits are, then that would be a good thing." (P9, industry group)*

Participants suggested that one way of improving the uptake of in-vehicle technologies could be the provision of an analysis that:

- differentiated between the different technologies
- provided a breakdown of their fixed costs
- included costs and savings in terms of areas such as fuel, maintenance, training and calibration of equipment
- provided a breakdown of costs associated with replacing parts, including availability and skills requirements.

3.5.4.2 Client requirements

Several fleet operators said their clients' requirements were a key factor influencing retrofitting technologies and selecting vehicles with factory-fitted technologies. This was specifically mentioned in relation to clients becoming more aware of their responsibilities in terms of driver safety and adherence to regulations. One participant explained that a technology provider's campaign that had made the customers from large companies more aware of their responsibilities under Health and Safety legislation meant that when putting a tender out, companies were starting to require safer drivers and the associated technologies. Therefore, more transparency and information sharing about the safety records of the fleet operators would be useful for the industry and provide customers with more information on which to base their choice of fleet operator.

However, the lack of standardisation in measuring and setting outputs across the various systems could complicate the industry's ability to make comparisons. Developing a framework that also adopted environmental and sustainability criteria for customers to use when considering fleet operators could act as an enabler to the uptake of technologies.

3.5.4.3 Vehicles with factory-fitted technologies

One of the fleet operators felt that controlling the quality of imported vehicles would be one way to ensure that in-vehicle technologies would become more prevalent. Currently, some vehicle safety features can be mandated in the Land Transport Rules. According to one of the participants, about two out of every three new vehicles coming into New Zealand's fleet currently comply with five-star ANCAP regulations. Therefore, the availability of vehicles with manufacturer-fitted technologies was improving as they transferred from commercial fleets into the second-hand market. Another participant explained that the ANCAP star rating system had become a market-driven enabler of manufacturers to incorporate technologies into vehicles, to increase their market share of sales. However, another participant pointed out that mandating technologies through legislation could lead to an increase in costs for companies, which might not be affordable for smaller operations.

The concern that some technologies could be turned off or the settings changed was raised by several participants. They believed that technologies that were integrated into vehicles at the point of manufacture tended to be more secure and tamper-proof.

Due to economies of scale, individual replacement parts for the technologies were reported as becoming cheaper and therefore, users were seeing an increase in the integration of technologies throughout different vehicle model ranges. However, this was price sensitive, especially in smaller, cheaper vehicles. One industry group participant reported that the technologies would have to become mandatory before they would be included in cheaper vehicles.

Several participants reported that the preference for buying premium trucks from Europe, the US or Japan was because the costs associated with maintenance made reliability a very important feature. High-end trucks tended to come fitted with the technologies and one participant felt that it would help if the requirements for the maintenance of in-vehicle technologies were built into service agreements.

3.5.4.4 Incentives

Several participants felt that providing incentives (such as those currently being offered for electric vehicles) for having safety features in a vehicle could have a positive impact on enabling the take-up of in-vehicle technologies. One participant suggested that it could be worth researching whether the costs of an incentive scheme could be offset against the high costs of trauma responses.

3.5.4.5 Pressure from drivers

One industry group participant felt that when technologies became more common across the HGV fleet, more people would be interested in exploring the safety benefits of the investment. They believed that as the visibility of technologies and their impact on safety increased, younger drivers would become more attracted to these systems and could potentially influence companies to adapt them.

3.5.4.6 Unions

Several participants reported that they worked closely with unions before they introduced new technologies and found them receptive to the concept. They felt that unions could act as enablers for the uptake of technologies since they were concerned about the safety of their members.

3.5.5 What barriers are there to the uptake of in-vehicle technologies?

3.5.5.1 International definitions

One participant reported that regulations would be unattainable until there was international consensus on how to define specific technologies, because regulations that incorporated a technology that was not yet internationally defined could not be made mandatory (AEB and LKA have international definitions and therefore, they can be regulated for).

3.5.5.2 Cost of in-vehicle technologies

One of the participants reported that due to the competitive nature of the goods transport market, margins were already low and the use of technologies could be too costly for fleet operators. Several participants stated that they had found that having technologies and a good safety record did not necessarily mean that the fleet operator could charge more for their services:

> *"Our customers – the users of the transport services – when they actually see the cost [of technologies], there's a lot of pushback. In some cases, I'd argue the benefit cost is actually quite hard to prove." (P9, industry group)*

Even though some of the costs associated with technologies could be offset (eg against efficiencies), several participants talked about the hidden costs associated with the technologies and a lack of transparency about these:

> *"There's usually gross underestimation of the resources required to actually administer these systems. The costs of some technologies are high, not only in terms of capital outlay but also associated administration costs …. The capital and the running costs are actually quite high too, particularly because it's a developing and emerging technology space." (P9, industry group)*

The expense of retrofitted technologies was generally considered to be higher than those that were part of a package of factory-fitted technologies. One participant explained that technologies that came in a factory-fitted package, such as AEB, FCW and LKA, tended to create only a marginal increase in the cost of the truck, while some retrofitted technologies, such as ISA, were very expensive. Additionally, they reported that retrofitted systems might not be as effective and secure as those that had been purpose-built for the vehicle. This linked in with a concern of several participants that some of the technologies could be tampered with.

There was also a concern that fast-evolving technologies with a short life span could not be upgraded and integrated within existing systems. This could become a barrier to the implementation of new technologies:

> *"Because it's a developing and emerging technology space, no sooner have you put one system in than it seems to be updated, and then something else has come along. Initially, the fatigue management digital analytics that is reasonably readily available now wasn't there when cameras first came out, which was in the order of 10 years ago. So, we've put cameras in, but within three years, there was the digital stuff. But it couldn't be retrofitted into our existing camera system, so some of it has an extremely short life because you've got to actually take it out and get another system." (P9, industry group)*

This raised concerns around the costs and benefits involved in purchasing vehicles with technologies or retrofitting vehicles that did not have them, the maintenance of these technologies, their life expectancy and how their long-term functionality could be assessed.

3.5.5.3 Age of drivers

Several participants reported that older drivers (50 plus) tended to be more resistant to the use of technologies. One participant said that many older drivers did not own a smartphone and struggled to use in-vehicle technologies that required tablet- or phone-based skills:

> *“[The manager] was aware that there was resistance to a lot of this electronic stuff, but it tends to be from the older, mature drivers.” (P6, industry group)*

However, one participant said they had learned not to assume that age played a role in the acceptance of in-vehicle technologies and they had also found some resistance from young drivers to their use.

3.5.5.4 New Zealand topology

The narrow roads and tight bends in New Zealand’s road infrastructure were reported by several participants to cause false alerts in DMSs and LDW/LKA, prompting drivers to temporarily disable the systems:

> *“We have quite a challenging network in terms of geometric design, quite windy roads, quite narrow lanes, and so I do know a lot of our drivers turn that stuff [LDW] off because they get fed up with hearing all the warnings. So, whilst it’s not a barrier to implementing it because it’s in the truck, I’d argue that it is a barrier if people just turn it off, because they’re not using it.” (P9, industry group)*

False alarms were considered to increase driver distraction, a hazard in itself. Several participants reported that patchy satellite coverage in New Zealand resulted in ‘shadows’ in some urban or mountainous areas. They felt that this required the proactive engagement and investment of government to develop and maintain the infrastructures required for the use of technologies.

3.5.5.5 Culture

A number of ‘culture’ factors were mentioned as potentially acting as a barrier to the acceptance of technologies, as follows:

- One participant mentioned that it often took time to get a new driver on-board with their safety culture. Even though they explained that they wanted their drivers to adhere to the rules and why this was important, some new drivers still believed that the company actually wanted them to deliver the goods as fast as possible, even if that was not in keeping with the company’s safety policies.
- Some drivers will always want to cut corners/get the job done/get home.
- A concern with privacy and being watched meant that some companies and drivers resisted technologies such as driver-monitoring technologies and EWDs/ELs.
- Most professional drivers considered second-hand older, privately owned vehicles to be the main safety concern, rather than the drivers themselves and other professional drivers.
- There was a general culture that ‘it will be okay’ or ‘it will not happen to me’.
- A belief that urban environments are safer than other environments led to a lack of focus on operating safely within urban environments.
- Some companies did not challenge unsafe driving behaviour in their drivers because they were concerned that the public might think they were unfair on them.

To mitigate these concerns, participants suggested the following:

- A consistent message regarding a safety culture must come from management, and management’s actions need to be consistent with that message.

- Drivers need to be educated on why adherence to safety regulations is important and how the technologies could enable this.
- Provide continuous and sensitive feedback and training to help drivers meet the safety requirements and use in-vehicle technologies effectively.
- Provide incentives that are linked to safe and efficient driving behaviour.

3.5.5.6 Insurers

Several participants mentioned that insurance companies tended not to be proactive when it came to in-vehicle technologies. Insurance companies were reported to be concerned that, due to the variation in vehicle ages within New Zealand, the vehicles with these technologies would not be protected from older vehicles that shared the road with them. Additionally, the costs of replacing parts of vehicles increased if they had technologies built in, meaning that insurance premiums would increase.

3.5.5.7 Regulations

For several participants, proactive engagement with technologies and the enforcement of safety practices, rules and regulations by government, based on evidence, were important. They felt that the government needed to take a leading role in driving safety practices forward, even if these were not currently popular with the public.

3.5.6 Other technologies that have been fitted to vehicles

3.5.6.1 Tyre pressure monitoring

In one of the commercial fleets, tyre pressure monitors had been retrofitted to HGVs and trailers. These not only improved fuel consumption but also had safety benefits for the driver and other road users, since they warned about potential blowouts. The participant explained that it was difficult and time consuming to keep track of up to 18 tyres on a vehicle and trailers, and this technology had proved effective in reducing the workload on the driver.

3.5.6.2 360° cameras

One participant reported that their drivers, who operated mainly in rural conditions, found cameras that alerted them to objects or people around them very useful when manoeuvring and reversing. Connected vehicle technologies that alerted them to oncoming traffic on narrow mountainous roads were also reported as something that the drivers would find useful in the future when that technology becomes available.

3.6 Summary

Based on the findings from the 16 stakeholder interviews, transparency and information about the costs and benefits of the different technologies would likely be a key enabler for their uptake. The costs of buying, maintaining and providing the associated services for vehicles with technologies were perceived to be high. To encourage fleet operators to invest in these technologies, it would be important to provide evidence of their effectiveness in terms of safety outcomes and the savings that could be made for the operation. Furthermore, operators needed to know the costs and benefits of each of the different technologies, so that they could make an evidence-based decision on which specific technologies, or combination of technologies, to adopt to maximise the impact on their fleet while minimising costs.

The safety of drivers and other road users was the main motivation of the companies that had adopted technologies in the current sample, although it should be noted that with a qualitative sample like this, findings cannot be generalised; indeed, in much previous work with commercial fleets, business savings have typically been found to be the dominant driver of technology fitment. Additionally, the interview data suggested that customers and their requirements played a significant role in the adoption of technologies. Several interviewees felt that while customers were becoming more aware of their duty of care in the supply chain, more could be done to highlight this. Customers making safety outcomes part of their tenders had a positive impact on the adoption of technologies; broadening the scope of tenders to include a sustainability component as well could improve driver compliance with data outputs and efficiencies within fleets. Several interviewees called for a safety- and efficiency-rating scheme within the industry to help potential customers compare how different companies fared on these issues.

All the commercial fleets provided initial training for their drivers when new technologies were introduced. The fleets that had adopted DMSs and FMT reported positive impacts on driver behaviour and savings. However, these fleets also provided feedback, incentives, and sensitive and active support to the data outputs from these systems. It was clear that these operators valued a safety culture and put policies and procedures in place to encourage drivers to comply with the rules and learn from the data outputs of the technologies.

The role that the government could play in the uptake of in-vehicle technologies was found to be significant. Some of the suggestions that were made included:

- being proactive in the development and maintenance of an infrastructure that supports the operation of in-vehicle technologies with clear safety benefits
- providing incentives to companies that could prove good safety outcomes and efficiencies for their fleets
- greater enforcement of operating rules and regulations
- clarifying the legislation associated with technologies so that operators were clear on how rules would be applied and therefore, which technologies would support this
- increasing the awareness of customers regarding their responsibilities in the supply chain and criteria related to sustainability.

4 Analysis of vehicle fleet characteristics in New Zealand

The aim of this section is to explore the current prevalence of in-vehicle technologies in the New Zealand vehicle fleet, as well as the trends in uptake. The results from this section could help to determine the spread of technologies in the fleet and the speed at which the impact of each technology could be realised. Section 4.1 describes the datasets used and Sections 4.2 and 4.3 present the results for factory-fitted technology and retrofitted technology, respectively.

4.1 Datasets

The dataset that formed the basis of the analysis in this section was the vehicle fleet open data recorded on the Motor Vehicle Register (MVR). This data provides a point-in-time ‘snapshot’ of all the vehicles active in the database for each month. This data is updated monthly, and the data for March 2021 was analysed in this study. This dataset comprised information on variables such as vehicle type, make and model, import status (used/new) and industry class (which industry the vehicle was associated with).

The second dataset used was the new safety features data. This data is collected by new car manufacturers, through a system called MIAMI (Motor Industry Association Incorporated), when a new car is introduced into the fleet. This data only relates to vehicles sold new from recognised distributors within New Zealand and therefore, it does not include any information about used vehicles that were imported from other countries. It must be noted that the information collected in this dataset was voluntary until 2012, after which it was formalised; data from 2014 onwards is known to be complete. Therefore, the data for vehicles registered before 2014 must be interpreted with caution.

The next datasets sourced were from the ANCAP (Australasian New Car Assessment Program) and JNCAP (Japan New Car Assessment Program), which hold the safety ratings for new cars sold in Australia/ New Zealand and Japan, respectively. While the ANCAP data covers a wide range of safety features, the JNCAP data provides information on only two features (AEB and LDW). Therefore, due to the limited amount of information provided, the JNCAP data was not analysed in this study. For each make and model included in the ANCAP dataset, the following four categories are used to describe each safety feature:

- standard (ie the technology is standard for all variants of the make and model)
- standard on some variants (ie the technology is standard on some variants only)
- optional (ie the technology is optional)
- not available.

The ANCAP data provides the most recent status of the vehicle (or its status when the rating was ‘retired’). This means that if a vehicle has been upgraded during its lifetime, the data shows only the latest specification and might not provide the historic information. A limitation of this data is that if a particular technology is labelled as ‘standard on some variants’, it is difficult to identify which variants of the model have the technology and which do not. Therefore, the analysis of this dataset was limited to new vehicles registered in 2020 only and was used to supplement the analysis of the MIAMI dataset (which is relevant only to New Zealand new vehicles and does not contain information on used imported vehicles). Therefore, further assumptions were required for used imported vehicles.

The list of technologies provided in the MIAMI new safety features and ANCAP datasets is presented in Table 4.1.

Table 4.1 List of in-vehicle technology available in each dataset

MIAMI new safety features data	ANCAP data
Autonomous Emergency Braking	• Autonomous Emergency Braking (City, Interurban, VRU, Backover, JunctionAssist)
Blind Spot Monitoring System	• Blind Spot Monitoring System
Lane Keeping Support System	• Lane Departure Warning • Lane Keep Assist • Lane Support System
Reversing Collision Avoidance System	• Reversing Collision Avoidance System
Speed Alert Systems	• Speed Assistance (Intelligent Speed Limiter) • Electronic Data Recorder • Fatigue Reminder • Fatigue Detection • Forward Collision Warning • Alcohol Interlock

Both the ANCAP and MIAMI new safety features data collect information only on light passenger vehicles, including vans, cars, sports SUVs and utility vehicles ('utes'). The analysis of these datasets in the later sections was limited to these vehicles.

Technologies can be added to a vehicle in two ways: fitted to the vehicle during the time of manufacture ('factory-fitted' technologies); or fitted during the lifetime of a vehicle after manufacture ('retrofitted' technologies). Different approaches were used to estimate the prevalence of factory-fitted and retrofitted technologies in the vehicle fleet. Section 4.2 presents the results on factory-fitted technologies and Section 4.3 presents the results on retrofitted technologies.

4.2 Results for factory-fitted technology

The analysis focused on estimating the prevalence of the following seven factory-fitted technologies:

- AEB
- BSM
- FCW
- LKA
- LDW
- RCW
- ISA.

As noted earlier, the MIAMI new safety features data contains information on technology fitted in light passenger vehicles that are sold new in New Zealand and does not include information on used vehicles that are imported from other countries. However, this dataset provided more detailed information on vehicles fitted with technology than the ANCAP dataset. Therefore, the current fitment rates were established through two steps.

The first step was to summarise the MIAMI new safety features data to establish the number of vehicles with technology fitted by year of registration. This was matched to the number of vehicles registered in the fleet by the year of registration, to establish the fitment rate for vehicles sold new in the country.

Next, the ANCAP data was matched to the MVR data, using make and model for vehicles that were registered in 2020 only. The match rate was the highest for vehicles sold new in New Zealand, with roughly 86% of the MVR data matching with the ANCAP data. However, this was much lower for the used imported vehicles, with only 40% of the vehicles matching. Therefore, the analysis was limited to vehicles sold new in New Zealand. The proportion of vehicles where the technology was 'standard' or 'standard in some variants' was estimated. This result was presented along with the results from the MIAMI dataset. However, it must be noted that due to the differences in data collection techniques, there may not be a match between the results of the two datasets.

The fitment rate for used vehicles was estimated by multiplying the fitment rates that applied to new vehicles in the MIAMI dataset for each year of manufacture to the used-vehicle fleet. Supplementary datasets provided by Waka Kotahi late in the project indicated the prevalence of vehicle technologies in domestic vehicles registered in Japan by vehicle type and year of manufacture. These were used to check whether the assumptions were an overestimate or underestimate.

4.2.1 Vehicle registration data

The first step in this part of the work was to explore the vehicle registration data, as of March 2021, to understand what proportion of the data comprised vehicles sold new in New Zealand. This was captured by the import status variable, which presented the status of the vehicle as it arrived in New Zealand. The import status has the following four categories:

- new – ie vehicles sold new in New Zealand
- used – ie used vehicles imported from other countries
- re-registered
- scratch-built.

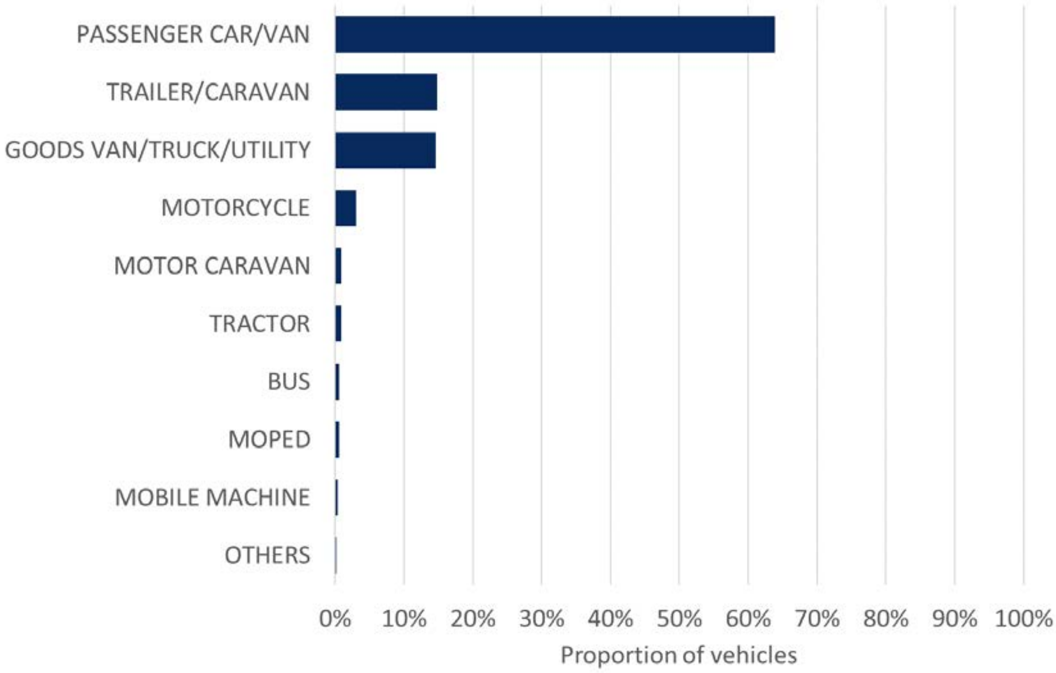
Table 4.2 Distribution of vehicles by import status (for all vehicles registered in New Zealand)

Import status	Number of registered vehicles	Proportion of registered vehicles (%)
New (vehicles sold new in New Zealand)	3,199,539	59
Used (used vehicles imported from other countries)	1,985,389	36
Re-registered	260,868	5
Scratch-built	21,530	0
Total	**5,467,326**	**100**

As shown in Table 4.2, about 59% of the vehicle fleet registered and active in March 2021 was vehicles sold new in New Zealand, and 36% of it was used imported vehicles. Of the used imported vehicles, most (90%) were imported from Japan, 3% from Australia or New Zealand and the remaining from the UK or US.

The distribution of vehicle types in the fleet is shown in Figure 4.1.

Figure 4.1 Distribution of vehicle types in the New Zealand fleet



The majority (around 60%) of the vehicles in the fleet were classified in the MVR as passenger cars or vans. This category included cars, SUVs, passenger vans and utilities. In this report, we used 'light passenger vehicle' to describe this category. The categories of goods van, truck or utility made up roughly 15% of the fleet. Each of the other vehicle types made up less than 10% of the fleet. Other categories included high-speed agricultural vehicle, trailer not designed for highway use, agricultural machine, special purpose vehicle and all-terrain vehicle.

As the ANCAP and MIAMI datasets contained information on light passenger vehicles only, the analysis results presented below refer to light passenger vehicles. Table 4.3 presents the distribution of light passenger vehicles by import status.

Table 4.3 Distribution of light passenger vehicle by import status

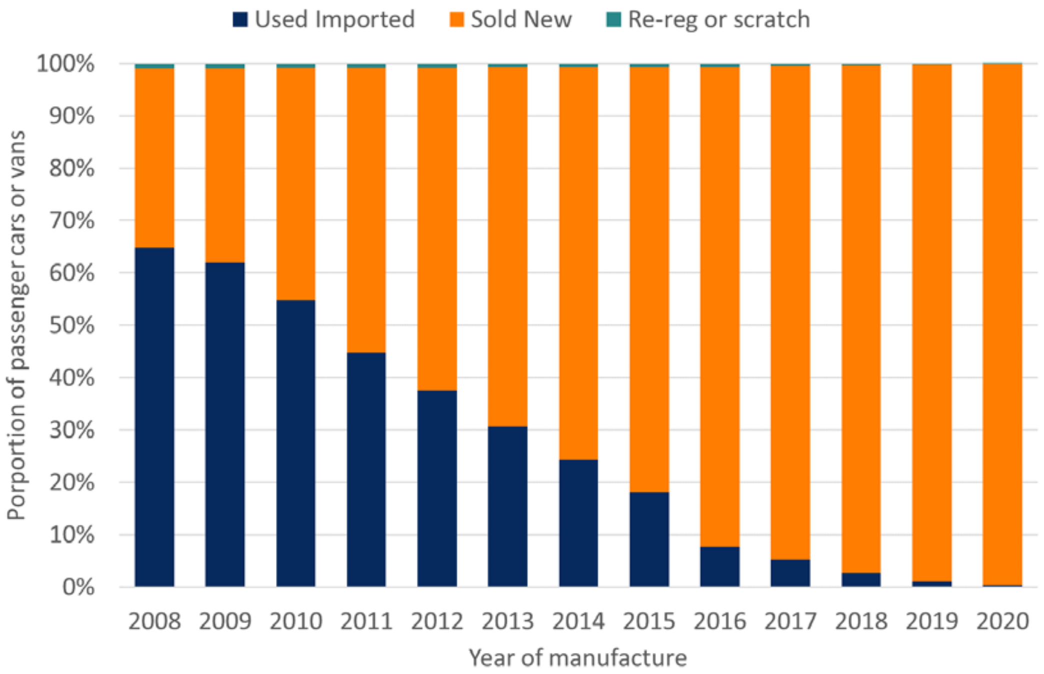
Import status	Number of light passenger vehicles	Proportion of vehicles[a]
New (vehicles sold new in New Zealand)	1,712,444	49%
Used (used vehicles imported from other countries)	1,705,075	49%
Re-registered	72,915	2%
Scratch-built	1,234	0%
Total	**3,491,668**	**100%**

[a] All numbers presented in this analysis have been rounded to the nearest integer.

Half (49%) of the light passenger vehicles in the vehicle fleet were sold new in New Zealand and the other half were used imported vehicles from other countries such as Japan.

The distribution of light passenger vehicles by import status and year of manufacture is shown in Figure 4.2. The figure below presents the trends from 2008 onwards, as most technologies were first available at that point. It does not show the trend for all the vehicles manufactured prior to 2008.

Figure 4.2 Distribution of light passenger vehicles by import status and year of manufacture

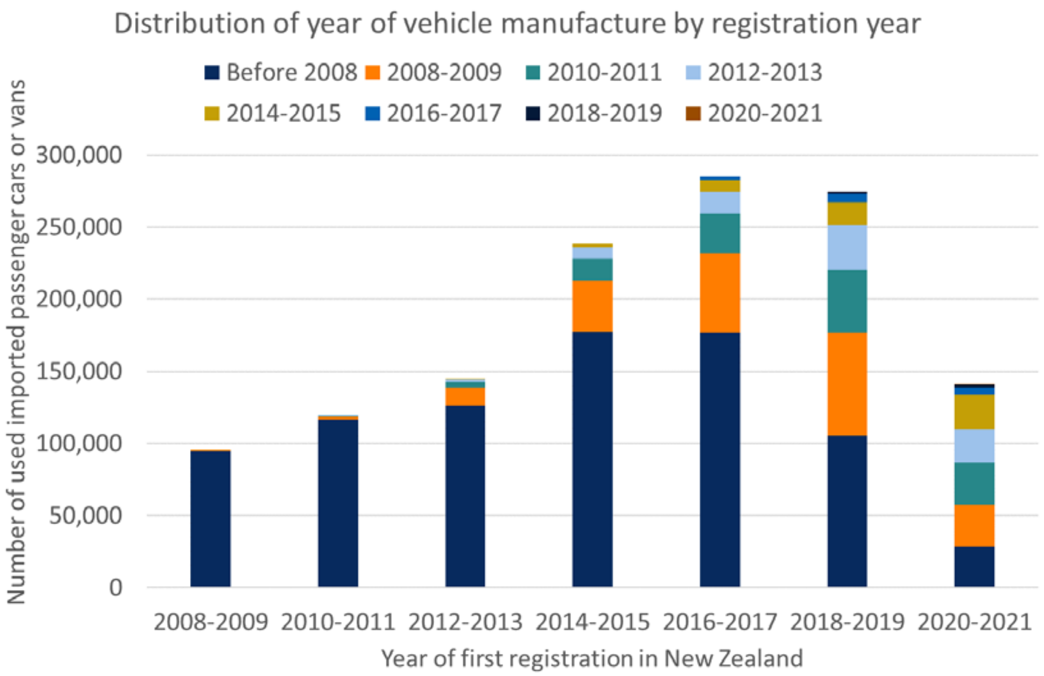


The figure above shows the distribution of light passenger vehicles by import status and year of manufacture for the current fleet (as of March 2021). Of the vehicles manufactured in 2008, roughly 65% were used imports and 35% were vehicles sold new in New Zealand. On the other hand, of the vehicles manufactured in 2017, roughly 90% were sold as new and less than 10% were used imports.

This suggests that light passenger vehicles in New Zealand that were manufactured in the last five years were predominantly sold as new vehicles. As nearly all the technologies were introduced after 2008 and it takes several years for the technologies to penetrate the vehicle fleet, any assumptions currently made for used imported vehicles would only account for a small percentage of the fleet. However, it is expected that the proportion of used imported vehicles manufactured between 2016 and 2020 will increase over time as older vehicles leave the fleet.

Figure 4.3 helps to illustrate this. It shows the distribution of the year of first registration (from 2008 onwards) by year of manufacture.

Figure 4.3 Year of manufacture of used imported light passenger vehicles by year of registration



The figure shows that around 141,000 used imported light passenger vehicles were first registered in New Zealand in 2020 or 2021. Of these, a very small proportion were manufactured after 2015 (meaning the vast majority of used imports first registered in 2020 or 2021 were more than five years old). A similar observation can be made for vehicles registered in 2018 or 2019. Hence, the prevalence of advanced vehicle technologies in these vehicles is likely to be very low.

Next, the distribution of vehicles by year of manufacture was explored. Figure 4.4 shows the distribution of vehicles by age (established through year of manufacture) and import status, and Table 4.4 and 4.5 present the summary statistics.

Figure 4.4 Distribution of vehicles by year of manufacture and import status

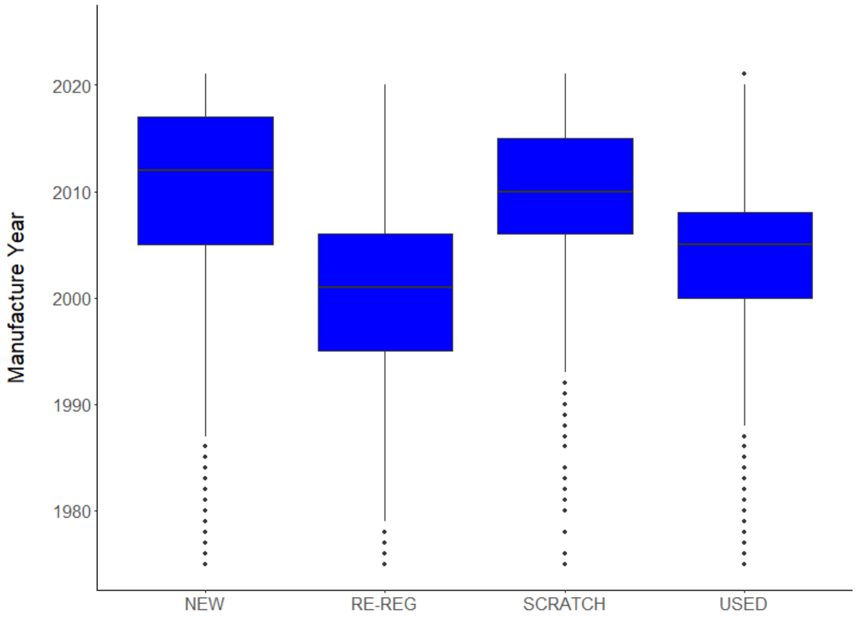


Table 4.4 Summary statistics on age of the light passenger vehicle fleet by import status

Import status	Mean year of manufacture	Median year of manufacture
New (vehicles sold new in New Zealand)	2008	2012
Used (used vehicles imported from other countries)	2003	2005
Re-registered	1987	1996
Scratch-built	2008	2010
Overall	**2006**	**2007**

Overall, the mean age of light passenger vehicles (as of March 2021) was 13 years (year of manufacture being 2008), and the median age was 14 years. Vehicles sold here as new tended to be newer (mean age of 13 years) than used vehicles imported from other countries (18 years). The data relating to year of first registration in New Zealand is shown in Table 4.5.

Table 4.5 Summary statistics on year of first registration in New Zealand by import status

Import status	Mean year of first registration in New Zealand	Median year of first registration in New Zealand
New (vehicles sold new in New Zealand)	2008	2012
Used (used vehicles imported from other countries)	2012	2014
Re-registered	1995	2002
Scratch-built	2009	2010
Overall	**2010**	**2013**

A comparison of Table 4.5 with Table 4.4. suggests that there was no difference between year of manufacture and year of first registration in light passenger vehicles sold new in New Zealand. However, used vehicles were likely to be older when imported into New Zealand.

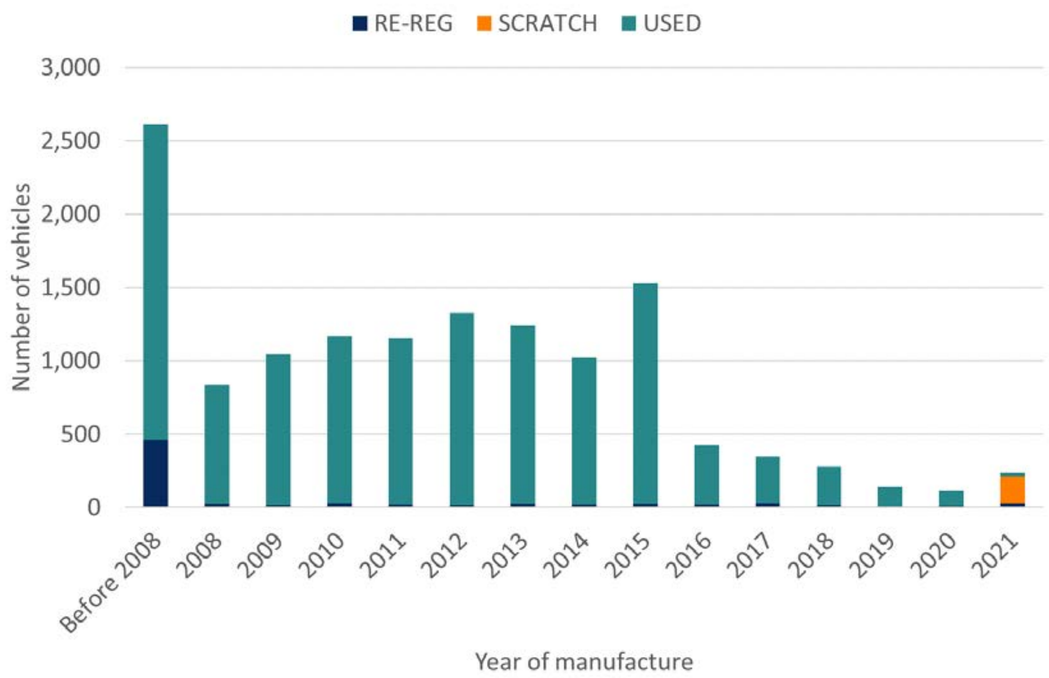
The next set of analysis focused on vehicles that were first registered in New Zealand in March 2021 and examined the distribution of vehicles by year of manufacture and import status.

Table 4.6 Import status of vehicles registered in the month of March 2021 (number and percentage)

Import status	Number of vehicles registered in March 2021	Percentage of vehicles
New (vehicles sold new in New Zealand)	20,560	60
Used (used vehicles imported from other countries)	12,561	37
Re-registered	738	2
Scratch-built	182	1
Overall	**34,041**	**100**

Around 60% of the vehicles registered in March 2021 were new and 37% were used imports. It must be noted that all the 20,560 vehicles sold as new in March 2021 were manufactured in 2021. The next figure shows the distribution of the other vehicles by year of manufacture and import status.

Figure 4.5 Distribution of used imported, re-registered and scratch-built light passenger vehicles by year of manufacture



The majority of the used imported vehicles registered in 2021 were manufactured prior to 2015. Around 2,000 of the used imported vehicles (roughly 17%) were manufactured prior to 2008. About 0.2% of the used imported vehicles registered in March 2021 were actually manufactured in 2021.

4.2.2 Summary of results

Table 4.7 presents the estimated prevalence of factory-fitted technologies within the light passenger vehicle fleet active in New Zealand, as of March 2021. The sections below cover the methodology and analysis conducted to obtain these results. Data from 2021 was removed from the analysis because the data for that year was incomplete.

The proportion of light passenger vehicles with a given technology was first estimated for light passenger vehicles sold new in New Zealand (ie where import status in MVR data is new), using the MIAMI dataset. This is explained in greater detail in the next sections. That proportion was then applied to used light passenger vehicles imported from other countries (ie the import status in MVR data is used) to estimate the proportions for the entire fleet. This initially assumed that for a given year of manufacture, the fitment rate for used imported vehicles was the same as the fitment rate for newly sold vehicles. The analysis was also updated using data on the proportions of vehicles with the technology in Japan, where available. However, due to the smaller number of used imported vehicles in the fleet manufactured in the last five years, the results remained unchanged. This is explained in greater detail in the later sections.

Table 4.7 Summary of technology prevalence for light passenger vehicles sold new in New Zealand

Technology	First available	Proportion of the 80,505 light passenger vehicles sold new in New Zealand first registered in 2020 with each technology	Proportion of the 1,683,947 light passenger vehicles sold new in New Zealand currently in the fleet with each technology	Assumed proportion of 3,463,157 light passenger vehicles in the total New Zealand fleet with each technology
Autonomous Emergency Braking	2009	91% (72,945)	18% (299,400)	**9% (311,569)**
Blind Spot Monitoring	2008	63% (50,574)	16% (269,901)	**9% (294,704)**
Lane Keep Support System	2009	87% (69,810)	18% (296,182)	**9% (308,131)**
Reversing Collision Avoidance System	2005	69% (55,807)	25% (423,886)	**14% (498,236)**
Speed Alert Systems (ISA)	2008	12% (9,533)	2% (41,709)	**1% (49,035)**

The table above shows that around 91% of light passenger vehicles sold new in New Zealand and first registered in 2020 were fitted with AEB. However, only 10% of all light passenger vehicles sold new in New Zealand were fitted with this technology.

The results suggest that although a considerably large proportion of light passenger vehicles registered in 2020 were fitted with each technology, the proportion of light passenger vehicles sold new and fitted with the technology was much lower when considering the overall fleet as of March 2021. This is mainly because the mean age of the light passenger vehicles within the fleet was considerably older.

The sections below present the method and results for each technology, by year of vehicle manufacture, to allow visualisation of trends over time. However, due to the limitations around each dataset, most of the analysis was based on the MIAMI new safety features dataset. The ANCAP dataset was used as a secondary data source to supplement the analysis.

4.2.3 Estimating prevalence for new vehicles imported into New Zealand

The MIAMI new safety features dataset was used to estimate the prevalence rate of the technologies. The prevalence for light passenger vehicles sold new was determined by calculating the following equation:

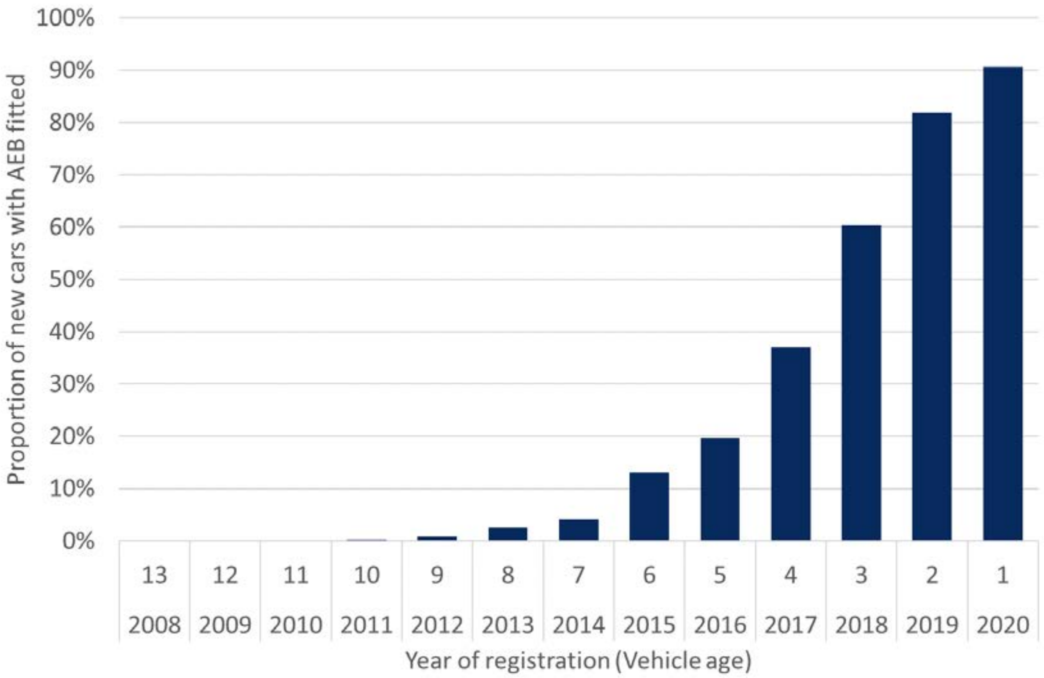
$$\mathit{Proportion\ of\ LPVs^{2}\ sold\ new\ with\ technology\ fitted} = \frac{\mathit{Number\ of\ LPVs\ with\ technology\ fitted\ by\ year\ of\ registration}}{\mathit{Number\ of\ LPVs\ registered\ in\ the\ fleet\ by\ year\ of\ registration}} \quad \text{(Equation 4.1)}$$

The number of light passenger vehicles (sold new in New Zealand) with the given technology was calculated from the MIAMI dataset, and the number of vehicles registered (with an import status of new) was calculated from the MVR registration dataset. It must be noted that the data for 2021 was not complete, as it presented vehicles registered up to March 2021; therefore, it was removed from the analysis.

Due to the limitation around identifying vehicles with technology fitted in the ANCAP data, the analysis was limited to vehicles where the technology was fitted as 'standard only'. Furthermore, this dataset did not provide complete historic information and therefore, it was used to estimate fitment for light passenger vehicles registered in 2020. This analysis supplemented the analysis of the MIAMI dataset and was likely to be an underestimate of true fitment rate.

Figure 4.6 presents the prevalence of AEB by vehicle age.

Figure 4.6 Proportion of light passenger vehicles sold new with AEB fitted (estimated from MIAMI and MVR data)



From when it was first introduced in 2009, the number of light passenger vehicles with AEB fitted increased substantially by year of manufacture. About 90% of light passenger vehicles registered in 2020 and sold as new were fitted with AEB. However, when looking at the proportion across the entire light passenger vehicle

[2] LPV = light passenger vehicle

fleet in New Zealand, by the end of 2020 only 18% of light passenger vehicles sold as new in the fleet were fitted with AEB.

The ANCAP dataset split AEBs into five separate technologies:[3] AEB City, AEB Interurban, AEB VRU,[4] AEB Backover and AEB Junction Assist. It must be noted that 14% of the MVR data did not match with the ANCAP data, so it is possible that the proportions presented are a slight underestimate. The proportion of light passenger vehicles registered in 2020 and fitted with these technologies as 'standard' is shown in Table 4.8.

Table 4.8 Proportion of cars registered in 2020 fitted with AEB as 'standard'

Technology type	Proportion of light passenger vehicles registered in 2020 with technology fitted as 'standard'
AEB City	51%
AEB Interurban	51%
AEB VRU	41%
AEB Backover	0%
AEB Junction Assist	2%

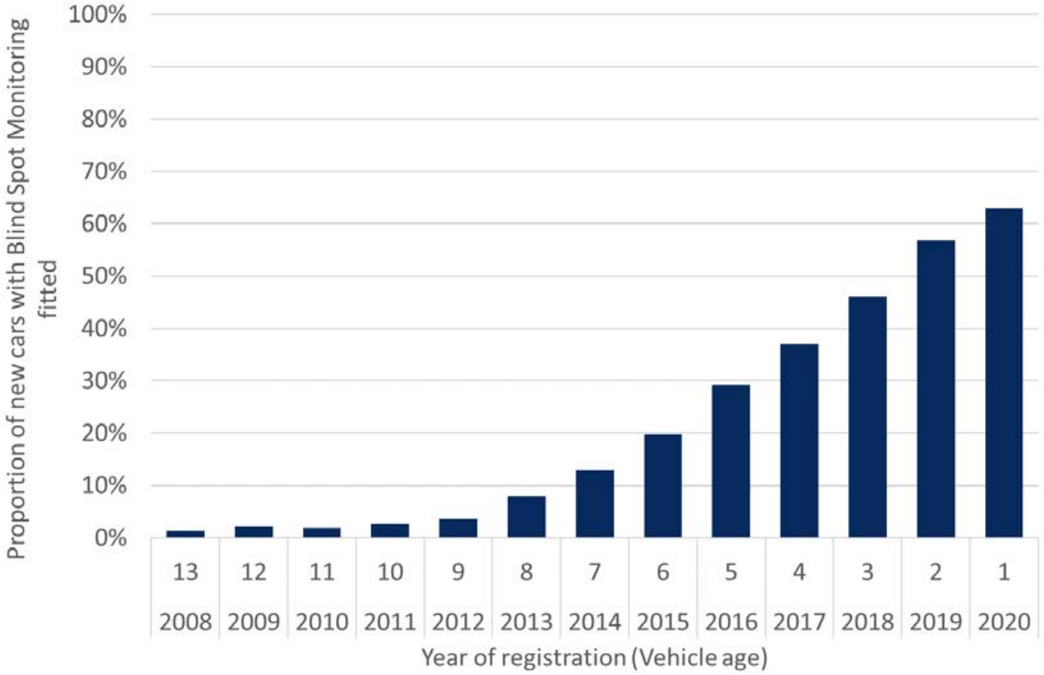
As per the ANCAP data, AEB City and AEB Interurban were more common, with roughly 50% of light passenger vehicles manufactured in 2020 being fitted with these technologies. AEB Backover and Junction Assist were much less common, with less than 2% of light passenger vehicles manufactured and sold new in 2020 being fitted with this technology. It must be noted that these proportions may not necessarily match with the MIAMI dataset, as this analysis did not include ANCAP vehicle make and models where the technology was fitted in some variants only, and there is a potential for overlap in categories where some vehicles could have more than one type of AEB fitted.

Figure 4.7 presents the prevalence of BSM by vehicle age.

[3] AEB City – Effective at lower speeds (usually in an urban environment); AEB Interurban – Effective at highway speeds; AEB VRU – Effective for collisions between vehicles and pedestrians or pedal cyclists in city environments; AEB Backover – Effective at reverse auto-braking; AEB Junction Assist – Effective at detecting risk of collision when turning at intersections.

[4] VRU usually includes pedestrians and pedal cyclists.

Figure 4.7 Proportion of light passenger vehicles sold new with BSM fitted (estimated from MIAMI and MVR data)

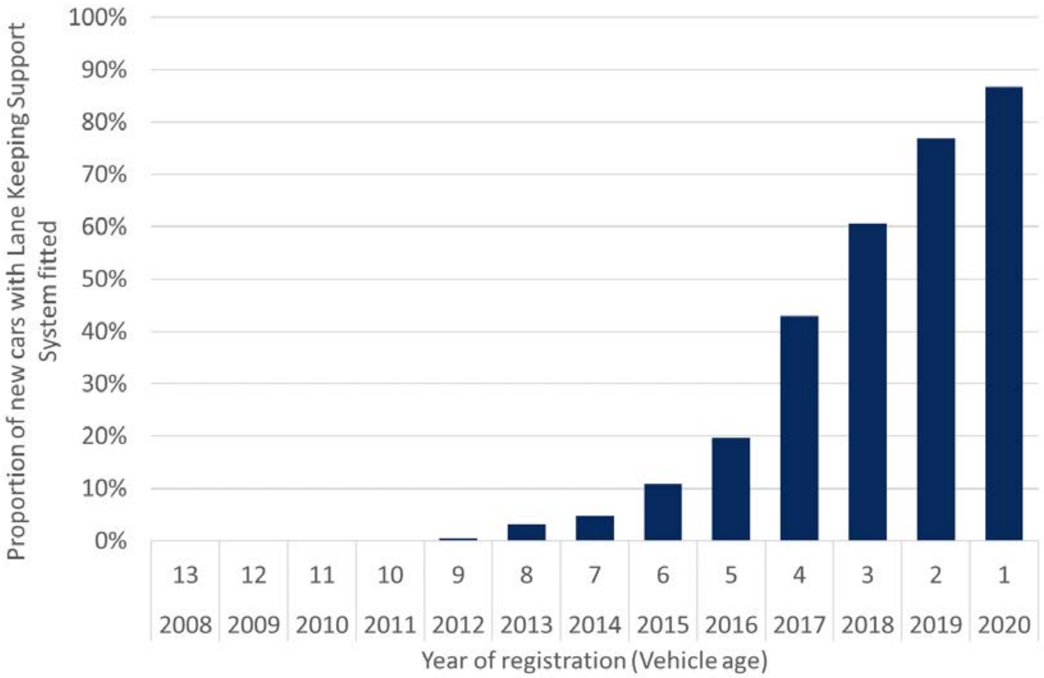


From when it first became available in 2008, about 16% of light passenger vehicles sold new in New Zealand were fitted with BSM by 2021. When looking at the distribution by year of manufacture (or vehicle age), around 60% of new light passenger vehicles registered in 2020 were fitted with this technology.

Next, the ANCAP dataset was analysed to find the proportion of light passenger vehicles where BSM systems were fitted in the vehicle as ‘standard’. The analysis showed that roughly 26% of light passenger vehicles registered in 2020 were fitted with BSM as ‘standard’. This result was different to the one seen from the MIAMI dataset (see Figure 4.7). This could be due to multiple reasons, such as differences in data collection and reporting of technology between the ANCAP and MIAMI data or under-reporting from the ANCAP analysis due to non-matches to the MVR data. Furthermore, the result from the ANCAP data only included vehicles where the technology was fitted as ‘standard’ and did not include vehicles where it was fitted as ‘standard on some variants’. This could have led to under-reporting, as there could have been a large number of vehicles that were fitted with BSM but only on some variants of the vehicle type.

The MIAMI new safety features data did not include LKA and LDW. It did, however, include data on Lane Keeping Support System. The proportion of passenger light passenger vehicles sold new and fitted with a Lane Keeping Support System is shown in Figure 4.8.

Figure 4.8 Proportion of light passenger vehicles sold new with Lane Keeping Support System fitted (estimated from MIAMI and MVR data)

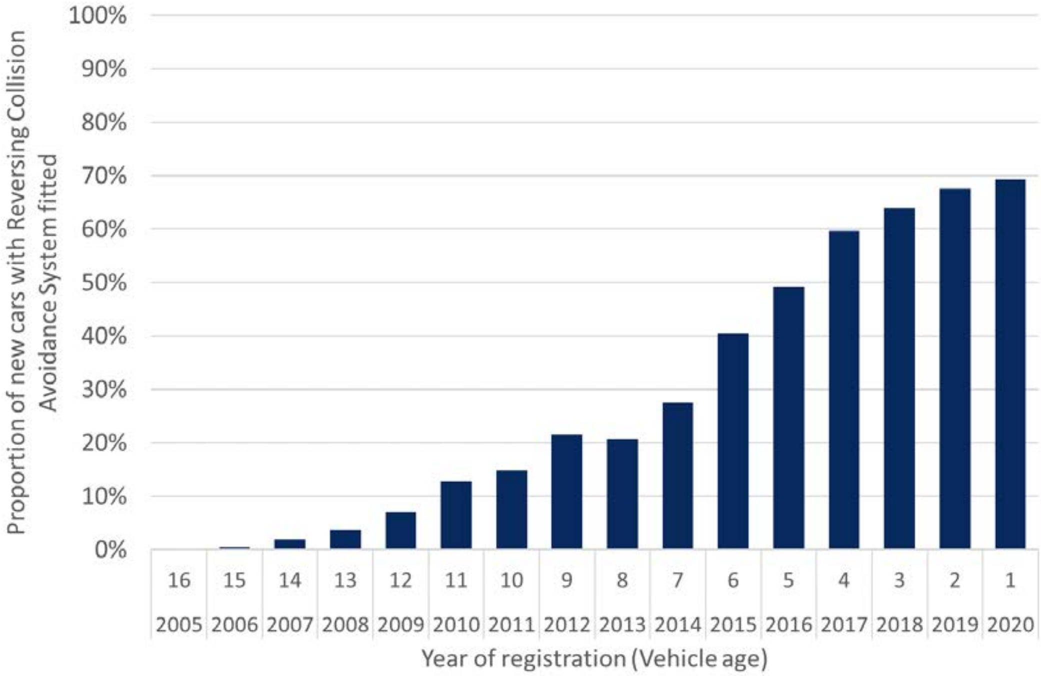


Since the availability of this technology, around 18% of light passenger vehicles sold new in New Zealand since 2009 and still active in the vehicle fleet (as of March 2021) were fitted with Lane Keeping Support System. The distribution by vehicle age shows that the proportion of new light passenger vehicles fitted with this technology increased substantially each year. Close to 90% of light passenger vehicles registered in 2020 were fitted with Lane Keeping Support System.

The ANCAP dataset provided information for LKA and LDW. Analysis of the ANCAP dataset showed that around 35% and 40% of light passenger vehicles registered in 2020, respectively, were fitted with LKA and LDW as ‘standard’. As explained previously, there could be a number of reasons for the results from the ANCAP data not matching the results from the MIAMI new safety features dataset.

Next, the distribution of light passenger vehicles fitted with Reversing Collision Avoidance System is shown in Figure 4.9.

Figure 4.9 Proportion of light passenger vehicles sold new with Reversing Collision Avoidance System fitted (estimated from MIAMI and MVR data)

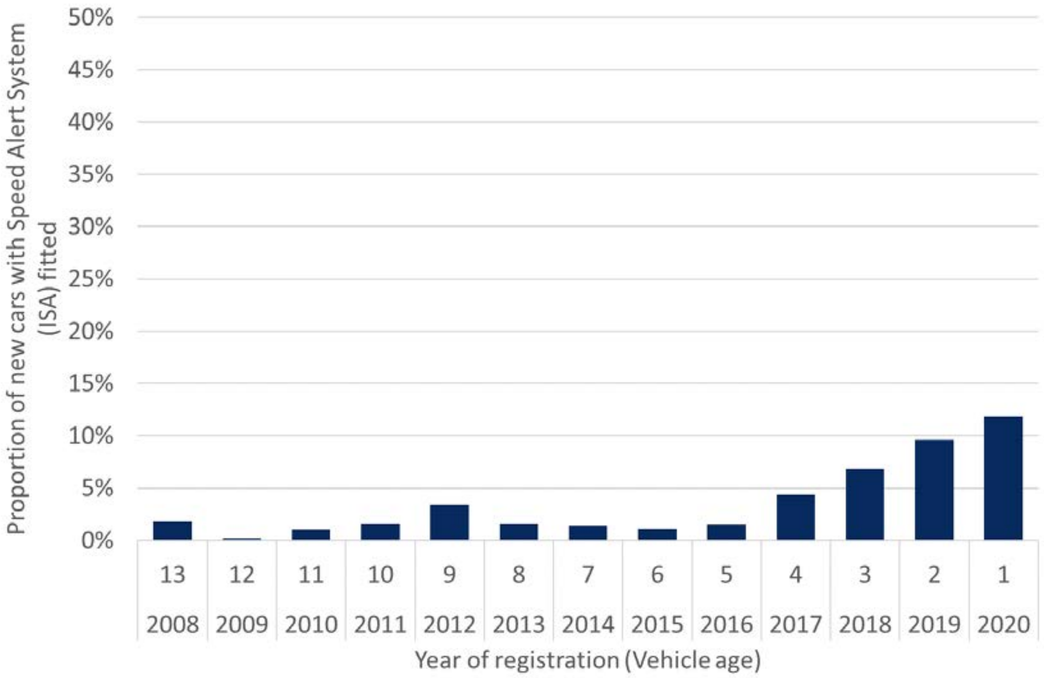


Around 25% of light passenger vehicles manufactured in New Zealand were fitted with Reversing Collision Avoidance System by the end of 2020. When looking at the distribution by vehicle age, the proportion of new vehicles with the technology fitted increased as the vehicle age decreased. Roughly 70% of new vehicles manufactured in 2020 were fitted with this technology.

Analysis of the ANCAP dataset matched the MIAMI dataset and showed that around 70% of new light passenger vehicles manufactured in 2020 were fitted with Reversing Collision Avoidance as a ‘standard’. This result matches with the results from the MIAMI dataset. This is potentially because most vehicles with Reversing Collision Avoidance System are recorded as ‘standard’, rather than ‘optional’ or ‘standard on some variants’.

The distribution for Speed Alert System (or ISA) is shown in Figure 4.10.

Figure 4.10 Proportion of light passenger vehicles sold new with Speed Alert System (or ISA) fitted (estimated from MIAMI and MVR data)



Since its introduction in 2008, by 2020 around 2% of light passenger vehicles in the fleet were fitted with a Speed Alert System (or ISA). The distribution by vehicle age shows that the prevalence of this technology is relatively low in the fleet and only 12% of new light passenger vehicles registered in 2020 were fitted with ISA.

The MIAMI dataset did not include information on FCW. Analysis of the ANCAP dataset showed that around 40% of light passenger vehicles registered in 2020 were fitted with FCW as a 'standard' feature. This suggests that the true fitment rate of this technology is likely to be higher.

4.2.4 Estimating prevalence for the entire light passenger vehicle fleet

Section 4.2.2 presented the estimated fitment rate for vehicles sold new in New Zealand by year of registration. However, the MVR data showed that around half of the light passenger vehicle fleet consisted of used imports from other countries (see Table 4.3). Therefore, the fitment rate for the entire light passenger vehicle fleet was estimated by multiplying the fitment rates that applied in each year of manufacture for new vehicles in the MIAMI dataset to used vehicles with the same year of manufacture.

Japan's domestic vehicle technology data from 2006 to 2018[5] was provided to check the validity of the assumption that fitment rates (by year of manufacture) were the same for both used and new imported vehicles. The dataset provided the number of vehicles equipped with each technology of interest and the total number of vehicles that were manufactured in each year. It must be noted that this dataset did not provide information on vehicles currently within the Japan fleet and therefore, it is slightly different from the New Zealand dataset.

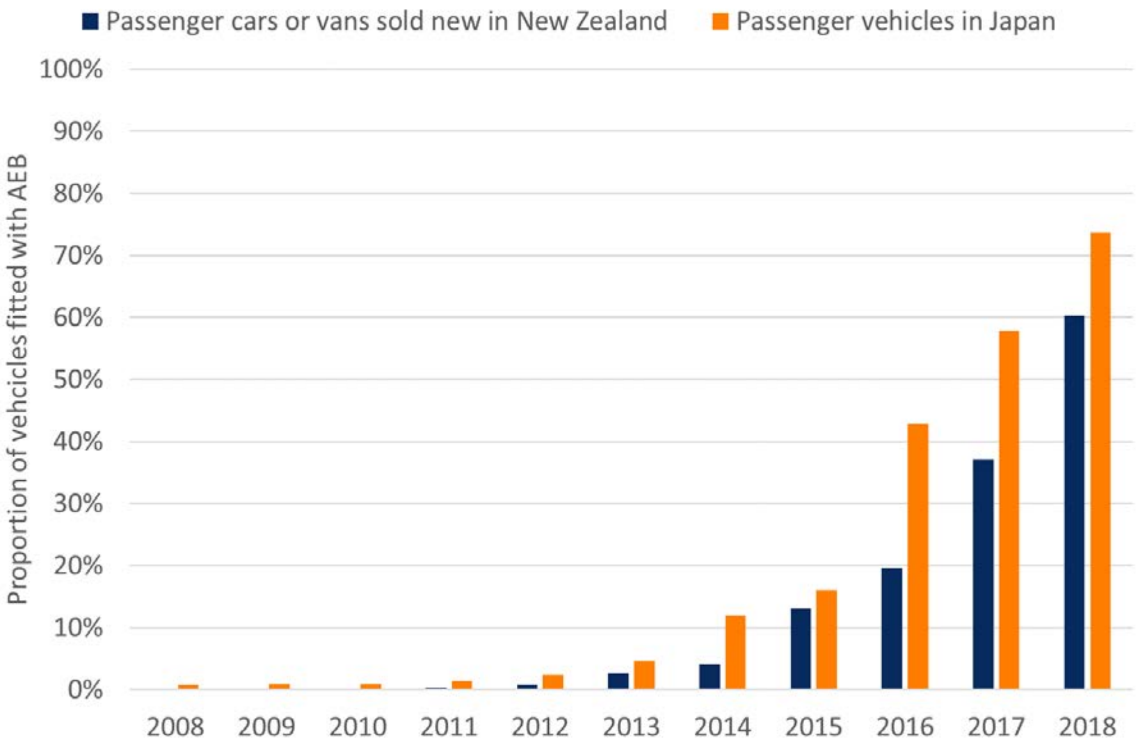
[5] Personal communication from Waka Kotahi.

The Japan dataset provided information on the following three technologies of interest in this study:

- AEB (labelled as Forward Collision-Mitigation Braking System in the Japan dataset) from 2006 to 2018
- LKS (labelled as Lane Keep Assistance System in the Japan dataset) from 2006 to 2018
- Reversing Collision Avoidance System (labelled as Reversing Collision-Mitigation System or Rear-Collision-Mitigation Braking System) from 2015 to 2018.

Figure 4.11 compares the proportion of vehicles with AEB fitted in the two datasets, by year of manufacture.

Figure 4.11 Comparison of vehicles with AEB fitted in New Zealand and Japan



The analysis above suggests that a higher proportion of vehicles produced in Japan were fitted with AEB compared with those sold as new in New Zealand.

The fitment rate for the entire light passenger vehicle fleet is shown in Table 4.9. For the two technologies (AEB and LKS), where data was available from 2008, the fitment rates for used imported vehicles follow the distribution seen in the Japan dataset. Used imported vehicles comprised a very small proportion of the light passenger vehicles in New Zealand that were manufactured in the last five years (as shown in Figure 4.2). Because of this, the overall estimated fitment rates remained unchanged if used imported vehicles were assumed to follow the same distribution as sold as new vehicles, by year of manufacture. For all other technologies, the fitment rates for imported light passenger vehicles were assumed to be the same as those sold as new in New Zealand for the same year of manufacture. The numbers for the entire light passenger vehicle fleet may be slightly different from the numbers for light passenger vehicles sold as new, as it applies the proportion to the overall fleet, including the re-registered and scratch-built light passenger vehicles, which accounted for less than 2% of the entire fleet.

Table 4.9 Prevalence of technologies in the New Zealand car fleet

Technology	Proportion of light passenger vehicles sold as new in New Zealand with technology	Assumed proportion of fleet with technology
AEB	18%	9%
BSM	16%	9%
LKS	18%	9%
Reversing Collision Avoidance System	25%	14%
Speed Alert Systems (ISA)	2%	1%

Table 4.9 shows the estimated proportion of light passenger vehicles in the fleet with each technology fitted, assuming that the used imported vehicles had the same fitment rate as those sold new in New Zealand by year of manufacture and followed similar trends as shown in the figures above. However, it is possible that this assumption was an overestimate or underestimate. Analysis of the MVR data showed that around 90% of used light passenger vehicles were imported from Japan.

Limited information was available on fitment rates in Japan by technology type, as the JNCAP data only covered two of the technologies of interest. Research showed that in 2018, around 85% of new light passenger vehicles in Japan were fitted with AEB (Brake Report, 2019). Comparing this statistic with New Zealand data (see Figure 4.4) suggests that the fitment rate might be slightly higher in Japan. Therefore, the assumption above could be a slight underestimate for AEB. Used imported vehicles are much older when they are first registered in Japan; therefore, the assumed proportion of the light passenger vehicle fleet with technology is lower than the proportion for newly sold light passenger vehicles in New Zealand.

4.3 Results for retrofitted technology

The prevalence of the following retrofitted technologies was analysed in this study:

- DMS
- FMT
- AIS
- EWDs/ELs.

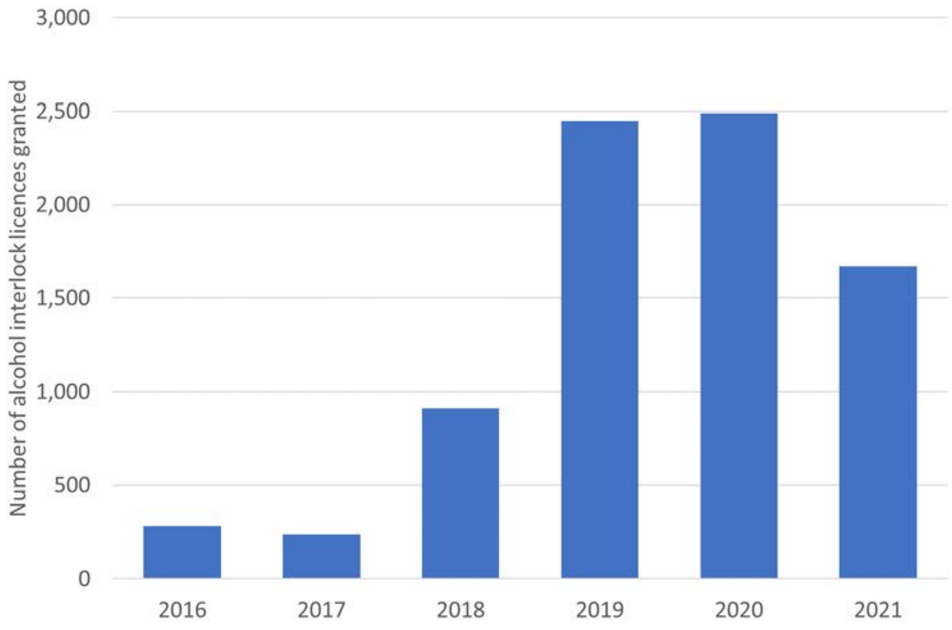
As the name suggests, retrofitted technology could be fitted to the vehicle at any point during its lifetime and therefore, it was not possible to estimate prevalence using the MIAMI or the ANCAP datasets. In this study, a combination of qualitative and quantitative approaches was used to estimate the fitment rates for these technologies.

AISs are more likely to be installed in light passenger vehicles because of driving offences involving alcohol, rather than for other reasons. Therefore, it is likely that the true fitment rate for this technology is extremely low and depends on the number of alcohol-related driving offences across the country.

Although the ANCAP did not provide actual fitment rates, it could provide some information on whether the vehicle had the technology to allow for AISs to be fitted. Analysis suggested that 86% of cars sold new in 2020 included the technology to enable AIS fitment as a standard in some variants. While this was a high proportion, it did not provide a complete picture of how many vehicles were actually fitted with an AIS. Next, alcohol interlock licence data from 2016 to 2021 was explored to understand fitment rates in greater detail.

An alcohol interlock licence allows the holder to drive a vehicle that is fitted with an approved alcohol interlock device and this must be held for at least 12 months before the holder can exit the alcohol interlock programme (Waka Kotahi, 2022). The licence is not specific to a particular vehicle type and can only be granted when all requirements to obtain this licence are met. Furthermore, some applicants might need to pass additional theory and practical tests to obtain an alcohol interlock licence. Alcohol interlock sentences became mandatory from July 2018. The number of licences granted or partially granted are shown in Figure 4.12.

Figure 4.12 Number of alcohol interlock licences granted or partially granted (estimated from alcohol interlock licence data)



A total of 8,037 alcohol interlock licences were granted between 2016 and 2021.

Most of the other technologies, mainly DMS, FMT and EWDs/ELs, were more likely to be fitted in commercial vehicles used for businesses. Market research conducted in Australia and New Zealand showed that the number of fleet management systems was forecast to grow from 1 million units in 2019 to over 1.8 million units by 2024 (Research and Markets, 2021). Furthermore, the fitment rate within the commercially owned vehicles in the fleet was estimated to increase from 19.5% in 2019 to 33.7% in 2024. Thus, it was likely that approximately 24% of commercial vehicles would have some FMT installed. Additionally, one industry group participant from New Zealand suggested that about 40% of the heavy-vehicle fleet that is involved with long-distance driving is fitted with EWDs/ELs.

Research conducted by service provider EROAD (personal communication) suggested that around 200,000 vehicles (including 20,000 LCVs) had at least one of the three technologies – FMT, DMS or EWD – installed.

The ANCAP dataset had some information around fitment for fatigue reminders and fatigue detection systems (DMSs). Analysis showed that around 31% of new light passenger vehicles in 2020 were fitted with either of these technologies as 'standard'.

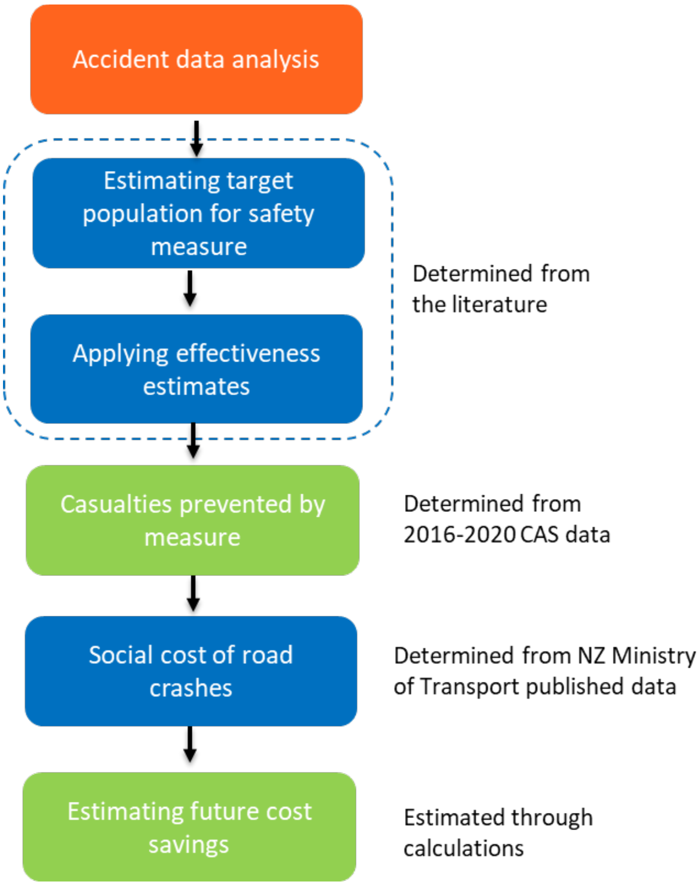
5 Analysis of crash data and potential crash savings

Collision data from New Zealand's Crash Analysis System (CAS) from 2016 to 2020 was analysed to determine the number of casualties or collisions that may have been prevented if vehicles had been fitted with each of the technologies. This section outlines the method followed to determine the number of casualties prevented and the corresponding cost savings. The method is explained in Section 5.1 and the results are presented in Section 5.2.

5.1 Method

The method for estimating the number of casualties that would have been prevented by a particular technology and consequently, the estimated cost saving associated with this, is shown in Figure 5.1.

Figure 5.1 Method to estimate number of casualties and cost savings associated with a given technology



5.1.1 Target population and effectiveness estimate

The first step was to estimate the target population from the 2016 to 2020 collision data. The target population represented the number of casualties that satisfied the collision criteria defined for a given technology. These were split by vehicle type; for instance, the target population for cars (as a primary vehicle type) was the number of casualties identified in collisions that could have been prevented if *all* light passenger vehicles had been fitted with the technology. A vehicle type was a 'primary vehicle type' of a collision if that collision could have been prevented by *that vehicle type* being fitted with the technology. For some technologies, the target population was identified at the collision level, as information at the casualty level was not present in the literature.

It must be noted that the target population did not represent the number of casualties (or collisions) that would have been prevented had the technology been fitted; this would only happen if the technology was 100% effective. The target population represented only the subset of casualties that could have been prevented if the technology had been present. While these would have been taken into consideration as part of the net effects on crashes for those studies that examined the effects of the technologies on crashes, the longer-term effects (eg a reduction in effectiveness over time) may not have been accounted for. Next, effectiveness estimates were applied to the target population for each technology. As the name suggests, 'effectiveness estimates' describe the likely effectiveness of each technology in preventing the casualty (or mitigating the severity of the casualty). In New Zealand, effectiveness estimates are also referred to as 'crash modification factors'.

The effectiveness estimates and the target population were determined from the literature review (see Chapter 2). Most of the effectiveness estimates were derived from Seidl et al.'s work for the European Commission (2018), as their comprehensive study presented well-researched data for most of the technologies of interest. In their work, the confidence estimates (low, medium, high) were based on the quality of the source.

A summary of the target populations and sources for the effectiveness estimates is presented in Table 5.1. The specific criteria that were used to extract these target populations from the CAS data is given in Appendix E. The effectiveness estimates at the casualty level and collision level are given in Table 5.2 and Table 5.3, respectively.

Table 5.1 Target population and source of the effectiveness estimates (or crash modification factors) for each technology

Technology	Abbrev.	Vehicle type(s)	Target population	Source
Automated Emergency Braking (vehicle to vehicle)	AEB-V2V	• Passenger cars • Buses, coaches • Vans • Trucks	Casualties in two-motor-vehicle (excluding powered two-wheelers) front-to-rear collisions	Seidl et al. (2018)
Automated Emergency Braking (vehicle to cyclist)	AEB-V2C	• Passenger cars • Vans	Cyclist casualties in impact with vehicle front	Seidl et al. (2018)
Automated Emergency Braking (vehicle to pedestrian)	AEB-V2P	• Passenger cars • Vans	Pedestrian casualties in impact with vehicle front	Seidl et al. (2018)
Forward Collision Warning	FCW	• Passenger cars • Trucks	Cars: casualties in two-motor-vehicle rear-end-striking collisions Trucks: casualties in front-to-rear collisions	Cars: Cicchino (2017) Trucks: Perez (2020)

Technology	Abbrev.	Vehicle type(s)	Target population	Source
(Emergency) Lane Keep Assist	(E) LKA	• Passenger cars • Vans	Casualties in head-on and single-vehicle crashes on roads with speed limits between 70 km/h and 120 km/h, and dry or wet surfaces (ie not covered by ice or snow)	Seidl et al. (2018)
Lane Departure Warning	LDW	• Buses, coaches • Trucks	Casualties in head-on, side-swipe and single-vehicle collisions where the vehicle of interest leaves its lane	Seidl et al. (2018)
Intelligent Speed Assist (Voluntary)	ISA (V)	• Passenger cars • Buses, coaches • Vans • Trucks	Casualties in collisions where the driver exceeding the speed limit contributed to the collision and there were no other contributory factors that indicated poor compliance[6] of the driver with the law (eg being impaired by alcohol/drugs, having uncorrected eyesight, using mobile phone, stolen vehicle, etc)	Seidl et al. (2018)
Rear Collision Warning (camera-based)	RCW	• Passenger cars • Buses, coaches • Vans • Trucks	Pedestrian and cyclist casualties caused by a reversing motor vehicle	Seidl et al. (2018)
Driver Drowsiness and Attention Warning	DDAW	• Passenger cars • Buses, coaches • Vans • Trucks	Casualties in collisions where drowsiness or long-lasting inattention/distraction contributed to the collision	Seidl et al. (2018)
Advanced Driver Distraction Warning	ADDW	• Passenger cars • Buses, coaches • Vans • Trucks	Casualties in collisions where drowsiness or long-lasting or short-term inattention/distraction contributed to the collision	Seidl et al. (2018)
Fleet Management Telematics	FMT	• Vans • Trucks	All casualties in collisions involving a commercial vehicle of primary type	Quayle & Forder (2008); Wouters & Bos (2000)
Alcohol Interlock Systems	AIS	• Passenger cars • Buses, coaches • Vans • Trucks	Casualties in collisions where the driver being impaired by alcohol contributed to the collision	Estimate based on Seidl et al.'s (2018) approach
Electronic Logbooks (Work Diaries)	ELs/EWDs	• Trucks	All casualties in collisions involving a commercial truck	Cantor et al. (2009)
Blind Spot Monitoring	BSM	• Trucks	Merging and side-swipe collisions	Krum et al. (2019)

[6] Factors identified in the CAS data indicating poor compliance are given in Appendix F.

Table 5.2 Effectiveness estimates by vehicle type and casualty severity

Technology	Vehicle types	Effectiveness estimates by severity (casualty level)[a]					Confidence
		Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Minor (avoid)	
AEB-V2V	• Passenger cars • Vans	19%	19%	19%	19%	42%	High
AEB-V2V	• Buses, coaches • Trucks	0%	25%	0%	25%	5%	Low
AEB-V2C	• Passenger cars • Vans	27.5%	27.5%	16%	16%	33%	High
AEB-V2P	• Passenger cars • Vans	24%	24%	21%	21%	42%	High
FCW	• Passenger cars	20%	0%	20%	0%	20%	Low
(E) LKA	• Passenger cars • Vans	53%	0%	38.5%	0%	38.5%	High
LDW	• Buses, coaches • Trucks	20%	0%	20%	0%	20%	Low
ISA	• Passenger cars • Vans	19%	7%	19%	8%	19%	High
ISA	• Buses, coaches • Trucks	9%	9%	1.5%	17%	20%	High
RCW	• Passenger cars • Vans	41%	0%	41%	0%	41%	High
RCW	• Buses, coaches • Trucks	33%	0%	33%	0%	33%	Low
DDAW	• Passenger cars • Buses, coaches • Vans • Trucks	17%	0%	17%	0%	17%	Low
ADDW	• Passenger cars • Buses, coaches • Vans • Trucks	17%	0%	17%	0%	17%	Low
AIS	• Passenger cars • Buses, coaches • Vans • Trucks	13%	0%	13%	0%	13%	Low

[a] All numbers have been rounded to the nearest 0.5%.

Table 5.3 Effectiveness estimates by vehicle type and collision severity

Technology	Vehicle types	Effectiveness estimates by severity (collision level)[a]							Confidence
		Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Minor (avoid)	Minor (mitigate)	Damage only (avoid)	
FCW	• Trucks	20%	0%	20%	0%	20%	0%	20%	Low
FTS	• Vans • Trucks	20%	0%	20%	0%	20%	0%	20%	Low
EL	• Trucks	15.5%	0%	15.5%	0%	15.5%	0%	15.5%	Low
BSM	• Trucks	40%	0%	50%	0%	50%	0%	50%	Low

[a] All numbers have been rounded to the nearest 0.5%.

Considering the four vehicle types listed above separately was convenient for the analysis, as most effectiveness estimates were given in this way. Table 5.4 shows the way these vehicle types were identified in the CAS data.

Table 5.4 Categories in the CAS data corresponding to each vehicle type

Vehicle types	CAS data vehicle category
Passenger cars	Car/Wagon, SUV
Buses, coaches	Bus
Vans	Van, Ute
Trucks	Truck, Truck HPMV, 50MAX[7]

The following subsections outline the important assumptions and caveats regarding the effectiveness estimates and the extraction of the associated target populations from the CAS data.

5.1.2 Autonomous Emergency Braking

In the absence of a field indicating the first point of impact, movement codes were used to determine the target population (the ‘damage area’ variable was not a suitable replacement for the ‘impact’ field in cyclist and pedestrian collisions, where vehicle damage can be minimal or non-existent). For vehicle-to-cyclist AEB, only collisions with movement codes showing that it was highly likely that the front of the vehicle collided with the cyclist were included. For vehicle-to-pedestrian AEB, all collisions with pedestrian movement codes were included, whether the vehicle colliding with the pedestrian(s) was moving forwards or the vehicle movement was not given. It was assumed that most of these collisions involved the vehicle front colliding with the pedestrian.

5.1.3 Forward Collision Warning

For passenger cars, the 20% estimate from the source applied to all crashes involving injuries. This estimate was split across all casualty severity levels.

[7] 50MAX trucks are a relatively new generation of trucks that are slightly longer than standard 44 tonne trucks. They have an additional axle and can weigh up to 50 tonnes.

For trucks, a 31% estimate was given for FCW when combined with other technologies. By considering the overall effectiveness of the other technologies and FCW (19%) across all collision types, the estimate was reduced to 20% for FCW only.

5.1.4 Lane Keep Assist

On expert opinion, single-vehicle crashes with movement codes indicating that the vehicle came off the road on a bend or whilst turning were not included. This is because the assistance provided by this system is unlikely to prevent a vehicle from leaving the roadway in these circumstances, particularly on tight bends.

5.1.5 Lane Departure Warning

The target population was identified using movement codes that strongly indicated the vehicle leaving its lane. Whilst these collisions were compatible with the target population description, the general nature of some of the codes could be reflected in the comparatively high number of casualties identified for this technology – most were associated with head-on collisions or a loss of control. Codes indicating collisions with obstructions and pedestrians were not included here, as it was not possible to determine whether the vehicle was out of lane as well.

5.1.6 Intelligent Speed Assist

The target population for this technology involved a vehicle either explicitly exceeding the speed limit or judged to have been driving at an ‘inappropriate speed’ at temporary traffic lights, on corners or on straights. The target population for this technology was determined based on contributory factors associated with speeding. Because of the method by which contributory factors are assigned to a collision, this factor could be under-reported. However, due to the limited information on under-reporting, the target population for this technology was not adjusted any further.

5.1.7 Rear Collision Warning

The effectiveness estimate for this technology assumed a camera-based system only. All cyclist and pedestrian casualties in collisions instigated (‘crashrole’ = 1 in the CAS data) by a reversing motor vehicle were included. If the ‘crashrole = 1’ condition was lifted, to include pedestrian and cyclist casualties in collisions involving a reversing motor vehicle, the number of casualties increased by about 60%. This approach was deemed too broad, as such collisions were not necessarily caused by the reversing vehicle, as specified in the target population.

5.1.8 Driver Monitoring Systems

The UK’s STATS19 contributory factors used for the DDAW and ADDW (formerly known as DDR-DAD and DDR-ADR) target populations in Seidl et al.’s work (2018) were matched with those in the CAS data. The DDAW target population incorporated all collisions with a fatigue-related contributory factor for the primary vehicle type. The ADDW target population was calculated using all fatigue-related factors, as well as factors suggesting short-term distraction, such as using a mobile phone or eating food.

5.1.9 Fleet Management Telematics

Only limited resources were available for these effectiveness estimates, with many recent studies focusing on leading indicators of risk, such as speed events. While they were more than 10 years old, the quoted sources were the most appropriate for the effectiveness of FMT at the collision level.

Only collisions with a vehicle listed as ‘commercial’ were included in the count, as it was not possible to determine the class of the vehicles that did not have this variable specified. There were 24,000 vehicles with vehicle class not listed, out of over 300,000 in total. The 20% estimate from the source applied to all crashes and was thus assumed constant across all crash severities, in the absence of more information in the data.

5.1.10 Alcohol Interlock Systems

The effectiveness estimate for AIS represented the proportion of drink-driving individuals who were taking part in alcohol interlock schemes. It was estimated based on Seidl et al.’s estimate (2018) and data provided by Waka Kotahi on alcohol interlock licences issued from 2016 to 2021. Around 3,000 licences were issued in the 12 months prior to July 2021 and over 25,000 collisions were identified in the target population for AIS.

5.1.11 Electronic Work Diaries/Logbooks

The estimate here should be treated with caution, as causation between the use of EWDs/ELs and safety benefits was not rigorously established, and the number of crashes in the sample was small. The 15.6% estimate from the source applied to all crashes and was thus assumed constant across all crash severities, in the absence of more information in the data. As with FMT, only collisions with a vehicle explicitly listed as ‘commercial’ were included.

5.1.12 Blind Spot Monitoring

The estimates here were low confidence, as the results presented in the source were not significant at the 5% level ($p = 0.08$). The 50% estimate for reduction in injury crashes was assumed constant across serious and minor crashes and was also applied to damage-only crashes.

5.1.13 Under-reporting factors

For certain technologies, the collision data did not offer the level of detail necessary to identify the target population accurately. For example, certain contributory factors, such as exceeding the speed limit, might have been under-reported; therefore, an adjustment factor was applied to the target population to account for this. The under-reporting factors were identified from Seidl et al. (2018); these were based on expert judgement and knowledge of the collision data in Europe and the UK. A summary of these factors and the justification for their application to the CAS data is shown in Table 5.5.

Table 5.5 Under-reporting factors applied to the CAS target populations

Technology	Under-reporting factor(s)	Source	Justification
RCW	**2** applied to all casualty severities	Seidl et al. (2018)	To account for the collisions happening away from public roads and hence, not reported in the accident statistics.
AIS	**0.75** applied to all casualty severities	Seidl et al. (2018)	To limit the target population to only alcohol-related collisions caused by repeat offenders.

An adjustment factor was also applied to the ADDW and DDAW target populations in Seidl et al.’s work, based on under-reporting of the relevant contributory factors in the UK STATS19 data. However, after careful analysis of the levels of reporting of the contributory factors in the past five years across the CAS data and STATS19 data, it was decided not to use these adjustment factors. The amount of reporting was similar (eg 26,977 in STATS19 and 25,430 in CAS for the ADDW contributory factors) in both datasets but the CAS data involved approximately three times fewer vehicles.

All the above adjustment factors were applied in calculating the results presented in Section 5.2 of this report.

5.1.14 Fitment rate

Once the effectiveness of a technology was determined, it was important to consider the level of impact the technology would have on the entire vehicle fleet, and the speed at which this impact could be realised. According to the study conducted by Seidl et al*.* (2018), the impact of each technology on the vehicle fleet could be estimated to follow an 'S-shaped' curve, showing the extent to which the technology would penetrate the vehicle fleet over time. An illustration of the estimates for pedestrian-capable AEB (for cars in the EU) is shown below.

Figure 5.2 Estimated percentage of newly registered cars in the fleet with a given technology, assuming voluntary uptake is undertaken by manufacturers (reproduced from Seidl et. al., 2018, p. 27)

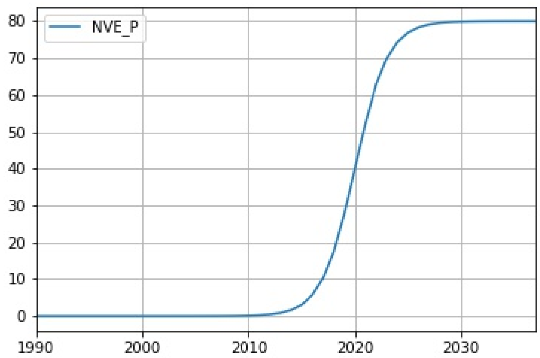


Figure 5.3 Estimated percentage of all cars within the vehicle fleet equipped with a given technology, assuming voluntary uptake is undertaken by manufacturers (reproduced from Seidl et. al., 2018, p. 27)

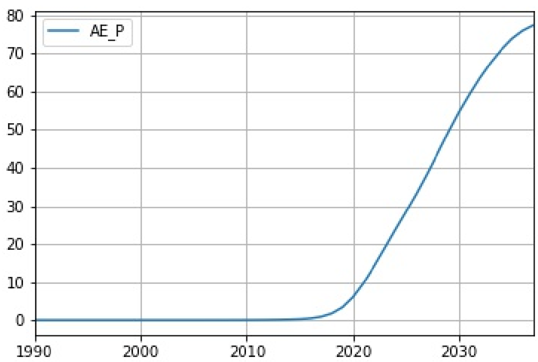


Figure 5.2 on the left illustrates the expected percentage increase in *newly registered* cars in the fleet, assuming voluntary uptake (or no regulation being introduced) by car manufacturers. It shows that the proportion of newly registered cars with a technology fitted would increase over time, as newer cars enter the fleet, although it might not reach 100% as not all new cars would have the technology fitted (due to voluntary uptake by manufacturers). Figure 5.3 on the right shows how the voluntary uptake in new cars would affect the level of fitment among *all* cars. These figures show that the level of fitment would change slowly over time as newer cars with the technology fitted gradually replace older cars (which do not have the technology fitted) in the fleet. The rate at which the turnover happens depends on a range of factors such as age of the fleet, number of new registrations and the overall size of the car fleet. It is possible that the fleet would not reach 100% fitment under voluntary uptake of a given technology.

This current study did not model the impact of future fitment rate using the 'S-shaped' curves shown above, due to the limited information on fleet turnover. However, it is extremely important to consider this factor in any decisions around future benefits, as fleet turnover helps to determine the length of time before the benefits from each technology may be realised.

The exploratory analysis conducted to estimate the current prevalence of technologies (see Chapter 4) showed that a higher proportion of newly registered cars would have each technology fitted (equivalent to Figure 5.1). However, it also highlighted that the average age of cars in the New Zealand fleet at the time of this research was around 10 years and therefore, it could take a long time for the benefits of each technology to be noticed.

5.1.15 Social cost

The average social cost of crashes, split by severity of the injury, is published by the New Zealand Ministry of Transport (2020). Table 5.6 presents the average social cost per injury by various cost components, using June 2019 prices.

Table 5.6 Average social cost ($) per injury by cost components with June 2019 prices (from Ministry of Transport data)

Cost components	Fatal injury	Serious injury	Minor injury
Loss of life/permanent disability	4,527,300	452,700	18,100
Loss of output (temporary disability)	0	1,400	300
Medical: hospital/medical	3,900	9,600	100
Medical: emergency/pre-hospital	3,100	1,200	700
Follow-on	0	4,700	100
Legal and court	21,100	2,800	900
Vehicle damage	6,600	5,200	5,200
Total	**4,562,000**	**477,600**	**25,500**

It is crucial to note that the estimates presented above have not been adjusted for the level of non-reporting.

For some technologies, the target population analysis did not have data at the casualty level. In these cases, the target populations were determined at the collision level. Therefore, the average social cost, by collision severity, is presented in Table 5.7.

Table 5.7 Average social cost ($) per collision type with June 2019 prices (from Ministry of Transport data)

Collision type	Cost (2019 prices)
Fatal	$5,374,100
Serious	$551,700
Minor	$30,800
Non-injury collision: vehicle damage	$3,200

5.2 Results

This section presents the results from the collision data analysis. The results are divided into three sections. Section 5.2.1 shows the target population for each technology and the number of casualties that would have occurred if all primary vehicles had been fitted with the given technology. Section 5.2.2 shows the number of casualties saved because of the technology and analyses the effects of varying fitment rates. Section 5.2.3 presents the social cost savings associated with each technology.

It is also important to note that the results for each technology and each vehicle type cannot be summed to produce the savings for multiple technologies or vehicle types combined, as there may be some overlap in the target populations. While in most cases, the overlap is non-existent or minimal, caution should particularly be taken when considering technologies with target populations linked to contributory factors (such as DDAW and AIS), as these can apply to more than one vehicle in a collision.

5.2.1 Target population and effectiveness of technology

This section presents the target populations for each technology, together with the number of casualties or collisions (2016–2020), if all vehicles of the primary type had been fitted with the technology. Figure 5.4, Figure 5.5, Figure 5.6 and Figure 5.7 present this information for the technologies, with casualty-level effectiveness estimates (or crash modification factors), across all vehicle types.

Figure 5.4 Target population (TP) and number of casualties if all cars had been fitted with the technology (EE) – 2016 to 2020

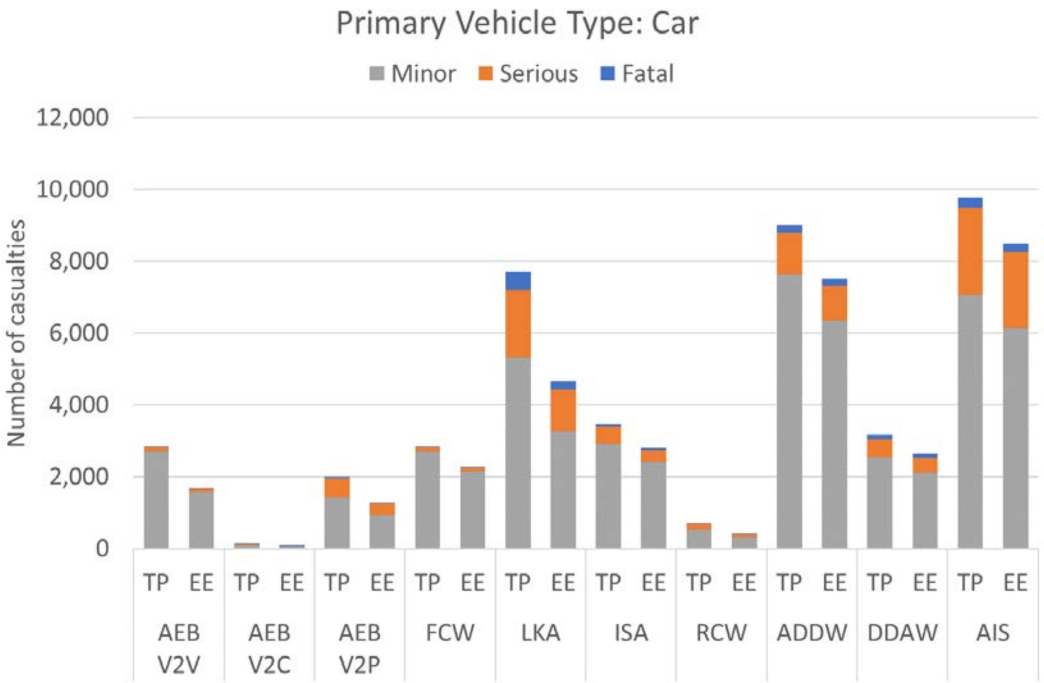


Figure 5.5 Target population (TP) and number of casualties if all buses had been fitted with the technology (EE) – 2016 to 2020

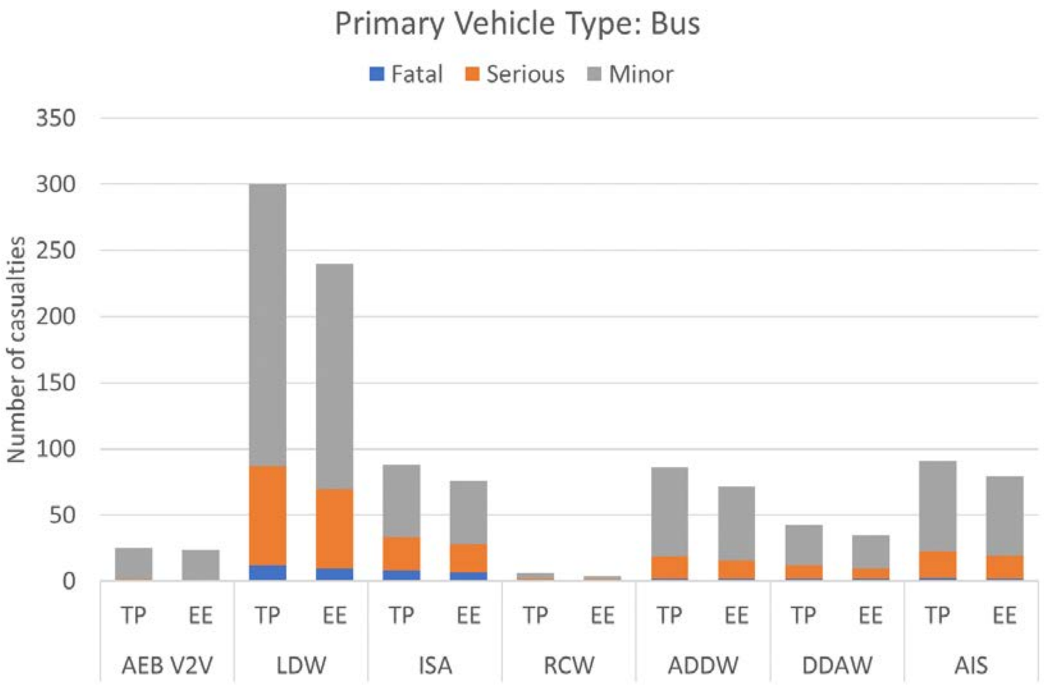


Figure 5.6 Target population (TP) and number of casualties if all vans had been fitted with the technology (EE) – 2016 to 2020

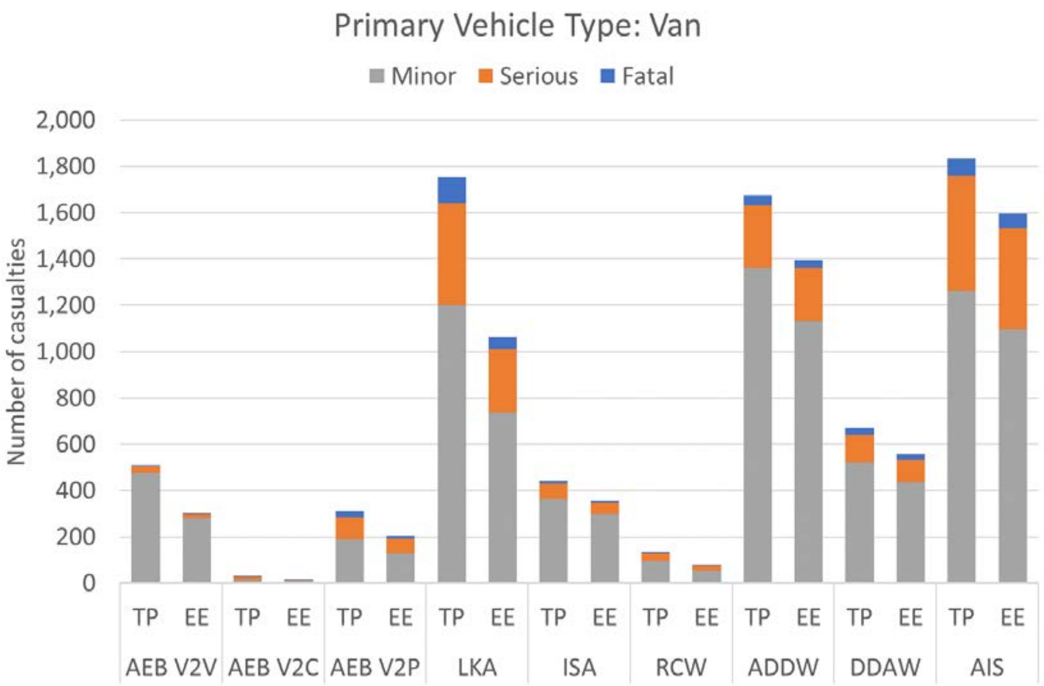
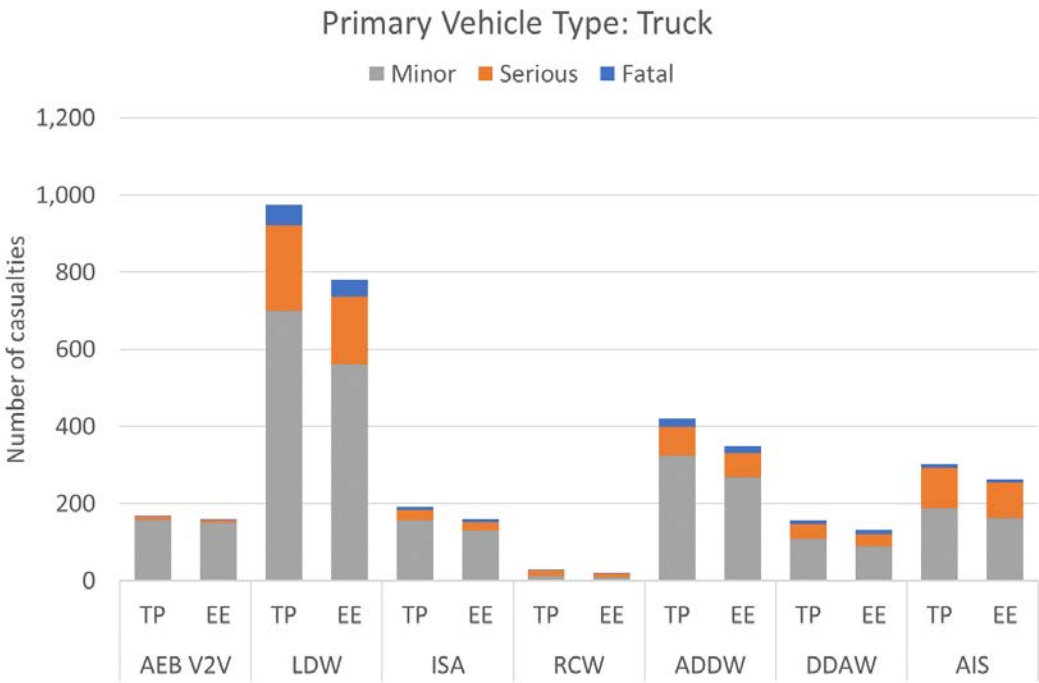


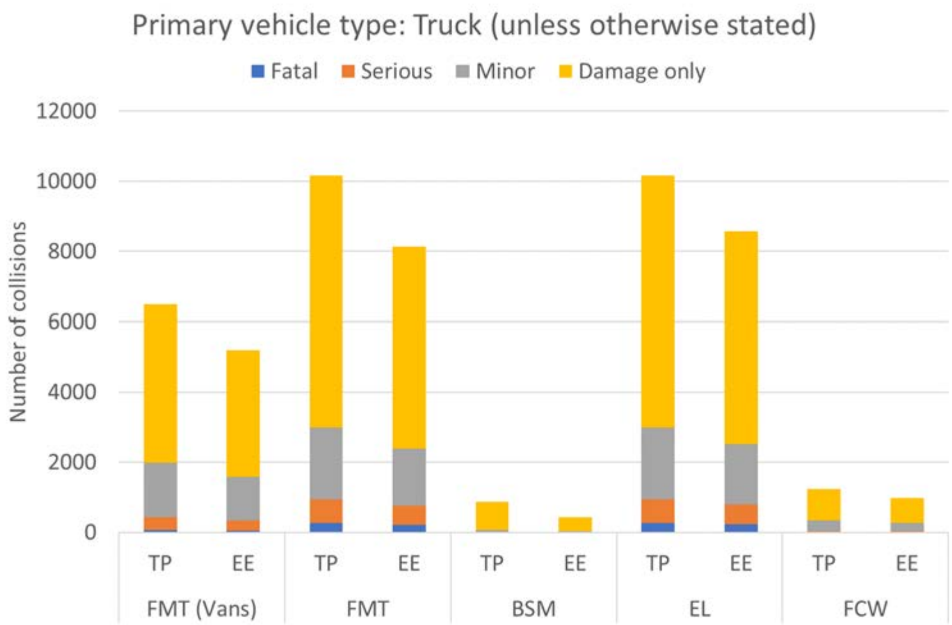
Figure 5.7 Target population (TP) and number of casualties if all trucks had been fitted with the technology (EE) – 2016 to 2020



AIS, ADDW and LKA had the highest number of associated casualties for cars and vans, and LDW had the highest number of associated casualties for buses and trucks. Nearly 9,000 casualties were identified in the ADDW target population for cars and just under 1,000 in the LDW target population for trucks. LKA showed the greatest reduction in the number of casualties if all vehicles had been fitted with the technology. There was likely to be a lot of overlap between the target populations identified for LKA or LDW and ADDW, as drifting out of lane is often linked with driver fatigue or distraction. For cars and vans, the AEB-V2V and AEB-V2P target populations were considerably higher than the AEB-V2C target population.

Figure 5.8 presents the same information for the technologies with collision-level effectiveness estimates. Trucks are the primary vehicle type for all technologies apart from FMT, which also applies to vans.

Figure 5.8 Target population (TP) and number of collisions if all vehicles of primary type had been fitted with the technology (EE) – 2016 to 2020



EWDs/ELs and FMT had the highest target populations and associated reduction in collisions if all primary vehicles had been fitted with the technology. Over 10,000 collisions involving a commercial vehicle were identified in the FMT and EL target populations for trucks. The smaller FMT target population for vans showed that there was a higher number of collisions involving commercial trucks than commercial vans, though this target population was still relatively large, at just over 6,000 collisions.

5.2.2 Casualties saved and fitment rate

This section presents the number of casualties and collisions that would have been saved by the technologies, assuming different levels of fitment. Ideally, the fitment rate for each technology over the next decade will be determined through fitment curves (explained in Section 5.1.14). Voluntary fitment for new vehicles is known to follow an S-shaped curve, and this shows the extent to which the technology would penetrate the vehicle fleet over time. Fitment rates are derived from factors such as age of the vehicles and turnover rate of the fleet. Chapter 4 has provided some information on the current fitment rates of each technology within the car fleet; however, there was limited information on fitment rates for other vehicle types. Therefore, three arbitrary fitment rates (10%, 50% and 90%) were used to illustrate the number of casualties saved if fitment with these technologies were to increase over time. It must be noted that it could take several years for these fitment rates to be achieved.

Figure 5.9, Figure 5.10, Figure 5.11 and Figure 5.12 present the total number of casualties saved assuming 10% fitment, 50% fitment and 90% fitment across all vehicles of each type between 2016 and 2020. For AIS, the level of fitment was restricted to vehicles driven by interlock licence holders; thus, the 90% bar is likely to be the most accurate.

Figure 5.9 Number of casualties saved by each technology assuming varying levels of fitment in cars – 2016 to 2020

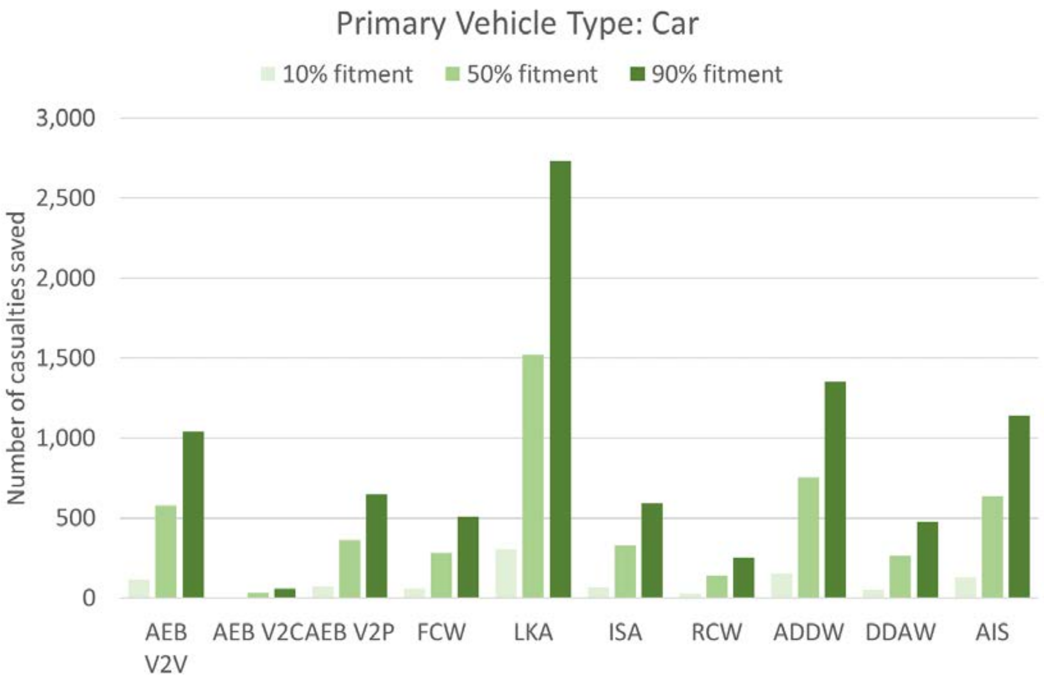


Figure 5.10 Number of casualties saved by each technology assuming varying levels of fitment in buses – 2016 to 2020

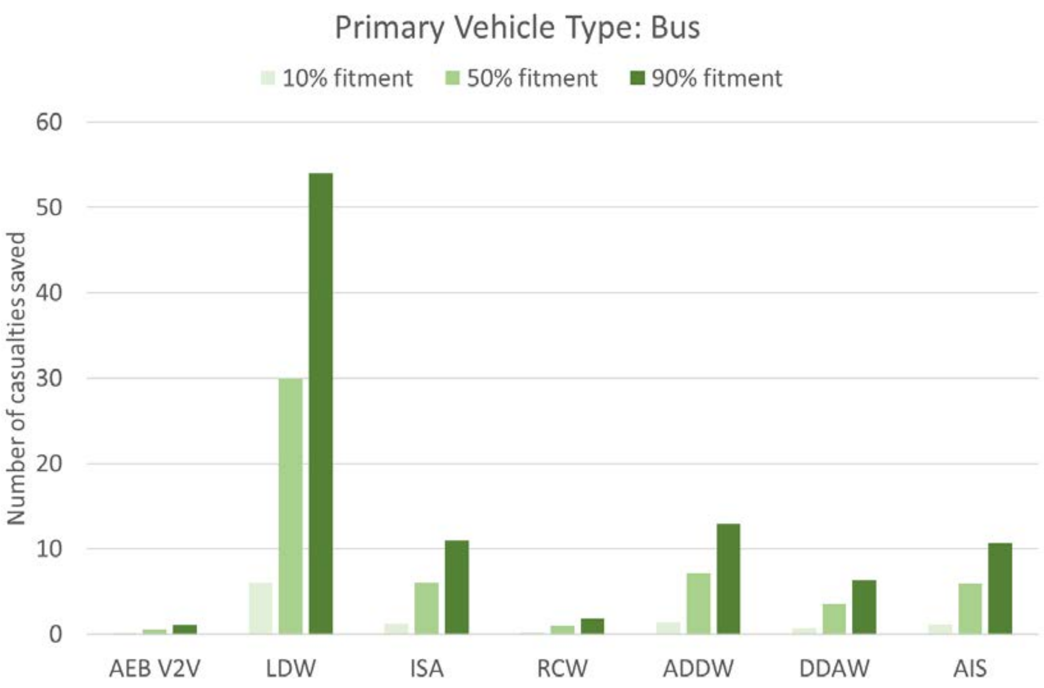


Figure 5.11 Number of casualties saved by each technology assuming varying levels of fitment in vans – 2016 to 2020

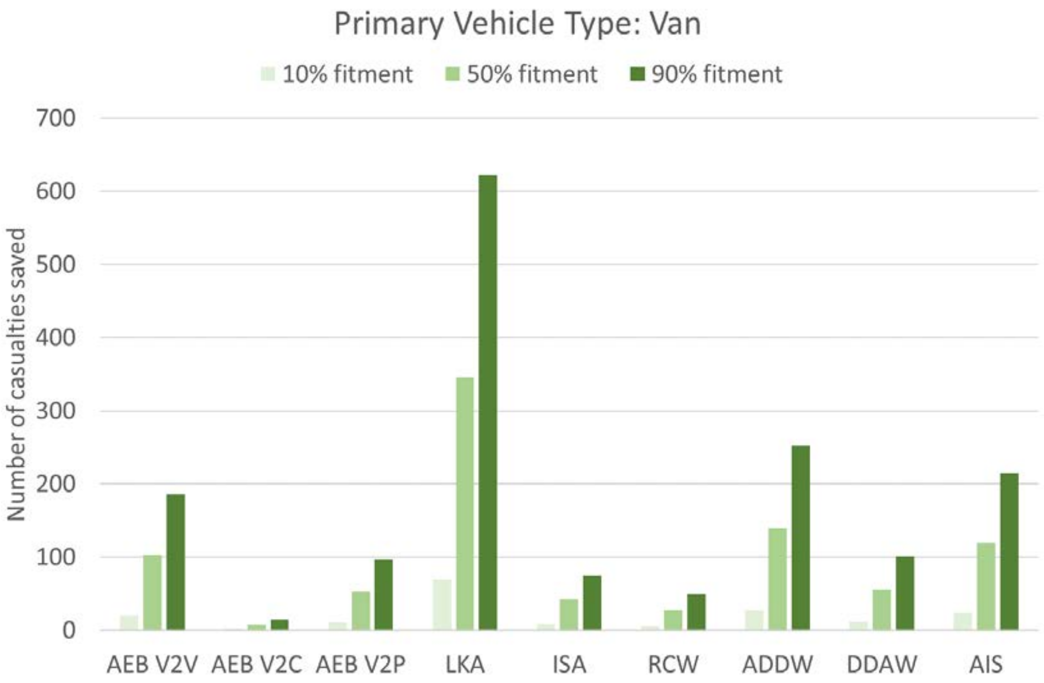
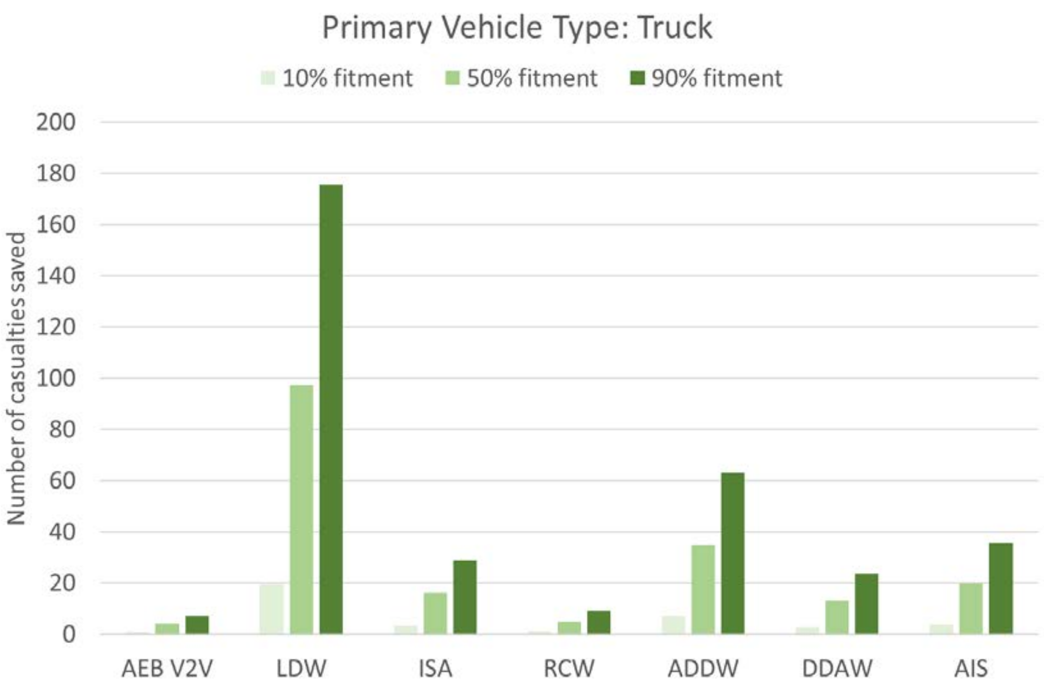


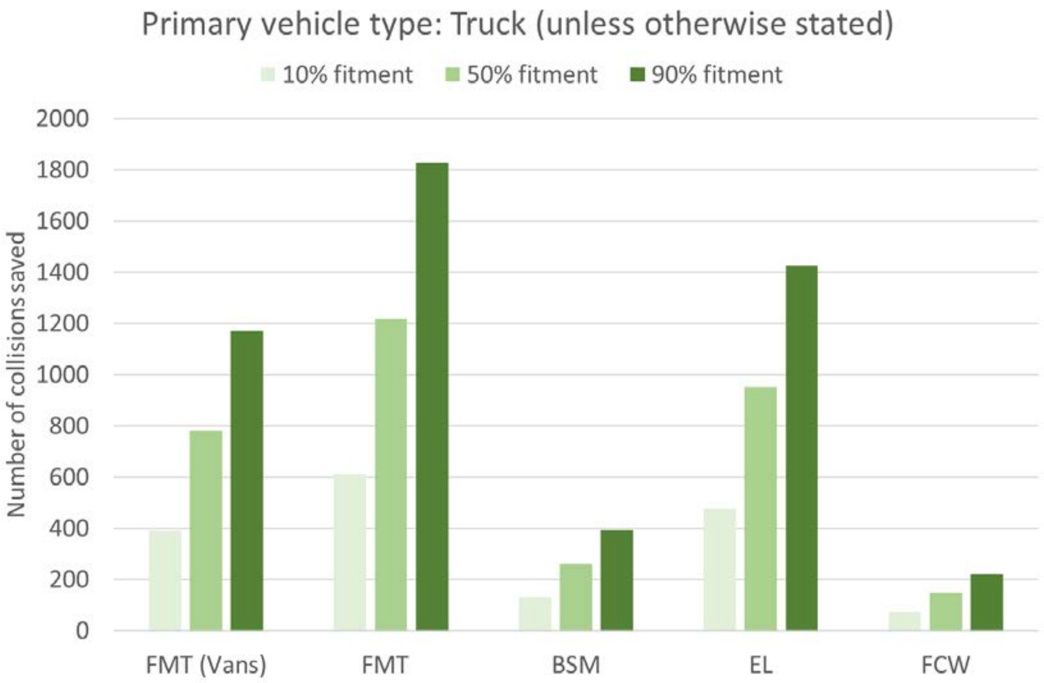
Figure 5.12 Number of casualties saved by each technology assuming varying levels of fitment in trucks – 2016 to 2020



As in the previous section, LKA had the highest number of associated casualty savings for cars and vans, and LDW had the highest number of associated casualty savings for buses and trucks. These comparatively high effectiveness estimates for LKA increased the difference between this technology and all others compared with the target populations in the previous section; the savings for LKA at 50% fitment were higher than for any of the other technologies at 90% fitment. For all vehicle types, ADDW had the second-highest number of casualties saved and for cars and vans, this was closely followed by AEB-V2V.

Figure 5.13 presents the number of collisions that would have been saved by the remaining technologies, again assuming 10% fitment, 50% fitment and 90% fitment. FMT and EL had the highest number of associated casualty savings amongst these technologies.

Figure 5.13 Number of collisions saved by each technology assuming varying levels of fitment in the primary vehicle type – 2016 to 2020



5.2.3 Social cost savings

This section presents the social costs associated with the casualties saved by each technology presented in the previous section. The average social cost of casualties split by severity was obtained from published data (Ministry of Transport, 2020).

First, the social costs were applied to the target population to estimate the total cost associated with all the casualties included in the target population for each technology. The target populations included the under-reporting factors, where applicable.

Next, the effectiveness estimates were applied and the number of casualties that would have been saved due to each technology was estimated. These were then multiplied by the respective social costs, to estimate the associated cost savings.

The numbers presented in Table 5.8 assume that none of the vehicles in the target population were fitted with the technology. Assuming all cars and vans in the fleet were fitted with the technology, the estimated savings were the largest for LKA, around $1,617 million and $364 million, respectively. For cars, technologies like AIS, DDAW, ADDW and AEB V2P were estimated to have large savings of over $100 million. In the case of buses and trucks, LDW was likely to have a high savings of around $19 million and $73 million, respectively.

Table 5.8 Potential cost savings (million $) associated with each technology (assuming a baseline of 0% fitment to 100% fitment)

Technology	Car	Van	Bus	Truck
AEB V2V	61	12	0.14	2
AEB V2C	30	11	-	-
AEB V2P	228	78	-	-
FCW	31	-	-	-
LKA	1,617	364	-	-
LDW	-	-	19	73
ISA	160	23	9	11
RCW	64	16	0.35	5
ADDW	290	59	3	24
DDAW	147	34	2	13
AIS	333	78	3	13

The calculations above assumed that fitment rate increased from 0% (none of the vehicles in the fleet had the technology) to 100% (all the vehicles in the fleet had the technology). As discussed in Section 5.1.14, achieving a fitment rate of 100% mainly depends on the speed at which the impact of the technology can be realised. While voluntary uptake of newly sold vehicles might increase over time, it could take decades for it to translate to the entire vehicle fleet as older vehicles slowly leave the fleet. Therefore, achieving such high levels of fitment might take decades or might even not be possible if not all manufactures decide to fit the technology within the vehicles.

The calculations above also assumed that none of the vehicles in the fleet currently had any technology fitted. The analysis of the vehicle fleet characteristics data shown earlier in Table 4.7 showed that less than 10% of passenger cars and vans were fitted with each technology in question: Reversing Collision Avoidance System was the highest, at 14% and Speed Alert Systems ISA was the lowest, at 1%. Due to the limitations of the dataset used for the analysis, there was no information for other vehicle types.

Therefore, a second set of potential cost savings calculations was conducted, assuming that 10% of the fleet for each vehicle type was currently fitted with the technology. This was done by applying the current fitment rate to reduce the cost savings estimated from the 2016 to 2020 collision data. Therefore, a 10% reduction was applied to the cost savings (where fitment was assumed to be 100%) using the collision data from 2016 to 2020.

The potential cost savings for each technology, going forwards, was then estimated under the following two conditions:

- Assume a maximum fitment rate of 50% is achieved.
- Assume a maximum fitment rate of 100% is achieved.

Table 5.9 presents the estimated cost savings if the fitment rate were to increase from 10% to a maximum of 50% or 100%.

Table 5.9 Potential cost savings (million $) if fitment rate increased to 50% or 100% (assuming a baseline of 10%)

Technology	Car		Van		Bus		Truck	
Max. fitment	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
AEB V2V	24	55	5	10	0.06	0.13	0.9	1.9
AEB V2C	12	27	4	10	-	-	-	-
AEB V2P	91	205	31	70	-	-	-	-
FCW	13	28	-	-	-	-	-	-
LKA	647	1,455	146	327	-	-	-	-
LDW	-	-	-	-	8	17	29	66
ISA	64	144	9	21	3	8	4	10
RCW	26	58	6	14	0.14	0.32	2	5
ADDW	116	261	24	54	1.3	2.8	10	22
DDAW	59	132	14	30	1	2.2	5	11
AIS	133	300	31	71	1.1	1.4	5	12

If the fitment rates were to increase from a baseline of 10% to 50% (or 100%) for cars and vans, the potential cost savings would be the highest for LKA, ADDW, ISA and DDAW. While AIS had similar potential benefits to ADDW, the widespread uptake of this technology is not feasible, compared with the benefits for ADDW and DDAW, which address a broader range of causes of impaired driving. If 50% of the fleet was fitted with the technology, the expected cost savings for LKA were around $600 million for cars and $146 million for vans. Similarly, for bus and trucks, the estimated cost savings were the highest for LDW, at $8 million and $29 million, respectively, if around 50% of the fleet was fitted with the technology. This increased to $17 million and $66 million if the entire fleet was fitted with the technology.

6 Roadmap development

The purpose of the roadmap development was to establish which actions Waka Kotahi should prioritise for the different technologies in the future. The work progressed in two phases. First, logic models were created purely to assist in the high-level thinking around the likely roadmap actions. We then took the activities listed in the logic models and arranged them on a timeline for further development in a workshop with Waka Kotahi and stakeholders, who added detail of the New Zealand context to the roadmap actions.

The roadmaps were intended as the output of the project; however, for interest, the logic models are included in Appendix G. They sought to unravel the causal chain between the current state and the desired state of increased uptake of in-vehicle technologies. The logic models outline which activities, stakeholder actions, inputs and outputs are needed to achieve the desired outcomes.

6.1 Roadmap development workshop method

The aims of the workshop were to:

1. give an overview of the research results presented in Chapters 2 to 5
2. present the initial logic models and roadmaps
3. harness the collective knowledge and expertise of attendees to further develop and improve the roadmaps with greater detail on actors, activities and dependencies, to maximise the potential effectiveness and feasibility of the resulting roadmaps.

6.1.1 Participant selection and invitation

Workshop invitees were nominated in collaboration with Waka Kotahi. The aim was to include people with diverse and practical insights into how to increase the uptake of in-vehicle technologies.

Invitations were sent out approximately three weeks prior to the workshop to ensure that as many people as possible could attend. They were provided with a copy of the slide pack prior to the workshop.

Twenty-seven participants attended the workshop. These included government policy and strategy advisors, technology distributors, insurers and industry associations, industrial/organisational experts, and fleet industry advocacy groups.

6.1.2 Overview of workshop

The workshop was held over Microsoft Teams and began with an overview of the project, including its purpose, the technologies under consideration, our findings regarding their prevalence and effectiveness, and the barriers and enablers related to the use of in-vehicle technologies.

We then moved into four smaller teams for group discussions, each with a TRL facilitator. Each group was introduced to the logic models for two or three specific in-vehicle technologies and preliminary roadmaps to increase the uptake of the technologies, as follows:

- Group 1: AEB, LKA and ISA
- Group 2: BSM and RCW
- Group 3: FMT and EWD/EL
- Group 4: DMS and AIS.

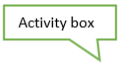
Participants were asked to contribute to filling in the gaps in the roadmaps (eg missing activities or actors), and they were told that they could make any changes, including adding or removing streams of work or activities, and extending or shortening time frames. Waka Kotahi representatives from each of the small groups then presented a summary of the conversations to the whole group and a whole-group discussion followed.

6.2 Outcomes

The group discussions are summarised below, including the updated versions of the roadmaps for each technology being considered.

6.2.1 Explanation of roadmaps

The roadmaps are schematics that present the:

- approximate order in which the activities shown in callout boxes 

 should occur along the timeline arrow 

 in the centre of the page
- streams of work or working groups (represented by thicker arrows) 

, with the work groups lower on the diagram providing direction and authorisation for the work and those higher on the diagram carrying out the work, following directions and reporting findings to inform the next stages of work.

The roadmaps are intended as initial ideas rather than conclusive instructions, and it is envisaged that they should be built on further (or cut down) in the initial stages of agreeing on aims and plans of work. The workstreams/groups that are common across all the roadmaps (from bottom to top) are as follows:

- The **working group** that coordinates activities across agencies and workstreams – This would be made up of government agencies who have responsibility for implementing or monitoring some aspect of each technology, and would most likely be led by Waka Kotahi. This could be one group encompassing all technologies.
- **The Vehicle Technology Advisory Group**, which provides expert input to plans and strategies, research and development, monitoring and evaluation activities and communications – This group would include representatives from government agencies who understand relevant government policy, processes, legislation and databases, including one person to act as a liaison between this group and the working group. This group should probably encompass all technologies. It should be led by Waka Kotahi, and its members should include organisations that use the technologies in their fleets to provide insights into practical issues, such as the Automobile Association (AA), a consumer advocacy group, Motor Industry Association,[8] Motor Trade Association,[9] Imported Motor Vehicle Industry Association,[10] fleet management organisations (eg Orix, Fleetwise),[11] after-market technology providers, Worksafe,[12] the Motor Industry Training Organisation (MITO) and the Ministry of Transport. A secondary but

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[8] Representing new-vehicle distributors in New Zealand.

[9] Representing automotive professionals and 'the motoring public' in New Zealand.

[10] Representing organisations involved in the used-vehicle import trade in New Zealand.

[11] Fleet management organisations (approx. 5 main players) give advice to fleets about what technologies they should purchase in their vehicles. These vehicles enter the used car market within 3 to 5 years.

[12] Worksafe was suggested because work health and safety law could also be used to influence uptake of technologies. As one participant put it, "If you're doing as much as practicable to keep your people safe, then there's really no excuse for having anything but a five-star car."

important role of this group would be developing stakeholder relationships to ensure ease of communication, feedback on policy and legislative proposals, and buy-in to long-term strategies and regulatory requirements.

- The **research, monitoring and evaluation** stream – This could be a sub-working group that has a mix of members with expert knowledge of relevant research, monitoring and evaluation techniques, data governance and experience in commissioning and managing this work (including a representative of the CAS Data Working Group that is led by Waka Kotahi).
- The public **communications/stakeholder engagement** stream – This could be led by a sub-working group that has industry-specific expertise in effective communications and stakeholder engagement. This group should either include or consult with organisations such as ANCAP and the AA, as well as liaise with the above Vehicle Technology Advisory Group for technical input.

Care should be taken with these groups to ensure that membership does not confer unfair advantages or disadvantages, or result in uncompetitive trading. This can be managed through the governance and terms of reference of the groups, to ensure that no industry member has access to information that would confer a privileged trading position over their competitors, nor has inappropriate influence over government decisions.

6.2.2 Technology Group 1: Autonomous Emergency Braking, Lane Keep Assist and Intelligent Speed Assist

6.2.2.1 Autonomous Emergency Braking and Lane Keep Assist

Regulatory approach

AEB and LKA technologies are available in most new vehicles already, as they are mandated in other jurisdictions (see Box 1) and are promoted by ANCAP; a 5-star ANCAP safety rating now requires the vehicle to be fitted with AEB, LKA or LDW. ANCAP protocols are regularly updated to include the technologies that are proven to keep vehicles from serious crash involvement and the organisation was perceived by participants in this group to have a strong influence on vehicle safety standards.

The group said that even if New Zealand does nothing extra, these technologies will probably dominate the fleet over time, but legislation may increase their uptake by ensuring they are not ‘de-specced’ from new imports entering New Zealand, as well as by mandating them in used imports.

The group felt the process followed for mandating ESC was good and that research to better understand the issues and regulatory impact statements should be undertaken. Developments in legislation around factory-fitted technologies worldwide should be monitored, because this strongly influences the technology fitted to vehicles imported into New Zealand. The UN regulations adopted in the domestic Japanese standard most strongly influence the technologies coming into used vehicles imported into New Zealand. As heavy vehicles are likely to come from a number of different countries, European and US regulations can be more relevant for these vehicle types.

Box 1: Current international regulatory environment for AEB and LKA

AEB and LKA are being (or have already been) mandated in various jurisdictions overseas. UN Regulation 152 (Jan 2021) mandated fitment of AEB that responds for vehicle-front-to-vehicle-rear impacts and pedestrian impacts for M1 and N1 vehicles (cars and vans) in Europe.[13] For HGVs (N2/N3) and buses (M2/M3), AEB is generally available for vehicle-front-to-vehicle-rear collisions only and UN Regulation 131 (Feb 2014) mandated fitment of AEB that responds for vehicle-front-to-vehicle-rear collisions only for N2/N3/M2/M3 vehicles.

Regulation (EU) 2021/646 (July 2022) will mandate fitment of a default on the Electronic Lane Keep system (which provides a heading correction for lane departure over solid lines and a warning for departure over dashed lines) for M1 and N1 vehicles (cars and vans).[14] UN Regulation 130 (July 2013) mandated fitment of LDW for N2/N3/M2/M3 vehicles (HGVs and buses).[15]

Effectiveness factors

For cars and vans, the capability of autonomous braking and lane support technology has developed significantly over the years, and this means that effectiveness estimates for these technologies are conservative, as they are based on historical data. The following recommendations were made:

- Initial AEB systems responded for vehicle-front-to-vehicle-rear collisions only. Later systems could also respond for pedestrian collisions and now, some current systems also respond for cyclist collisions. These began as low-speed systems and some have more recently progressed to being able to respond in higher-speed scenarios.
- Initial lane support systems gave warnings only for lane departure over lane markings (ie LDW). Later systems, which could be easily switched OFF by the driver, apply a correction when a vehicle is *heading for* lane departure over lane markings (ie LKA). Current systems, which are switched ON by default, apply a correction when a vehicle is heading for lane departure over solid lane markings and some can also apply a correction when a vehicle is heading for departure over road edges or into oncoming or overtaking traffic in an adjacent lane (ie Emergency Lane Keep). There are also systems available to provide continuous support to keep the vehicle in the lane and effectively steer it.

Promoting technology

The group agreed that promotion of benefits and encouragement to buy were required before any regulatory changes could take place. They also pointed out that as manufacturers, technology providers and end-users require sufficient lead time to implement changes in process across their supply chain, they need advance notice of plans to make technology mandatory and clarity about what will be required and when.

Future ANCAP protocols are likely to require vehicles to have technology such as AEB and LKA to achieve a 5-star safety rating, putting pressure on manufacturers to include these technologies in vehicles imported into New Zealand. Communicating the benefits of safety technologies is one of the keys to influencing demand and uptake in buyers. One of the representatives from ANCAP provided links to examples of current ANCAP campaigns on AEB and LSS.[16]

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[13] https://op.europa.eu/en/publication-detail/-/publication/fc2d3589-1a7c-11eb-b57e-01aa75ed71a1

[14] Scope defined in primary legislation Regulation EU 2019/2144. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0646&from=EN

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:42014X0618(01)&from=EN

[16] https://youtu.be/2nHgi0S0pGQ; https://youtu.be/cqc6o2wLFqk; www.ancap.com.au/rewrite

Advisory group

The group felt that creating a Vehicle Safety Technology Advisory Group could be beneficial for New Zealand, to advise on what needs to happen and monitor the implementation of any plans. As this idea was relevant to several of the technologies, it was included in greater detail in the earlier explanation of the roadmaps in Section 6.2.1.

Maintenance and repair

The group acknowledged the need to ensure that the skills to repair the technology were available in this country, as well as noting the additional expense and complexity for companies of maintaining and repairing them. Therefore, skills development for mechanics and insurance provisions should be considered.

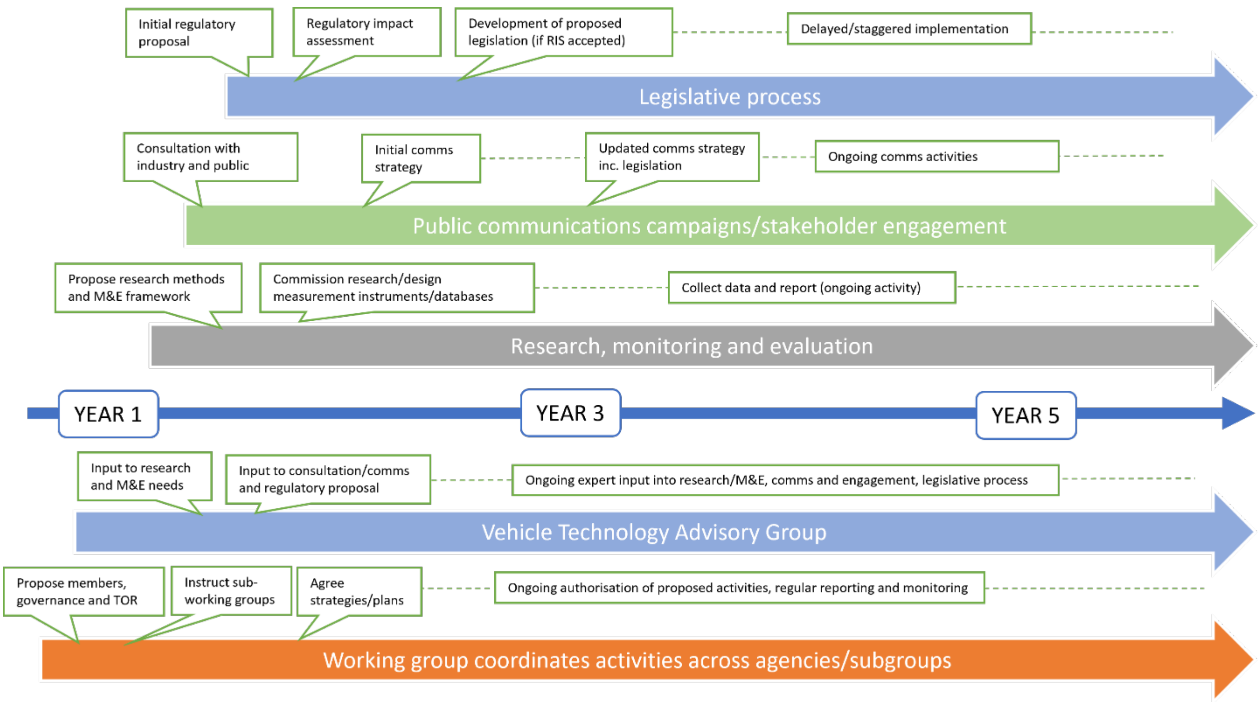
Data and monitoring

It was agreed that more data about fitment rates, particularly in used vehicles, would be helpful to measure progress and inform future decisions. It was thought that this could be collected as part of vehicle registration.

Roadmap

Figure 6.1 shows the roadmap for AEB and LKA. In addition to the base workstreams described in Section 6.2.1, this roadmap includes a legislative process workstream.

Figure 6.1 AEB and LKA roadmap



Note: RIS = Regulatory impact statement; M&E = monitoring and evaluation; TOR = terms of reference

6.2.2.2 Intelligent Speed Assist

Functionality and requirements

ISA involves a combination of two functions: a speed limit information function and a speed limitation function, which work as follows:

- The speed limit information uses a camera to 'read' road signs and often map data as well, to determine the speed limit of an area. The use of a camera is necessary to ensure temporary speed limits (eg for road works) are recognised. For ISA to work well in New Zealand and avoid giving incorrect information (which can lead to driver mistrust and disabling of the system), the speed limit information may need to be designed specifically for operation in New Zealand, to ensure road signs are recognised correctly and relevant map data is available.
- The speed limitation function can vary in its level of intervention, from visually warning the driver that the speed limit is being exceeded, to providing intrusive acoustic warnings and/or haptic warnings, to cutting the engine power to reduce the vehicle's speed.

Regulatory environment

Box 2: Current international regulatory environment for ISA

An EU regulation to mandate the fitment of a default ON type of ISA to M and N category vehicles (cars, vans, HGVs and buses) has been developed and is expected to be published in the Official Journal of the European Union soon.

Feasibility

There is some debate about the feasibility and level of user acceptance of ISA in New Zealand, and this has significant implications for the roadmap for this technology.

So far, the ISA systems' camera technology has been designed to work on road signs in bigger markets (ie Europe and the US) and New Zealand does not currently have a speed limit map. The group thought this could mean that sign recognition technology would not work in New Zealand, as it has not been designed (or the machine learning algorithms have not been trained) to recognise New Zealand signs. The group perceived little incentive for large manufacturers to program the technology specifically for this comparatively small market. It was considered that this was especially an issue for used imports from other countries. The group also expressed concerns that advisory signs could be difficult for the camera systems to handle (eg the 30 km/h signs could be perceived by the camera systems as 80 km/h, or vice versa) and this could create a problem for trust and the use of the technology.

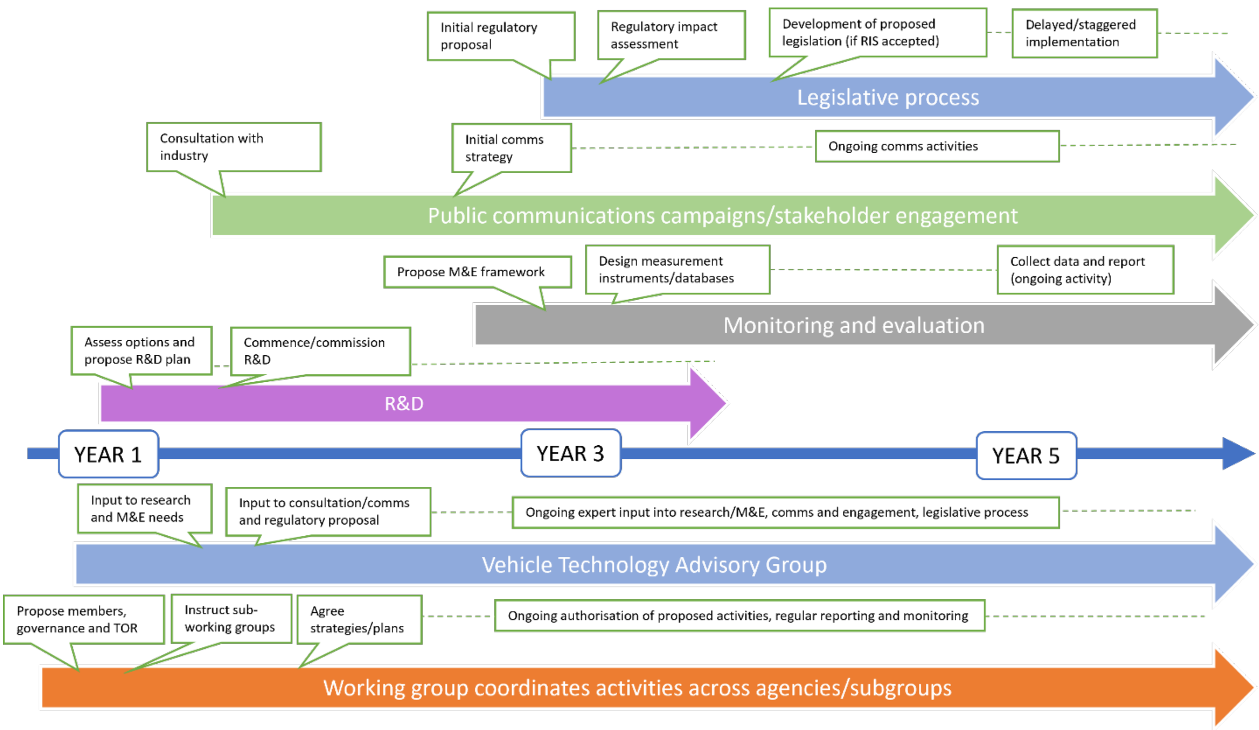
New Zealand is currently developing a speed limit map to facilitate future automated vehicles. It was noted that GPS and fleet telematics providers in New Zealand are already having to work on training their systems to recognise New Zealand signs, and that some work has been done on sign recognition for global manufacturers. There is also a proposal to make New Zealand road signs bilingual and it was suggested that this might present an opportunity to standardise this country's signs to align with those in other jurisdictions that are already compatible with ISA cameras being able to read the speed limit information.

Therefore, it may be possible to overcome some of the barriers to feasibility and in terms of a roadmap, it may be worthwhile to set up a research and development working group (if one does not already exist and/or there are no firm commitments to address this issue) with the goals of (1) coordinating research to better understand the issues and options; (2) developing a plan based on this to overcome the barriers; and (3) implementing the plan and monitoring its success. This is represented by the Research & Development (R&D) workstream in the roadmap in Figure 6.2.

User acceptance

Speed is a sensitive topic and it can be political. This means that the messaging around the introduction of any technology designed to control speed should be managed carefully. The development of a good and successful communications campaign around ISA could take a significant effort and this is allowed for in the roadmap. Reliability and accuracy are also important for user acceptance and use of the technology.

Figure 6.2 ISA roadmap



Note: RIS = Regulatory impact statement; M&E = monitoring and evaluation; TOR = terms of reference

6.2.3 Technology Group 2: Blind Spot Monitoring and Rear Collision Warning

While BSM technology is available for both light-duty vehicles – cars (M1) and vans (N1) – and HGVs (N2/N3), it has a slightly different focus for each of these vehicle types. For light-duty vehicles, the focus is to help the driver detect vehicles in the mirror blind spots before they undertake a lane-change manoeuvre, whereas for heavy vehicles, the focus is to detect cyclists on the near side of the vehicle (left in New Zealand) in city traffic and help prevent accidents with a cyclist when the vehicle turns to its near side.

RCW is available for both M and N category vehicles. It is usually a reversing camera coupled with sensors that warn the driver about any object in their path, whether a stationary object or a pedestrian. Some models can automatically apply the vehicle's brakes. Reversing cameras can be retrofitted, but they are more accurate and reliable if they are built in.

The current regulatory environment for both technologies is presented in Box 3.

Box 3: Current international regulatory environment for BSM and RCW

There is no regulation related to fitment of BSM for light-duty vehicles but there is for HGVs – UN Regulation 151.[17]

UN Regulation 158 (June 2021) mandated devices for detecting VRUs behind vehicles when a vehicle is reversing for all M and N category vehicles (light and heavy duty).[18]

The US FMVSS 111 regulation (May 2018) effectively requires a camera with given specifications on all new vehicles with a gross weight < 10,000lbs.[19]

The group concluded that BSM should be considered together with LKA, as they are related technologies and rely on similar capabilities and goals (ie preventing side-swipe collisions).

Skills and technologies to maintain and repair systems

The group said it is important that maintenance and repair technicians have the capability to repair these systems, to ensure they remain effective over time and after a crash. However, they are considered expensive to service or repair, and there is currently no legislation or policy that requires a vehicle that has been in an accident to undergo a warrant of fitness to check the technology against the manufacturer's specifications. It could be worthwhile to investigate this being a future regulatory requirement. An intermediary step would be to work with industry to ensure that codes of practice are available and any other issues are worked through, including who pays for repairs. This issue may need further attention, as with several new technologies coming into vehicles at the same time, these costs could escalate quite quickly.

Currently, where a servicing equipment is present, the hardware is shared around different providers and the public may not be aware of the need to have their systems checked and re-calibrated; for example, windscreen suppliers are currently not educating the public on the need to reset the LKA calibration after a repair.

Encouragement and awareness raising versus mandating

The group felt that the development of guidance and communications activities needs to occur well before any legislation. They commented that in other jurisdictions, legislation is used to 'mop up the last 20%' once voluntary compliance is already high. One point to note, however, is that if manufacturers, fleet managers and technology providers know that a technology is likely to be mandated in the future, this may encourage them to start planning to develop or purchase it sooner. Stakeholders said that providing clear indications of future potential regulatory moves would be valuable for these groups and would enable them to better plan and prepare (and therefore may encourage earlier uptake).

While it is normal for industry groups to develop codes of practice for their members, it may be beneficial for Waka Kotahi to play an active role in encouraging the development and voluntary uptake of relevant codes. This would help to develop the necessary relationships with stakeholders and pave the way for later requirements for warrants of fitness, if necessary. The group also felt that reference to the Health and Safety at Work Act in consultation and communications activities could help to encourage employers to provide safer vehicles.

[17] https://op.europa.eu/en/publication-detail/-/publication/afd9b826-1a7c-11eb-b57e-01aa75ed71a1/language-en

[18] https://op.europa.eu/en/publication-detail/-/publication/ff6f4851-bcf3-11eb-8aca-01aa75ed71a1

[19] https://www.govinfo.gov/app/search/%7B%22query%22%3A%2249%20CFR%20571.111%22%2C%22offset%22%3A0%7D; https://camerasource.com/blog/understanding-new-rear-visibility-guidelines-and-how-to-comply/

Currently in New Zealand, employers mostly use the overall ‘star rating’ to assess vehicles, but the workshop attendees thought it would be useful for promotional campaigns to focus on two or three ‘winners’ out of all the in-vehicle safety technologies, to encourage people to buy vehicles that had them fitted. They recommended that Waka Kotahi should publish a plain-English list of the standard definitions of the technologies and their benefits.

Monitoring

The group identified the need for Waka Kotahi to increase their level of monitoring of the uptake of technologies, potentially at the time when a vehicle is registered. The difficulty is around used imports – the MIAMI database only captures new vehicles.

Driver training, behavioural and human factors issues

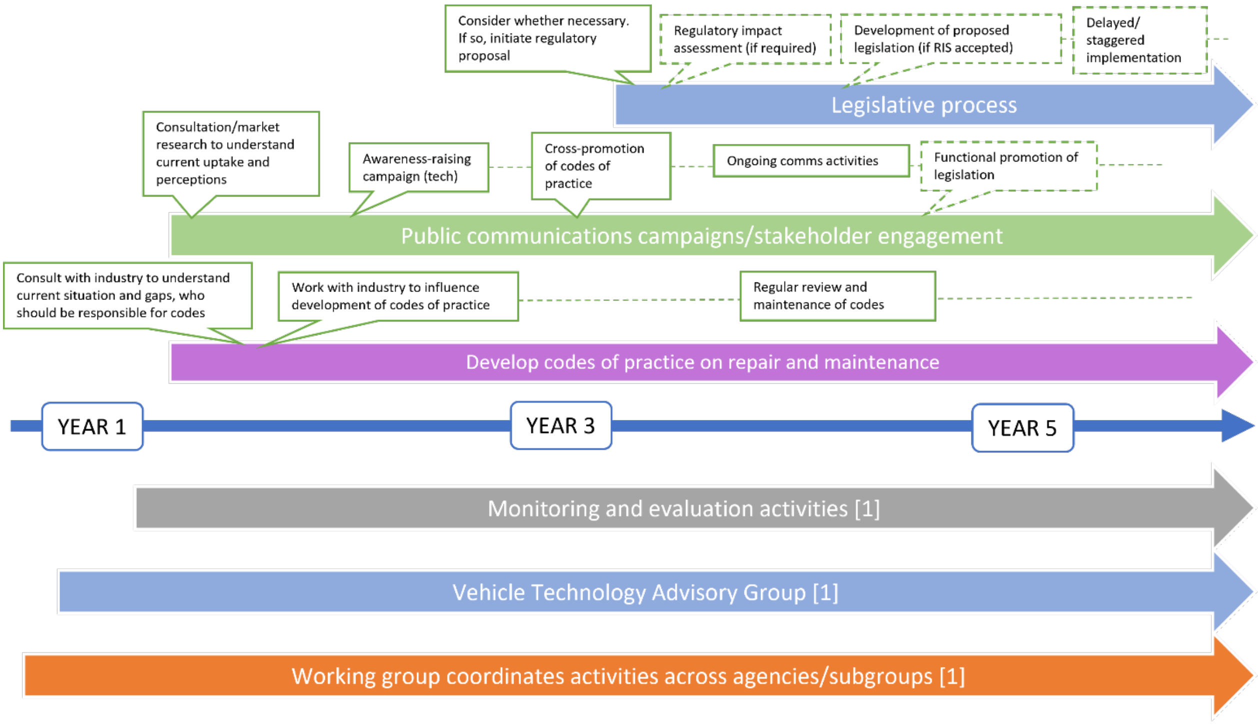
The group identified the need for drivers to understand how to use the different systems that can be fitted in different vehicles (eg people who might drive different family or work vehicles, professional drivers moving between different vehicles in a fleet). Over-reliance on these kinds of technologies was raised as an issue, particularly when people might drive one vehicle that is equipped and another one that is not. It was thought that a skill or habit could be quickly lost in the presence of compensatory technology.

Issues around people being able to turn systems off and change their settings (eg following distances) were also discussed.

Roadmap

The issues noted above were used to update the roadmap that is shown in Figure 6.3. The streams that are labelled [1] are the same as for the previous roadmaps in this section, and the details for these can be found in Figure 6.1. Dotted lines have been used to indicate actions that should be considered as options but may be deemed unnecessary after further consultation or monitoring of how industry and the public respond to earlier actions.

Figure 6.3 BSM and RCW roadmap



Notes: RIS = Regulatory impact statement; M&E = monitoring and evaluation; TOR = terms of reference
[1] Refer to Figure 6.1 for details.

6.2.4 Technology Group 3: Fleet Management Telematics and Electronic Work Diaries/Logbooks

6.2.4.1 Regulatory environment

The technology provider in the group clarified that EWDs/ELs are simply an electronic version of the current paper-based logbook. EWDs/ELs have a lot more functionality and could, for example, require a driver licence to be linked to a particular trip so that the device records a particular driver's hours (rather than the vehicle's hours). Australia's National Heavy Vehicle Regulator website[20] provides guidance for people such as drivers, operators, record keepers and technology providers, and the consultation results available on that website contain some useful information that New Zealand could consider in the development of such technology, if that path is chosen.

[20] https://www.nhvr.gov.au/safety-accreditation-compliance/fatigue-management/electronic-work-diary/overview

Box 4: Current international regulatory environment for FMT and EWD/EL

There are no regulatory requirements for FMT beyond laws that seek to ensure that in-vehicle interaction with telematics devices does not cause unnecessary distraction.

Work-time and logbook requirements are stipulated on the Waka Kotahi website.[21] There is no requirement to use an EWD/EL, but if one is used, it must be one of the seven logbooks approved by Waka Kotahi.[22]

Australia has a specification for EWDs, and the original analysis of the costs and benefits from 2013 can be found on the Transport Certification Australia website.[23] The relevant legislation is the National Transport Commission (Model Legislation – Heavy Vehicle Driver Fatigue) Regulations 2007. A regulatory impact statement would have been conducted for this.

6.2.4.2 Understanding the costs, benefits and limitations of Fleet Management Telematics and Electronic Work Diaries/Logbooks

The group agreed on the need to commission **further research to better understand the costs, benefits and limitations** of FMT, as well as the methods of use that would lead to the greatest benefits. This would enable **greater clarity around the costs and management effort required** for using the technology and **the development of useful guidance for operators on how to get the best safety and efficiency benefits** and avoid the common pitfalls. While the prevalence of this technology in heavy vehicles is quite good, the light fleet is 'largely untouched', indicating a need to find out what would make FMT attractive to this group.

The technology provider in the group noted that organisations that invest in FMT are often looking for a solution to a specific problem, rather than looking for something that could help them more broadly; therefore, they often end up with something that is not a good fit for their overall needs.

6.2.4.3 Human-Machine Interface design

The group agreed that the Human-Machine Interface design can sometimes be too complex, leading to drivers becoming distracted. Guidance would help people choose the systems that are the least distracting and the most helpful. Case studies could be used to demonstrate good driving practices and the technology could be used to reward good driving.

6.2.4.4 Encouragement versus mandating

There was consensus that while mandating the use of FMT was not desirable, a good way to increase uptake (in addition to providing greater clarity around costs, benefits and good practice) might be a 'regulatory encouragement' approach. For example, a database of publicly accessible driver and operator ratings could be used to generate competition in terms of company safety and efficiency, increasing a company's attractiveness to customers. FMT would help operators/managers to identify any behaviours that needed addressing to improve these ratings. In the larger group chat, it was noted that several organisations are already developing fleet- and driver-scoring mechanisms.

Mandating of EWDs/ELs was viewed more positively, but consideration would need to be given to the advantages/disadvantages of ELs versus EWDs and how to support smaller businesses to implement them.

[21] https://www.nzta.govt.nz/commercial-driving/commercial-safety/work-time-and-logbook-requirements/

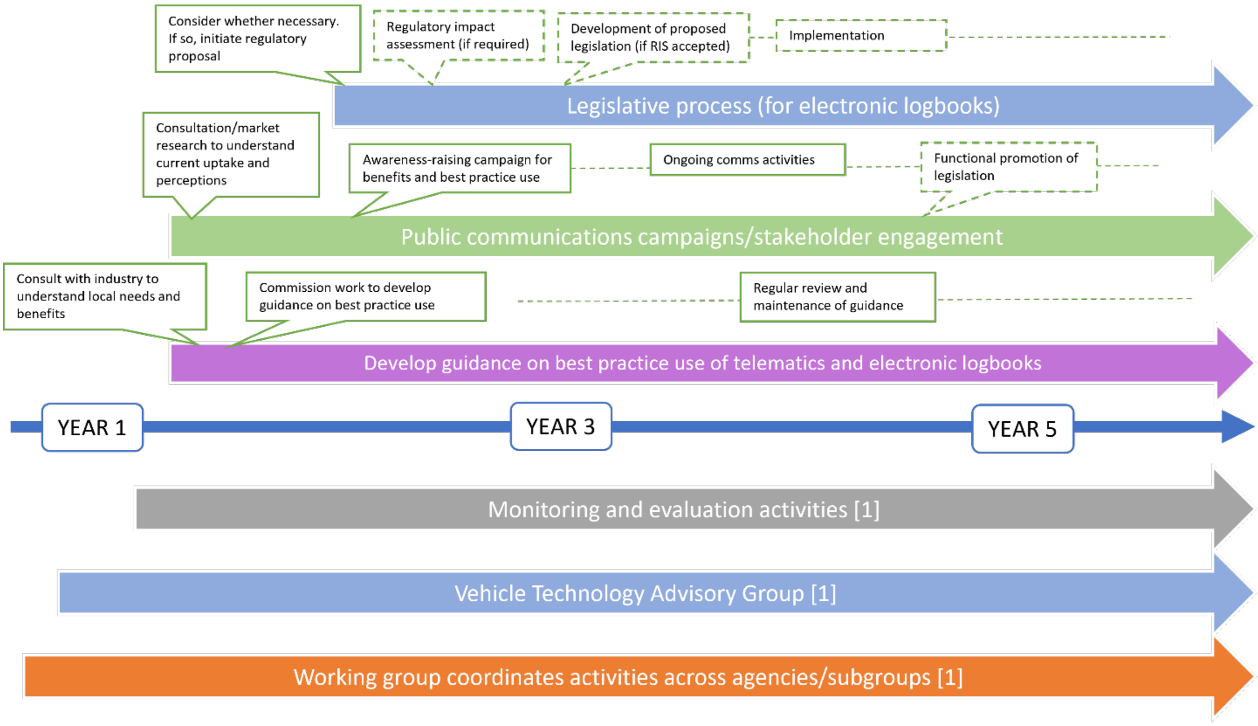
[22] https://www.nzta.govt.nz/commercial-driving/commercial-safety/work-time-and-logbook-requirements/electronic-driver-logbooks/

[23] https://tca.gov.au/publication/operational-pilot-of-the-electronic-work-diary-ewd/

6.2.4.5 Roadmap

Figure 6.4 shows the updated roadmap for FMT and EWDs/ELs. As with Figure 6.3, the streams that are labelled [1] are the same as for the first roadmaps in this section, and the details for these can be found in Figure 6.1. Dotted lines have been used to indicate actions that should be considered as options but may be deemed unnecessary after further consultation or monitoring of how industry and the public respond to earlier actions.

Figure 6.4 FMT and EWD/EL roadmap



Notes: RIS = Regulatory impact statement; M&E = monitoring and evaluation; TOR = terms of reference
[1] Refer to Figure 6.1 for details.

6.2.5 Technology Group 4: Driver Monitoring Systems and Alcohol Interlock Systems

6.2.5.1 Driver Monitoring Systems

Driver drowsiness and distraction can be major factors in accident causation. One member of the discussion group thought distraction contributed to approximately 6% of fatalities and serious injuries on New Zealand's roads. It can be detected directly by eye-monitoring sensors, for example, or indirectly by identifying driving behaviours (eg through pedal, steering wheel or g-force sensors) that are characteristic of an impaired driver. These systems are still undergoing development, as more is learned about how to better monitor a driver and methods of doing this improve.

Regulatory environment

The forthcoming mandating of DMSs in the European General Safety Regulations in 2022 (outlined in Box 5) may present an opportunity to look at whether such systems could be made mandatory over time in New Zealand. There was some disagreement around how feasible this would be for used imports.

Box 5: Current international regulatory environment for DMS

In Europe, regulation has been developed to mandate the fitment of a DMS (a driver drowsiness and attention warning system) that meets minimum requirements to all M and N category vehicles with a maximum speed above 70 km/h from July 2022 for new types (ie models) and July 2024 for all new vehicles.[24] Legislation to mandate fitment to new vehicles is also expected in the US from circa 2027.

Current use

The insurance representative in the group noted that they promote DMSs to heavy-vehicle fleets and other vehicle fleets they insure. They felt there was quite good uptake of the technology and that cameras were popular.

It was noted that as some manufacturers were putting these systems in their vehicles, they could become more mainstream over time. ANCAP is introducing this technology in forthcoming protocols, which means that monitoring aspects of driver behaviour will become worth points in the ratings. Future working groups could follow up on what protocols are being developed in the JNCAP.

It was also thought that while commercial fleet organisations tend to procure five-star vehicles, the public do not. However, fleet vehicles eventually become safer second-hand vehicle purchases in the public domain.

Potential reliability and socioeconomic issues

Questions were raised around whether DMSs that detect changes in facial movements or expressions might vary in their reliability depending on the driver's race and gender. Some work may need to be done to ascertain whether this is a problem, and if so, how much and what can be done about it.

Important stakeholders

Suggestions for stakeholders to include in the Vehicle Technology Advisory Group included:

- ANCAP
- companies already using DMSs, to provide real-world insights into the practicality of these systems and how they can best be used
- those in the supply chain
- consumer advocacy groups (eg AA, Consumer NZ), to focus on quality and user experience, and to manage false positives, usability, poor performance
- a representative with AI expertise
- Motor Trade Association (repair industry)
- Motor Trade Association
- MITO, which facilitates apprenticeships and industry training for New Zealand's automotive, transport, logistics, textile fabrication and extractive industries.

Retrofitting

A very strong theme of discussion regarding any retrofitted technology was that the retrofit must occur at the point at which the vehicles are imported and the technologies should be checked during the New Zealand

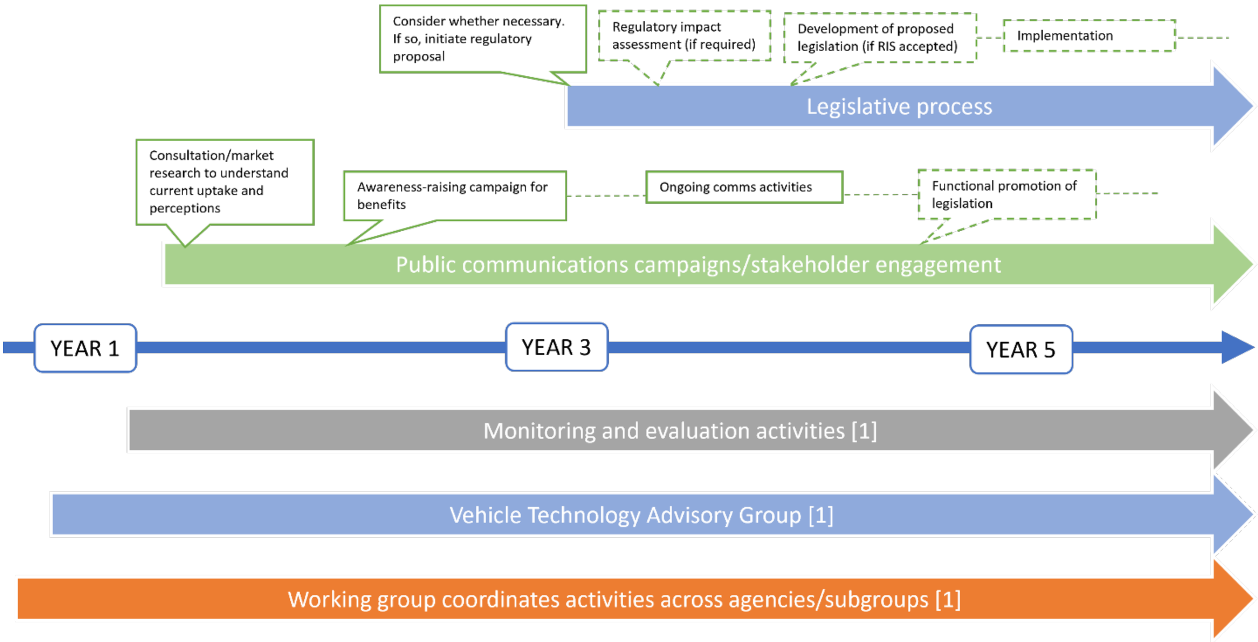
[24] Regulation (EU) 8164/2021 https://data.consilium.europa.eu/doc/document/ST-8164-2021-INIT/en/pdf

inspection process that occurs at the point of import. This would also have the added benefit of permitting data gathering on fitment rates.

Roadmap

The current prevalence of these technologies in the New Zealand fleet is not well understood. However, the move to mandate them in new vehicles in Europe indicates that the technology has reached a good level of maturity and should quickly become more common in new vehicles in this country. A first step toward increasing uptake of this technology in New Zealand would be to enhance understanding of its prevalence through reforms to the current data collection regime and/or a survey. The streams that are labelled [1] in Figure 6.5 are the same as for the first roadmaps in this section, and the details for these can be found in Figure 6.1.

Figure 6.5 DMS roadmap



Notes: RIS = Regulatory impact statement; M&E = monitoring and evaluation; TOR = terms of reference
[1] Refer to Figure 6.1 for details.

6.2.5.2 Alcohol Interlock Systems

As in all motorised countries, drink driving is a significant contributor to fatalities and serious injuries in New Zealand. The installation of AISs has not been mandated in general vehicles anywhere in the world. In Europe there has been a move to ensure that the platform for fitting them exists (see the information in Box 6). This will facilitate their use as a valuable part of offender rehabilitation.

Box 6: Current regulatory environment for AIS

European legislation requires vehicle manufacturers to make available on their websites a document with clear instructions for the installation of alcohol interlocks ('installation document'), to allow technicians to properly install an AIS in a specific vehicle model.[25]

In most countries, AISs are used as part of offender rehabilitation schemes to force drivers to separate drinking and driving.

Feasibility and user acceptance

It is not feasible to mandate the universal installation of AISs in their current form, even in new vehicles, as they are too inconvenient and expensive to maintain. However, the group noted that their use in commercial fleets in some Scandinavian countries is quite common, and this approach could be considered. This points to a potential strategy of targeting specific groups in addition to offenders (eg commercial drivers, including taxi and bus drivers, and young drivers).

Passive alcohol-sensing technology was considered promising. However, they said this technology has not yet attained a sufficient level of reliability and in many countries, drug driving is rivalling drink driving as a crash contribution factor. Other technologies that detect impairment based on driver behaviour could reach maturity before passive alcohol sensors. The group discussed the potential merger of AIS functions into DMSs that detect impairment, regardless of its cause, and provide in-cab warnings to drivers and/or alerts to managers. Preliminary research has found that psychoactive substances produce alterations to bio-behavioural processes, such as attention and motor control, that DMSs have the potential to capture. Further research on this issue is warranted.

Stakeholders and potential working group members

The Ministry of Justice and Police were identified as important stakeholders in any working group. Depending on the exact nature of any working group, it could be more appropriate to have them on the Vehicle Technology Advisory Group to provide feedback and insights into how technologies and any legislation might interact with current legislation and enforcement.

Expertise in data governance was identified as being needed (probably for the monitoring and evaluation working group). Stakeholders noted that the AA should also be involved, as they could already have some research on this issue to inform development and uptake.

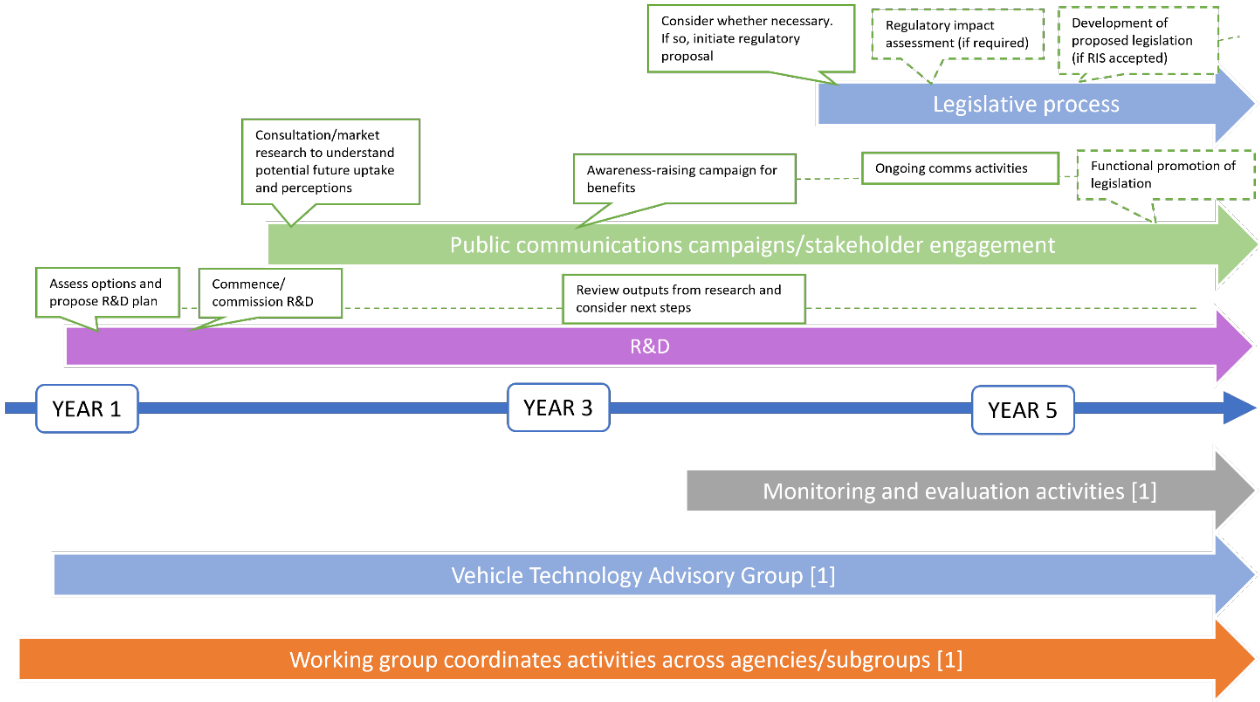
It was suggested that medical stakeholders could make a valuable contribution to the communications work, including advocating for a reduction in impaired driving. The National Trauma Network was also mentioned as a possible stakeholder.

Roadmap

It would be a major challenge to promote the uptake of AISs in their current form. Research is required to understand the state of maturity of these types of technologies and their capacity to prevent impaired driving. The streams that are labelled [1] in Figure 6.6 are the same as for the first roadmaps in this section, and the details for these can be found in Figure 6.1.

[25] Regulation (EU) 2021/7997 - https://data.consilium.europa.eu/doc/document/ST-7997-2021-INIT/en/pdf

Figure 6.6 AIS roadmap



[1] Refer to Figure 6.1 for details.

7 Discussion

This report has provided recommendations on the best ways to increase the uptake of in-vehicle technologies to increase safe and efficient driving behaviour in New Zealand. The literature review has given an overview of the evidence linking in-vehicle technologies to safety and efficiency behaviour improvements, and the data analysis and stakeholder interviews have indicated the extent to which such technologies are likely to deliver cost-effective improvements in New Zealand. The stakeholder interviews have also provided insights regarding the barriers and enablers related to the uptake of technologies. Finally, roadmaps for individual technologies have been suggested, based on logic models and stakeholder insights gathered in a co-creation workshop. This last chapter presents the research findings on the current situation, the differences that the technologies could make and the challenges in achieving these differences, ending with our recommendations and suggestions for further research.

7.1 Fleet characteristics and implications

Our analysis of all registered vehicles sold in New Zealand between 2008 and 2020 found that 59% were new imports and 36% were used imports. Passenger cars and vans accounted for 60% of all vehicles registered in New Zealand. Around 49% of all passenger cars and vans registered in the country were used imports.

The average age of vehicles at the time of this analysis was 13 years for vehicles that had been imported as new and 18 years for vehicles that had been imported as used. Only 15% of vehicles in the New Zealand fleet were 5 years old or less. This is important because most of the technologies under consideration in this report were only introduced around 10 years ago and have only been installed in a significant portion of new vehicles in the last three to five years. Thus, even though the analysis found that AEB was installed in 91% of *new* cars and vans that were manufactured in 2020, it was present in only 9% of all the cars and vans that were registered in New Zealand at the time of this research.

7.2 Factory-fitted technologies with general application

The project investigated five types of factory-fitted technologies that have potential safety benefits throughout the general fleet. These were AEB, LKS, BSM, RCW and ISA.

7.2.1 Current prevalence and trend

We found that at the time of our analysis, the prevalence of factory-fitted technologies in cars and vans registered in New Zealand was around 9% for AEB, BSM and LKS, 14% for RCW and < 1% for ISA.

Installation of AEB and LKS had increased rapidly in new vehicles in the last five years of this study’s time frame, and they were installed in close to 91% and 87% (respectively) of new cars and vans sold in New Zealand in 2020. RCAS and BSM had increased in prevalence less quickly, and they were installed in 69% and 63% (respectively) of new cars and vans sold in New Zealand in 2020. ISA was installed in only 12% of new vehicles in 2020.

7.2.2 Potential crash and cost savings

We found that the technology that would produce by far the greatest savings in terms of crashes and associated costs was LKA. For 2016 to 2020, it was estimated that the savings would have been close to $2 billion if LKA had been installed in all light passenger vehicles. The technology with the second-greatest savings was AEB, at $420 million (including pedestrian and cyclist protection), followed by AIS ($401 million) and ADDW ($349 million).

Crash savings are not additive, as some technologies will prevent the same types of crashes as others, but in different ways.

7.3 Retrofitted technologies that mainly benefit commercial fleets

It was difficult to estimate the prevalence of systems such as driver monitoring, FMT and EWDs accurately, as no New Zealand database systematically collects this data. Our best estimate from the published literature and stakeholder interviews was that around 25% of commercial fleets in New Zealand had some form of FMT in place.

Our crash analysis indicated that FMT and EWDs/ELs have a significant potential to reduce crash involvements among commercial vehicles.[26] However, their effectiveness is highly dependent on how well they are used to manage driver behaviour. Previous research by TRL for the UK's Health and Safety Executive has provided some preliminary guidance on this, but further research is required.

7.4 Other technologies

AISs were estimated to be present in less than 1% of the whole New Zealand vehicle fleet. They are predominantly used as an offender management and rehabilitation device. In their most common form, they were considered to pose too much of an impediment to drivers to be acceptable among the general driving population. In a commercial setting, other solutions such as random drug testing may be more cost effective than installing and maintaining AISs in vehicles that are used by multiple people. Further, DMSs are likely to gain the capability of detecting bio-behavioural changes reflecting driving impairment related to psychoactive substances.

Tyre pressure monitoring was considered a cost-effective technology that could help to improve fuel efficiency. e-Road User Charging was also considered likely to result in efficiency gains.

7.5 Impacts on efficiency

While some of the vehicle technologies of interest have the potential to improve fuel efficiency (by encouraging smoother driving and fuel-efficient speed choices) or to influence kilometres driven (through better monitoring and coordination of routing), we found very little published research that provided insights into the magnitude of these effects or their mechanism of effect. The one study that met our inclusion criteria found a modest fuel efficiency gain of 3% in a fleet of corporate cars in Switzerland (Tulusan et al., 2012). This represents a gap in the research.

Other business efficiencies due to reduced administrative burdens, such as calculating road user charges, filling in paper logbooks and estimating when vehicles are due for service were considered likely to translate into companies receiving fewer penalties arising from their errors in manual book-keeping.

[26] https://trl.co.uk/publications/update-of-indg382-to-include-vehicle-safety-technologies

7.6 Risks of reliance on advanced driver assistance systems

Globally, previous research has identified disbenefits associated with reliance on advanced driver assistance systems. These have included:

- passive fatigue (fatigue from lack of engagement in the driving task, resulting in lack of orientation to the driving task and slower response to safety-critical events)
- skill atrophy
- challenges for the training and education of drivers.

The crash-savings estimates noted earlier take into consideration these kinds of disbenefits. However, good management of these kinds of disbenefits would maximise the benefits accrued from adopting safety technologies.

7.7 Increasing uptake

Our stakeholder consultation aimed to uncover challenges and enablers related to increasing the uptake of technologies in commercial fleets. The options for increasing the uptake of factory-fitted technologies are detailed in the following sections.

7.7.1 General public

- Promote the existing sources of information on the benefits of in-vehicle technologies (eg ANCAP, *My Car Does What?*).
- Provide clear information on the costs and benefits of the technologies.
- Encourage faster turnover of old vehicles and encourage people to buy newer used vehicles through incentives and tax breaks (if appropriate).
- Once the availability of the technologies reaches a critical mass, consider mandating the technologies in both new and used imports. This would have the dual effect of increasing the proportion of new vehicles with the technology installed and decreasing the age of used vehicles being purchased, thereby increasing the prevalence of safety technologies.

7.7.2 Commercial fleet settings

- Ensure government contracts require the most effective technologies.
- Provide incentives, such as tax breaks, to encourage uptake.
- Government to encourage/support bulk buying of vehicles for fleets, to achieve discounts.
- Highlight the health and safety imperative for purchasing the safest vehicles possible for fleets.
- Encourage fleet managers to purchase vehicles with optional safety technologies already installed.

While education is important, mandating some technologies may be necessary, especially where there is a real or perceived conflict between profit and safety (and especially where the risks are perceived as being low, such as driving at up to 3 km/h over the speed limit).

7.7.3 Social considerations

It is well known that road trauma is unequally distributed across demographic, geographic and socioeconomic groups (Austroads, 2016). For example, younger (particularly male) and older drivers are at greater risk of road trauma, as are people from rural and socioeconomically disadvantaged areas. This is an important consideration in the context of in-vehicle technologies, for the following reasons:

- People and businesses with less financial resource are less likely to be able to afford newer vehicles with advanced safety technologies. Young people usually have a lower income and level of accrued savings, and people and businesses in rural areas often have less financial resource than people in urban areas.
- People in rural and low-income areas are often more reliant on personal vehicles, due to factors such as living further from work, education and social opportunities, and the lower availability of public transport. Therefore, they have higher exposure to risk, and improvements in the safety of their vehicles would likely have a greater impact per vehicle.
- Funding for safety improvements on rural roads is challenging because of the vast, sprawling nature of the rural road network and the comparatively low traffic flows. Improvements in the safety of the vehicles travelling those roads, in particular the ability of technology to help drivers avoid drifting out of their lane and travelling at excessive speeds, are likely to be extremely beneficial.

It was out of the scope of this report to consider these issues in more detail. However, it is important to note that the cheap availability of unsafe vehicles likely increases this group’s over-representation in trauma statistics. Increasing access to safer vehicles for this group is a policy issue that warrants further attention.

7.8 Roadmaps and recommendations

The roadmap development workshop highlighted that there are common activities required to enable the increased uptake of any of the safety technologies being considered in this report. When making decisions about which technologies to prioritise, the following factors should be considered:

- **Savings:** The technologies are likely to facilitate crash savings (lane keep systems, in particular, have a high potential to reduce serious crashes).
- **Effort:** How easily could this intervention be implemented?
- **Need for/potential gain from the intervention:** Some technologies will not become common unless there is regulatory pressure or competitive pressure, and for some of them, suboptimal use would mean that the benefits would not be (fully) realised.
- **Synergies:** Promoting one technology could enable the uptake of other technologies (eg the use of EWDs could result in increased use of fleet telematics generally; mandating ESC could already be acting to curtail imports of older vehicles that are less likely to have advanced vehicle safety technologies).
- **Maturity of the technology:** Is the technology’s function likely to be eclipsed by another technology before it becomes mature enough to promote it widely?
- **Feasibility and acceptance:** How practical would it be to implement the technology in a private or commercial setting, and does it have a good level of acceptability among drivers and people making the purchasing decisions?

Actions to support specific interventions include:

- **promotion and education** to generate interest, with clear information on what the technology does, its benefits and limitations, and requirements for maintenance and repairs, to make it easier for people to decide to purchase safer vehicles
- **encouraging competitive pressure** through the star rating systems of vehicles and potentially, by holding information on the safety ratings of commercial drivers and operations on a public site

- **regulation** to mandate fitment of a specific technology where this makes sense, or creating information on the safety and efficiency advantages of using the technology
- **providing incentives**, such as tax rebates for newer/safer vehicles, discounts on safety technologies, supporting industry groups to negotiate bulk-buying discounts for vehicles, and encouraging organisations with fleets that turn over vehicles into the used-car market to purchase safer vehicles.

Based on this, we recommend that Waka Kotahi should do the following:

1. Set up the working groups and advisory groups noted at the beginning of Chapter 6 with clear terms of reference and governance, to coordinate the work effectively.
2. Consider monitoring and evaluation early in each roadmap, to ensure that the necessary data is collected to enable effective monitoring and evaluation of any interventions from baseline, and to inform any business cases or regulatory impact statements. Consider whether changes need to be made to current data collection processes at vehicle registration and whether supplementary surveys might be necessary.
3. Engage early with stakeholders and work with the communications group for each technology to:
    a. understand industry and community needs (including differing needs across demographic, socioeconomic and geographic groups), knowledge, attitudes and behaviours (to inform the communications needs and the approaches and channels of communication that would be most effective)
    b. ensure that clear and relevant information is made available to industry and private buyers of new and used cars regarding the costs and benefits of the technology, as well as how to keep it in working condition
    c. communicate clearly about plans to mandate the technology, to enable industry to plan and encourage early adoption.
4. Based on the factors above, we suggest prioritising the work as follows:
    a. Work towards mandating LKA and AEB in new vehicles because:
        i. LKA has the greatest safety benefit and is maturing quickly to cover a wider range of road types and lane/road edges; AEB has significant benefits for pedestrians and is maturing quickly to cover a broader range of scenarios
        ii. at the time of this research, uptake of these technologies in new vehicles had already risen to 87% (LKA) and 91% (AEB) in the last year; Japan and Europe were moving towards mandating them, and some jurisdictions in Australia were pushing for them to be included in their Australian Design Rules
        iii. the sooner they are mandated in new vehicles, the sooner they can be mandated in used imports.
    b. Also consider working towards mandating BSM and RCW. The technology has existed for a very long time, has reached 60% to 70% fitment in new vehicles, and it should not be difficult for manufacturers to include it.
    c. Set up a small working group to consider feasibility issues for ISA and strategies to overcome any obstacles.
    d. Work towards mandating EWDs/ELs because:
        i. this technology can help improve compliance with fatigue laws in high-exposure and high-risk industries

   ii. increased familiarity with this technology, and skills in using it, may lead to greater comfort with related technology and may encourage the uptake of FMT.

   e. Promote awareness of the benefits of DMSs (DDAW and ADDW) in private and commercial vehicles, and:

      i. monitor their prevalence in the New Zealand fleet to determine when it may be appropriate to mandate them
      ii. ascertain whether concerns about variance in reliability, dependent on the driver's race and sex, are valid.

   f. Investigate the levels of maturity of AISs and the likelihood of future alternative technologies that could detect the impairing effects of a broader range of psychoactive substances than just alcohol, and monitor advancements in those technologies with a view to promoting their use when they come to market.

5. Engage with relevant bodies to:

   a. ensure the repair and maintenance of advanced driver assistance systems is being taught in apprenticeships and relevant automotive courses

   b. develop codes of practice to guide repairs and maintenance

   c. consider developing a warrant-of-fitness test for safety-critical technologies.

6. Commission research to inform better guidance for commercial fleets on how to get the best safety and efficiency outcomes from FMT.

7.9 Further research

It would be worth building on this current work in the following ways:

- Analyse fatal and serious injuries by Crash Movement Type from CAS to fine-tune the estimates of the impacts of technologies on fatalities and serious injuries if the uptake of technologies were to increase. (Note: some of the analysis in this report took this approach, whereas some applied an adjustment factor to all crashes, based on estimates from previous research.)
- The analysis in this report was undertaken for individual technologies in isolation; however, the resulting benefits that were found were not additive, as (1) multiple technologies could have been present in vehicles, all contributing to reducing crashes to varying degrees; (2) multiple vehicles with different technologies could have been involved in a crash; and (3) multiple crash factors could have contributed to a crash's occurrence and severity. Therefore, it would be useful to conduct further analysis that attempts to attribute crash savings to the technology that would have contributed the most to crash mitigation in a way that would enable a summation of cumulative benefits.
- It would be beneficial for future work to consider separating out light passenger vehicle types to enable an evaluation of the potential sequencing of a staged mandating of technologies in different types of light vehicles.
- Calculate the estimated social cost savings from in-vehicle safety technologies as a proportion of the total New Zealand social costs of crashes over time, taking into consideration the implementation of the interventions suggested in the roadmaps in this report. This could be done as part of forecasting for future road safety strategies.
- Quantify the regulatory costs associated with implementing these recommendations (to support future business cases).

These actions would help to prioritise actions to increase the uptake of in-vehicle safety technologies in future road safety strategies by making it possible to compare the costs and benefits of these interventions with other interventions across the Safe System pillars and over time.

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Appendix A: Literature review method

A list of search terms relevant to the research questions was generated to conduct the literature search (see Table A.1). These search terms were applied in several research databases (TRID, ScienceDirect, GoogleScholar) as Boolean search expressions. Multiple searches were conducted within each database through an iterative process, wherein each search term was tested individually, as well as with others, to identify which terms generated the results that were most relevant. Any relevant variations of given terms were also used (eg benefit, benefits, beneficial) using wildcard terms (*) where possible. Boolean operators, wildcard characters and filters were also used to refine the search output to only the results that were most relevant.

The first-level terms in Table A.1 cover the various technologies under investigation, as well as alternative phrasings of each. For example, “Driver drowsiness and attention warning system” was also searched for using a combination of the terms “drowsiness”, “distraction”, “attention”, “warning” and “system” (ie “driver drowsiness system”, “driver distraction system”, “drowsiness and attention warning system”, etc). Second-level terms relate to impacts and outcomes, while third-level terms cover any additional relevant terms that were likely to help further refine the search output.

Fourth-level ‘NOT’ terms were included as necessary, to remove non-relevant literature from the search output. Specifically, the term “autonomous vehicle” was used to exclude research focusing on ‘driverless’ vehicles; “development” was used to exclude research focused on the technical design stages of a technology; and “acceptability” was used to exclude research focusing on perceptions and opinions on specific technologies.

Table A.1 Search terms

1st level		2nd level		3rd level		4th level
“Vehicle tech”*	AND	Behaviour	AND	Safe	NOT	“Autonomous vehicle”
“Vehicle monitoring system”*		Drowsiness		Efficient		Development
“Driver monitoring system”*		Distraction		Improve		Acceptability
“Driver monitoring tech”*		Crash		Impact		
Telematics		Collision		Likelihood		
“Black box”		Incident		Reduction		
“Intelligent speed assist”		Hazard		Effective		
ISA		Risk		Efficacy		
“Collision warning system”		Benefit		Rate		
“Autonomous emergency braking”		Accident		Analysis		
AEB		Use		Comparison		
“Lane keep assist”		Cost				
“ALKS”						
“Electronic logbooks”						
“Event data recorder”						
EDR						
“Event vehicle data recorder”						
EVDR						
“Cyclist warning”						

1st level		2nd level		3rd level		4th level
"Pedestrian warning" **"Blindspot detection"** **"Drug interlock"** **"Alcohol interlock"** **"Driver Drowsiness and Attention Warning system"** **DDAW** **"Advanced Driver Distraction Warning system"** **ADDW** **"Efficient driving tech"***						

After conducting and refining the literature search, the relevant literature was compiled in a spreadsheet for systematic review. Search output that was clearly irrelevant based on the title or abstract was removed. The initial list of literature that was included in the spreadsheet at this stage totalled 55 separate research papers. The literature was then scored on the inclusion criteria (see Table A.2). These criteria ensured that only literature that was the most relevant and of the highest scientific quality was taken forward for full review. Only literature with a score of 3 in one criterion and a score of at least 2 in the other criteria was given a full-text review.

Table A.2 Literature inclusion criteria

Criterion	Score = 1	Score = 2	Score = 3
Relevance	Not relevant to the objectives of the project	Some indirect relevance to the objectives of the review	Directly relevant to the objectives of the review (ie research that evaluates the impact of specific in-vehicle technologies)
Quality	Study does not meet the criteria to score either 2 or 3	Study provides some insight into the impact of the technology (though not necessarily through an assessment of change) or fails to account for some confounding variables	Study demonstrates an assessment of the change associated with the introduction of the technology (relative to not having it), and attempts in some way to take account of confounding variables (eg through control groups)

In addition to the scoring criteria outlined above, the timeliness of each paper was also considered when selecting the literature. For the technologies that were covered in Seidl et al. (2017), this current review focused on research that had been completed since that work. For technologies that were not covered in Seidl et al. (2017), literature that was up to 10 years old was considered for review, while work published more than 10 years ago was only considered if it was already known to the project team. The main reason for this restriction was the assumption that in-vehicle technologies have advanced in the last 10 years and thus, findings from older research might not have been truly reflective of current systems.

Once a shortlist had been determined by the inclusion criteria, the literature was then given full review, with the findings systematically recorded within the review spreadsheet, with a row for each individual source and a summary of its research goals, methods and findings. Conclusions were drawn from each reference relating to the research questions of this current investigation. In total, 34 separate research papers were reviewed in full.

Appendix B: Participant information sheet

Information Sheet – Use of in-vehicle technologies

What is the purpose of this study?
Waka Kotahi NZ Transport Agency has commissioned TRL to undertake research into the up-take and use of in-vehicle technologies to assist with and encourage safe and efficient driving in New Zealand. The aim is to understand how technologies are implemented in fleets and other settings, the barriers to implementation and the broad lessons learned in the actual use of such technologies.

Why have I been selected?
You have been invited to participate as you have been identified as a person that could contribute to our understanding of the up-take and use of in-vehicle technologies in New Zealand.

What does the study involve?
If you decide to take part, you will be asked to fill out a registration survey (which will take around 5 minutes to complete) and, if chosen, participate in an interview via Teams. We will agree a convenient time for the interview with you and expect it to last between 45-60 minutes.

Interviews will begin with the researcher explaining the research and providing you with the opportunity to ask any questions you may have. There will also be time to answer any questions you may have after finishing. During the interview, you will be asked about your understanding of how technologies are implemented in fleets and other settings, the barriers to implementation and the broad lessons learned in the actual use of such technologies.

With your consent we will record the interview so that we can check our understanding of what was said later on. We may also make notes during the interview. We will treat any information about you obtained during this research in the strictest confidence. Any personal identifying data will be kept in an electronic database and then deleted confidentially. Your personal details, interview notes and recordings will be handled in accordance with our data protection policies (available on request or on our website – TRL's Privacy Notice). Both paper and electronic data will only be accessible to members of the research team who need access to it. When reporting the findings of the study, all information and data (including your responses) will be fully anonymised to ensure that individuals are not identifiable, and their data cannot be linked to their identity. All information will be anonymised before being delivered in a presentation and written report to Waka Kotahi.

What are the possible benefits of taking part?
The outcomes from this research will contribute to Waka Kotahi's understanding of the implementation of in-vehicle technologies in New Zealand and their effective use. There is no compensation for taking part in the pre-interview screening survey. Interview participants will be able to nominate one of three New Zealand based charities to receive a $50 NZD donation: Blind Low Vision NZ, Philips Search and Rescue Trust, or Brake NZ.

What are the possible disadvantages or risks of taking part?
None are anticipated.

What will happen to the results of the research?
The results of the research will be compiled and anonymised before being presented as a presentation and written report. This written report will contain recommendations informed by the results of our research. Waka Kotahi may publish the results in their inhouse publications.

Ethical review of the study
The project did not require an ethical review.

Contacts for further information
If you have any further questions, please contact the Technical Lead, Victoria Pyta on vpyta@trl.co.uk

Thank you for your help in advance!

Appendix C: Pre-interview survey

WAKA KOTAHI NZ TRANSPORT AGENCY TRL THE FUTURE OF TRANSPORT

Thank you for your help with our research about in-vehicle technologies that assist and encourage safe and efficient driving behaviour. The survey will help us to understand a little about you and your organisation prior to our discussion with you.

The survey will take around 5 minutes to complete. Completing the survey is entirely voluntary and you can stop at any time.

At the end of the survey, you will be asked if you are willing to take part in a discussion over Teams with a TRL researcher.

Findings from this survey will help us to plan our discussion with you, and findings from this research overall will help Waka Kotahi to understand how technologies are implemented into fleets and other settings, the barriers to implementation and the broad lessons learned in the actual use of such technologies.

For more details about this study or if you have any questions, please email Victoria Pyta at vpyta@trl.co.uk

1. Before you complete the rest of the survey, it is important for us to obtain your consent. Please select 'Yes' or 'No' for each statement as appropriate. *

	Yes	No
I confirm that I have read the above information for this survey, and I have had the opportunity to consider the information.	☐	☐
I understand that my participation is voluntary and that I am free to withdraw at any time without providing a reason.	☐	☐
I understand that if I decide to withdraw, any data that I have provided up to that point will be deleted.	☐	☐

2. What type of organisation do you represent? (If more than one applies, please choose all that apply) *

- [ ] An organisation with a commercial fleet (i.e. any vehicle owned/leased and operated by your organisation)
- [ ] Insurer
- [ ] Industry group
- [ ] In-vehicle technology provider
- [ ] Vehicle leasing company
- [ ] Other (please specify):

3. What is your job title and brief responsibilities?

3. Fleet operators

4. How many vehicles are in your organisation's fleet?

- [ ] 1-5
- [ ] 6-10
- [ ] 11-20
- [ ] 21-50
- [ ] 51-100
- [ ] Over 100

5. For each of the following in-vehicle technologies, please indicate whether your organisation... is using the technology in any of its vehicles is considering using might consider using in the future would not consider using Definitions of each technology are listed here.

	Using	Considering using	Might consider in the future	Would not consider	Don't know
Autonomous /automated emergency braking	☐	☐	☐	☐	☐
Forward collision warning system	☐	☐	☐	☐	☐
Lane departure warning/ lane keeping assist	☐	☐	☐	☐	☐
Intelligent speed assistance	☐	☐	☐	☐	☐
Intelligent speed adaptation	☐	☐	☐	☐	☐
Driver monitoring systems	☐	☐	☐	☐	☐
Fleet management telematics	☐	☐	☐	☐	☐
Alcohol interlock system	☐	☐	☐	☐	☐
Electronic log books	☐	☐	☐	☐	☐
Blind spot monitoring	☐	☐	☐	☐	☐
Rear collision warning system	☐	☐	☐	☐	☐

Comments:

4. Fleet operators

6. Was the forward collision warning system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

5. Fleet operators

7. Was the intelligent speed assistance technology factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

6. Fleet operators

8. Was the rear collision warning system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

7. Fleet operators

9. Was the driver monitoring system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted

- [ ] Don't know

8. Fleet operators

10. Were the fleet management telematics factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

9. Fleet operators

11. Was the alcohol interlock system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

10. Fleet operators

12. Were the electronic logbooks factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

11. Fleet operators

13. Was the blind spot monitoring factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

12. Insurers

14. Does your insurance company actively encourage the uptake of technologies in commercial fleets?

- [ ] Yes
- [ ] No
- [ ] Don't know

13. Insurers

15. Which of the following technologies does your insurance company encourage? Definitions of each technology are listed here.

- [ ] None
- [ ] Autonomous/automated emergency braking
- [ ] Forward collision warning system
- [ ] Lane departure warning/Lane keeping assist
- [ ] Intelligent speed assistance
- [ ] Intelligent speed adaptation
- [ ] Driver monitoring systems
- [ ] Fleet management telematics

☐ Blind spot monitoring

☐ Rear collision warning system

☐ Other (please specify):

16. Vehicle leasing companies

18. For each of the following in-vehicle technologies, please indicate whether your organisation... is using the technology in any of its vehicles is considering using might consider using in the future would not consider using Definitions of each technology are listed here.

	Using	Considering using	Might consider in the future	Would not consider	Don't know
Autonomous/automated emergency braking	☐	☐	☐	☐	☐
Forward collision warning system	☐	☐	☐	☐	☐
Lane departure warning / Lane keeping assist	☐	☐	☐	☐	☐
Intelligent speed assistance	☐	☐	☐	☐	☐
Intelligent speed adaptation	☐	☐	☐	☐	☐
Driver monitoring system	☐	☐	☐	☐	☐
Fleet management telematics	☐	☐	☐	☐	☐
Alcohol interlock system	☐	☐	☐	☐	☐
Electronic logbooks	☐	☐	☐	☐	☐
Blind spot monitoring	☐	☐	☐	☐	☐
Rear collision warning system	☐	☐	☐	☐	☐

Comments:

17. Vehicle leasing companies

19. Was the forward collision warning system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

18. Vehicle leasing companies

20. Was the intelligent speed assistance technology factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

19. Vehicle leasing companies

21. Was the rear collision warning system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

20. Vehicle leasing companies

22. Was the driver monitoring system factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

21. Vehicle leasing companies

23. Were the fleet management telematics factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

22. Vehicle leasing companies

24. Was the alcohol interlock system technology factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

23. Vehicle leasing companies

25. Were the electronic logbooks factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted

- [ ] Don't know

24. Vehicle leasing companies

26. Was the blind spot monitoring technology factory-fitted (i.e. fitted at the point of manufacture) and/or retrofitted (added at a later date)?

- [ ] Factory-fitted
- [ ] Retrofitted
- [ ] Don't know

27. Do you have any views on barriers which might prevent uptake of in-vehicle technologies in commercial fleets in New Zealand? If so, please briefly list them here.

28. Do you have any views on what would encourage uptake of in-vehicle technologies in the commercial fleets in New Zealand? If so, please briefly list them here.

29. Do you have any data which you would be able to share with TRL regarding the current uptake of in-vehicle technologies in New Zealand? If so, please describe, share a link or upload. Please tell us if there are any conditions for using this data (e.g. there is anything you would rather not be shared).

30. File upload

☐ File: {{filename}}delete

Choose File

Uploading...

31. As mentioned previously, we will be exploring some of the survey responses further using interviews. These will last for around 45-60 minutes and will be carried out at a time convenient to you between 31st May and 18th June. For those that take part in the interviews, a donation will be made on your behalf, of $50 NZD, to one of these 3 charities: Brake - Road safety organisation Blind low vision - NZ guide dogs charity Rescue - NZ rescue helicopters charity Interviews will be held via Microsoft Teams (accessible via an internet browser). Should you be selected to take part, a member of our research team will be in contact with you soon to arrange a timeslot. Are you interested in taking part in an interview? *

☐ Yes / maybe

☐ No

Thank you for your interest, here is some further information on the interviews:

During the interview, our researcher will take notes and, if you agree, video and/or audio record the interview. The recording is to act as a back-up and a resource for us to review our notes after the interview, and will be deleted after the report is completed. If you would not like us to video and/or audio record the discussion, you are still able to take part. Your responses will be kept completely confidential and stored securely.

All data will be anonymised, and it will not be possible for anyone to identify who has answered the questions. The data collected will not be shared with any third parties. TRL may use anonymised or pseudonymised quotes in the project report.

TRL's Data Privacy Notice is available here. Any personal information that we hold will be processed as described in this document and for the purpose of achieving the research objectives.

Should you have any questions or require any additional information, please contact us at vpyta@trl.co.uk.

If you are interested in taking part in an interview, please complete the consent form and personal details below.

32. Consent to take part in interviews Do you agree with all of the following points? I confirm that I have read the above information about the interviews, and I have had the opportunity to consider the information. I understand that the information I provided in this survey will be used by TRL to decide whether to invite me to take part in the interviews. I understand that my participation is voluntary and that I am free to withdraw at any time without providing a reason. I understand that if I decide to withdraw, any data that I have provided up to that point will be excluded from analysis. I consent to the processing of my personal data for data analysis purposes as described in the above information and TRL's Data Privacy Notice. I understand that my data will be anonymised and that my anonymised data may be used in future research. I understand that the interviews will be audio recorded for data analysis purposes. I consent to the use of anonymised quotes (from the interview) in reports. *

- [ ] Yes, I agree with all 7 points
- [ ] No, I do not agree with one or more points

33. You did not agree with one or more of the consent questions. This means we are not able to invite you to take part in an interview. If you would like to attempt to complete the consent form again, please indicate below, otherwise please select 'end survey'.

- [ ] Complete consent form
- [ ] End survey

34. Consent to take part in interviews Do you agree with all of the following points? I confirm that I have read the above information about the interviews, and I have had the opportunity to consider the information. I understand that the information I provided in this survey will be used by TRL to decide whether to invite me to take part in the interviews. I understand that my participation is voluntary and that I am free to withdraw at any time without providing a reason. I understand that if I decide to withdraw, any data that I have provided up to that point will be excluded from analysis. I consent to the processing of my personal data for data analysis purposes as described in the above information and TRL's Data Privacy Notice. I understand that my data will be anonymised and that my anonymised data may be used in future research. I understand that the interviews will be audio recorded for data analysis purposes. I consent to the use of anonymised quotes (from the interview) in reports. *

- [ ] Yes, I agree with all 7 points
- [ ] No, I do not agree with one or more points - this will end the survey

35. Please provide your... *

Name *	
Organisation name *	
Email address *	
Contact phone number *	

36. Are you based in New Zealand or elsewhere?

- ☐ New Zealand
- ☐ Elsewhere

37. Please indicate when you may be available for a 45-60 minute interview. We would appreciate it if you could indicate which of the following times would be suitable (our researchers are based in the UK), and we will be in touch soon to arrange. If none of these times are suitable, please leave the question blank and we will get in touch with you.

	08:00	09:00	17:00	18:00	19:00	20:00
Thursday 1st July	☐	☐	☐	☐	☐	☐
Friday 2nd July	☐	☐	☐	☐	☐	☐
Monday 5th July	☐	☐	☐	☐	☐	☐
Tuesday 6th July	☐	☐	☐	☐	☐	☐
Wednesday 7th July	☐	☐	☐	☐	☐	☐
Thursday 8th July	☐	☐	☐	☐	☐	☐

	08:00	09:00	17:00	18:00	19:00	20:00
Friday 9th July	☐	☐	☐	☐	☐	☐

Comments:

38. Please indicate when you may be available for a 45-60 minute interview. We will contact you soon to arrange.

	Morning	Afternoon
Thursday 1st July	☐	☐
Friday 2nd July	☐	☐
Monday 5th July	☐	☐
Tuesday 6th July	☐	☐
Wednesday 7th July	☐	☐
Thursday 8th July	☐	☐
Friday 9th July	☐	☐

Comments:

Appendix D: Topic guide

Topic Guide

1 ART 19 07 – Use of in-vehicle technologies to assist with and encourage safe and efficient driving behaviour

Thank you very much for agreeing to take part in this interview. Waka Kotahi NZ Transport Agency has commissioned TRL to undertake a project to research the up-take and use of in-vehicle technologies to assist with and encourage safe and efficient driving in New Zealand.

The interview should take up to 45 minutes and during the interview, you will be asked about your understanding of how technologies are implemented, the barriers to implementation and the broad lessons learned in the actual use of such technologies.

With your consent we will record the interview so that we can check our understanding of what was said later on. We may also make notes during the interview. We will treat any information about you obtained during this research in the strictest confidence and any responses will be anonymised so that participants cannot be identified.

Do you have any questions about the interview or the study?

Could you please confirm that:

Is all this okay with you? ☐ ☐

Would you be happy for me to record this interview? ☐ ☐

1.1 Understand the real-world experiences, barriers and facilitators to implementing in-vehicle technology designed to improve the safety and efficiency of driving behaviour

1.1.1 Fleet operators or vehicle leasing companies who installed or are actively considering technologies

RESPONDENTS: Fleets that have installed (or tried to install) at least one of the technologies of interest (with a preference for those that have installed multiple technologies and can talk to their experience of this).

[Fill in before interview based on survey responses:]

	Using	Consider using	Might consider in the future	Would not consider
Autonomous /automated emergency braking				

Forward collision warning system				
Lane departure warning/lane keep assist				
Intelligent speed assistance/adaptation				
Rear collision warning system				
Pedestrian warning system				
Driver monitoring system				
Fleet monitoring telematics				
Alcohol interlock system				
Electronic logbooks				
Blind spot monitoring				

In the survey, you indicated that your organisation has installed or is actively considering the following in-vehicle technologies:

Installed: ....

Actively considering:...

Prevalence - fleet and leasing companies

For each technology installed/being considered:

- Roughly how much of the fleet is fitted / will be fitted with xxx technology?
  - How did you decide which vehicles to purchase/fit with the technology?
  - What proportion of the vehicles were factory fitted with xxx technology and how many were retrofitted?
- How did you make the decision to fit xxx technology/purchase vehicles with xxx technology factory fitted? Why did you decide this?
    - *Prompts: Relative importance of finance versus safety, what information did the participant have to base these decisions on, how did they go about finding the required info?*
- Did you consider using any other technologies? Why did your company decide not to use those? Might you introduce any in the future?

Use in fleet – fleet operators only

- Are drivers / would drivers be provided with training/support in how to use xxx technology?
- Are drivers / would drivers be required to use xxx technology, or are they able to choose whether to use it?
    - If required – for all drives or just a proportion e.g. over a certain distance?
    - If choose – please elaborate
- Are there / would there be any data outputs associated with xxx technology?
    - If yes – who can access the data (drivers/management)? How is this used? Could it be changed to be more effective/user-friendly? Are drivers / management expected to act on feedback?
        - *Prompts: are drivers expected to perform better against set objectives, is there an impact on employment or promotions/incentives/sanctions, any insurance consequences?*
- What are driver attitudes towards xxx technology?
    - *Prompts: Generally negative or positive? Have any drivers joined/left the company as a result of the introduction of the technology? For those that have used the technology, did their attitudes change with experience?*

Changes in behaviour/efficiencies – fleet and leasing

- Has the use of xxx technology led to a real change in:
    - driver behaviour including safety outcomes? How?
    - driving efficiencies? What types? How?

In the survey, you indicated that your organisation has considered but decided against / might consider / would not consider using the following in-vehicle technologies:

ASK ALL:

Barriers/enablers

- In the survey you mentioned xxx barrier/s to preventing the uptake of in-vehicle technologies. Could you please explain this in more detail?
    - [If not stated:] Do any relate specially to purchasing vehicles with xxx factory fitted technologies?
    - [If not stated:] What about retrofitting vehicles with xxx technology?
        - *Prompt for both: Availability, cost, incompatible with New Zealand's legislation*

- *Prompt for both: work culture, union interventions, conflicting business objectives i.e. safety versus time and money, insurance issues, retrofitting issues, concern around the usefulness of this, financial, managerial concerns, employee resistance and concerns*

- In the survey you mentioned xxx to encourage the uptake of technologies in New Zealand. Could you please expand on this?
  - [If not stated:] What needs to change to enable the purchase of vehicles factory fitted with technologies? [Which?]
  - [If not stated:] What needs to change to enable retrofitting to commercial vehicles? [How will this make a difference?]
- In addition to what you already mentioned, is there anything else that you can think of in the New Zealand context which could contribute to these barriers? [How? Why?] What about enablers?
  - *Prompts: regulations, vehicle fleet characteristics, retrofitting, factors to do with insurance, unions, work cultures*
- How important is/was management buy-in and support in (considering) introducing in-vehicle technologies?
- How do you approach/resolve competing priorities between driver safety and business objectives?
  - What role do drive efficiencies play in this?
- Are there any drivers who are less willing to engage with technologies? [Why do you think this is? How could this be changed?]
  - *Prompts: culture, demographics, age, personality*

1.2 Understand the fleet make up in New Zealand, including the prevalence of after-market (or retrofitted) technologies that influence driver safety and efficiency

1.2.1 Insurers, industry groups, in-vehicle technology provider, vehicle leasing company

RESPONDENTS: Stakeholders who have an understanding of the New Zealand context, especially those things that are likely to impact on the feasibility of increasing the uptake of various technologies and their effectiveness on implementation, including…

Prevalence

- What is your understanding of the prevalence of in-vehicle technologies within the commercial fleet in New Zealand? [If they have not already added this to the survey, can you provide us with any data?]

Barriers / enablers

- In the survey you mentioned xxx barrier/s to preventing the uptake of in-vehicle technologies in New Zealand. Could you please expand on this?
    - [If not stated:] Do any relate specially to purchasing vehicles with xxx factory fitted technologies?
    - [If not stated:] What about retrofitting vehicles with xxx technologies?
        - *Prompt for both: Availability, cost, incompatible with New Zealand's legislation*
        - *Prompt for both: work culture, union interventions, conflicting business objectives i.e. safety versus time and money, insurance issues, retrofitting issues, concern around the usefulness of this, financial, managerial concerns, employee resistance and concerns*
- In the survey you mentioned xxx to encourage the take-up of technologies in the commercial fleets in New Zealand. Could you please expand on this?
    - [If not stated:] What needs to change to enable the purchase of vehicles factory fitted?
    - [If not stated:] What needs to change to enable retrofitting?
- In addition to what you already mentioned, is there anything else that you can think of in the New Zealand context which could contribute to these barriers/enablers? [How? Why?]
        - *Prompts: regulations or legislation, vehicle fleet characteristics, retrofitting, factors to do with insurance, unions, work cultures*
- What needs to change to facilitate increased up-take and use of technologies?
        - *Prompts: legislation, regulations, insurance provision*

Impact of drivers or organisations

- What are the attitudes of drivers and organisations towards work related road risk? Why?
- Is the safety of commercial drivers on the road seen as the responsibility of the individual/company or both?
- What policies/procedures are in place to reduce work related road risk?
- Generally, what do you think are the attitudes of workers and companies towards health and safety? What factors do you think have an impact on this?
- Do you find that some drivers are more willing to engage with technologies? Why do you think this is? How could this be changed?
        - *Prompts: culture, demographics, age, personality*

Is there anything else that you would like to add that you feel we should know and have not already discussed?

Thank you very much for contributing to this study. Which of the following charities would you like to donate the $50 NZD to: Blind Low Vision NZ, which trains and provides guide dogs; Philips Search and Rescue Trust, which is the charity responsible for North Island's largest pool of community rescue helicopters; or Brake, the road safety organisation?

Before we go, do you have any questions about the interview or the research study?

[Please note down the choice of charity on the participant spreadsheet.]

Appendix E: Target populations from CAS data

Table E.1 presents the criteria (fields and codes) used to determine the target population for each technology from the CAS data.

Table E.1 Criteria for extracting the target population from the CAS data

Technology	Target population – CAS definition
Automated Emergency Braking (vehicle to vehicle)	All casualties in the following collisions: • Crash movement code is an F code or GA or MG • First vehicle ('crashrole' = 1) is the primary vehicle type of interest • First vehicle has 'vehiclestate' moving forward or Null • Second vehicle ('crashrole' = 2) is a bus, car/wagon, SUV, truck, truck hpmv, van, ute
Automated Emergency Braking (vehicle to cyclist)	Cyclist casualties in the following collisions: • Movement codes: AB, BA, BB, BC, BD, BE, BF, BO, F codes, GA, MG • For rear-end-related codes: Crashrole = 2 must be cyclist; 'vehiclestate' of vehicle with crashrole = 1 is 'moving forwards' or Null; First vehicle (crashrole = 1) is listed in primary vehicle type column • For head-on codes: Crashrole of cyclist is 1 or 2; other vehicle must be a primary vehicle type; other vehicle must be 'moving forwards' or 'Null'
Automated Emergency Braking (vehicle to pedestrian)	Pedestrian casualties in the following collisions: • N or P movement code • 'vehiclestate' of vehicle with 'crashrole' = 1 is 'moving forwards' or Null • First vehicle ('crashrole' = 1) is listed in the primary vehicle type column
Forward Collision Warning	Same as for AEB. At a crash level only for trucks
(Emergency) Lane Keep Assist	All casualties in any of the following crashes: 1. At least 2 vehicles involved; speed limit at least 70 km/h; movement code is a B code; 'crashrole' = 1 vehicle is a primary vehicle type; 'crashrole' = 2 vehicle is not a cycle, other, train or 50MAX; primary surface condition is dry or wet; not contributory factor 823 (flooding) 2. Movement code BA or BD; 'crashrole' = 2 vehicle is a primary vehicle type; 'crashrole' = 1 vehicle is not a cycle, other, train or 50MAX; primary surface condition is dry or wet; not contributory factor 823 (flooding) 3. Single vehicle; 'crashrole' = 1 vehicle is a primary vehicle type; speed limit at least 70 km/h; movement code is CB or CC; primary surface condition is dry or wet; not contributory factor 823 (flooding)
Lane Departure Warning	All casualties in any of the following crashes: 1. 'crashrole' = 1 vehicle is a primary vehicle type; 'crashrole' = 2 vehicle is not a cycle, other, train or 50MAX; movement code is a B code 2. 'crashrole' = 2 vehicle is a primary vehicle type; 'crashrole' = 1 vehicle is not a cycle, other, train or 50MAX; movement code is BD 3. 'crashrole' = 1 vehicle is a primary vehicle type; movement code is one of: CB, CC, DB, DC, DE, DF, DH, DJ, DO

Technology	Target population – CAS definition
Intelligent Speed Assist (Voluntary)	All casualties in the following crashes: • Crashes with at least one vehicle (of the associated primary vehicle type) having contributory factor 518 (exceeding speed limit); vehicle also has no factor indicating they were engaged in other non-compliant behaviour
Rear Collision Warning (camera-based)	• For pedestrians: Casualties with 'roadUserType' as pedestrian or wheeled pedestrian in the following collisions: Vehicle with 'crashrole' = 1 is a primary vehicle type; vehicle state (of crashrole = 1 vehicle) is 'reversing' • For cyclists: Casualties with 'roadUserType' as cyclist in the following collisions: Vehicle with 'crashrole' = 1 is a primary vehicle type; vehicle state (of crashrole = 1 vehicle) is 'reversing'
Driver Drowsiness and Attention Warning	Casualties in collisions where a vehicle of primary vehicle type has a contributory factor of one of the following (indicating fatigue): 410, 411, 412, 414, 415
Advanced Driver Distraction Warning	Casualties in collisions where a vehicle of primary vehicle type has a contributory factor of one of the following (indicating fatigue or distraction): 330, 350–356, 358, 359, 361–364, 366, 410, 411, 412, 414, 415
Fleet Management Telematics	All crashes involving a commercial vehicle of primary type
Alcohol Interlock Systems	Casualties in collisions where a vehicle of primary vehicle type has CF103 (alcohol test above limit or refused), CF101 (alcohol suspected) or CF100 (other alcohol)
Electronic Work Diary/Logbook	All crashes involving a commercial vehicle of primary type
Blind Spot Monitoring	The following collisions: • Vehicle with 'crashrole' = 1 must be a truck • Movement codes AA, AC, GB, GC, KA, KB, KC, KO • 'crashrole' = 2 vehicle – must be bus, car/wagon, SUV, truck, truck hpmv, van, ute • 'crashrole' = 1 vehicle is not engaged in non-compliant behaviour

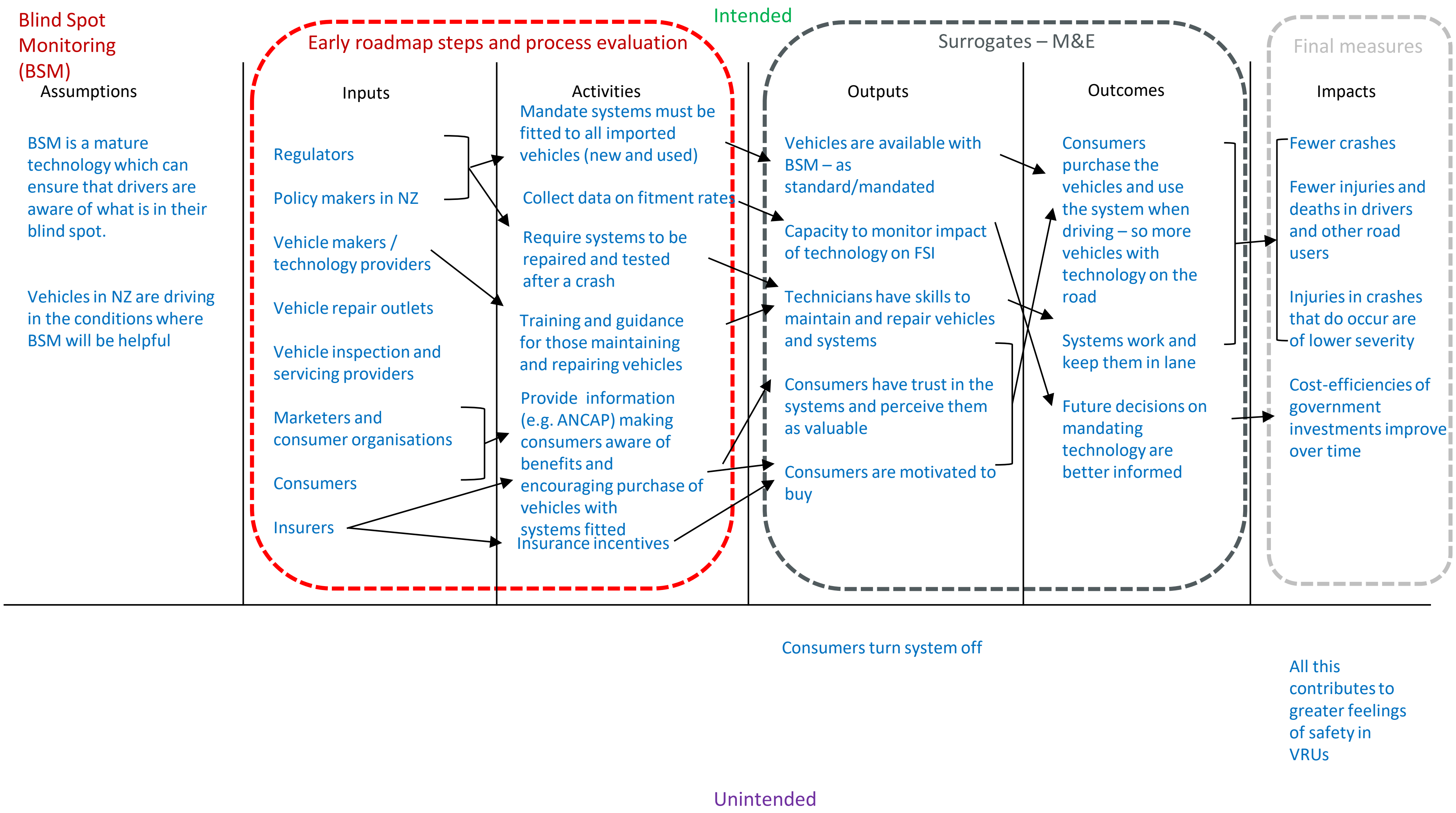
Appendix F: List of non-compliance factors

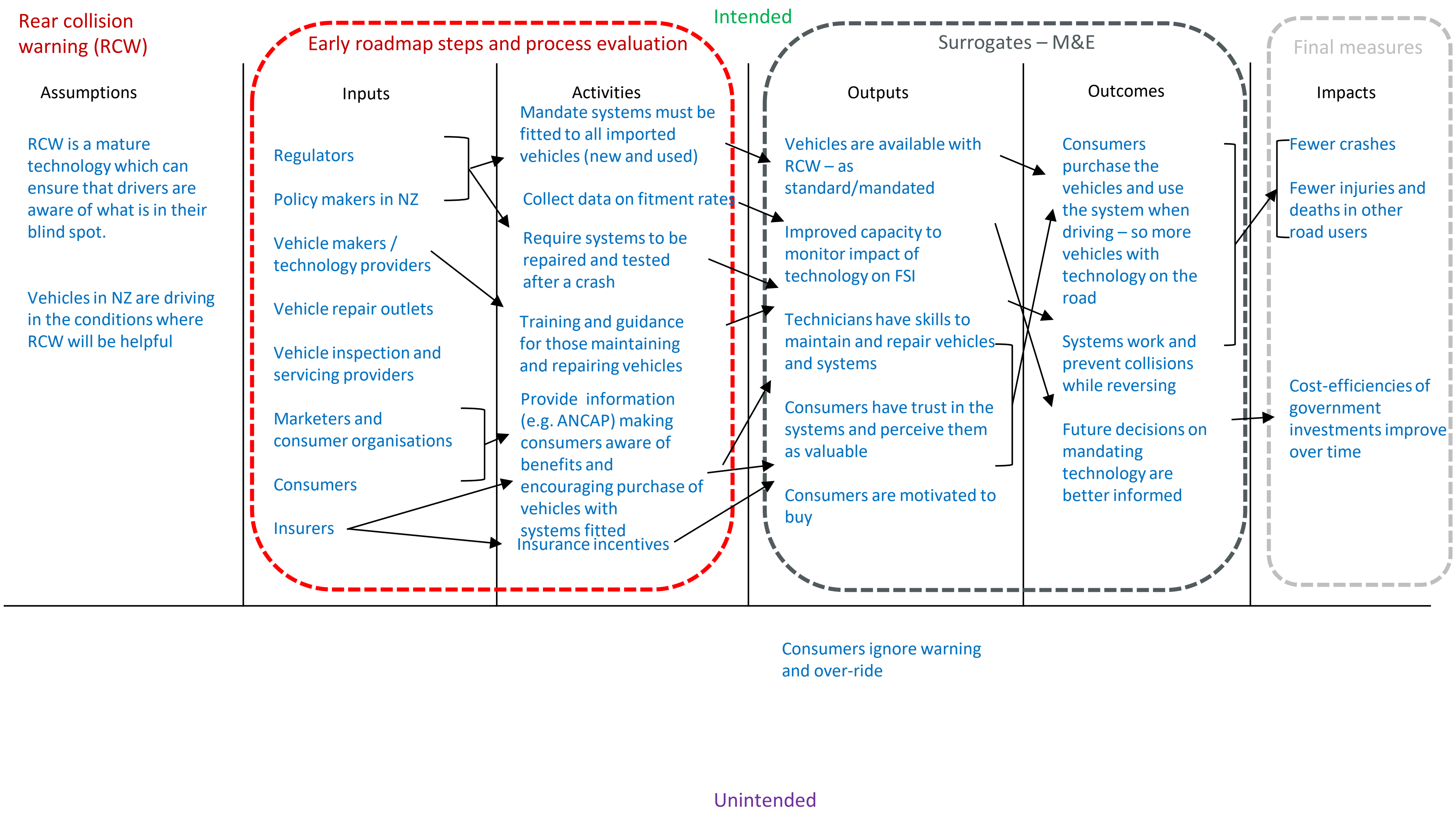
Table F.1 gives the list of non-compliance factors identified in the CAS data, by factor ID (given in the data as 'contributingfactortypeid') and name ('contributingfactortypename').

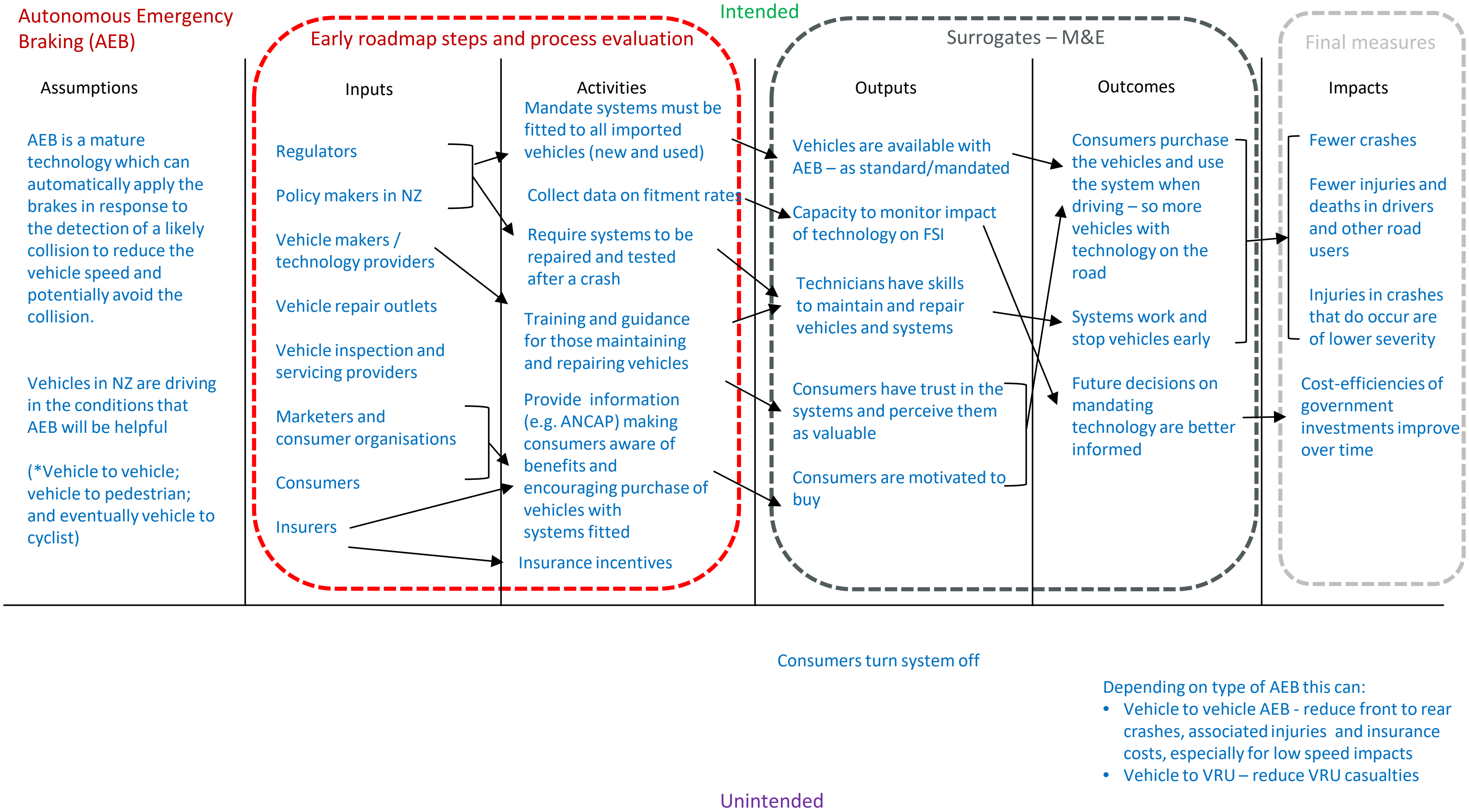
Table F.1 Non-compliance factors identified in the CAS data

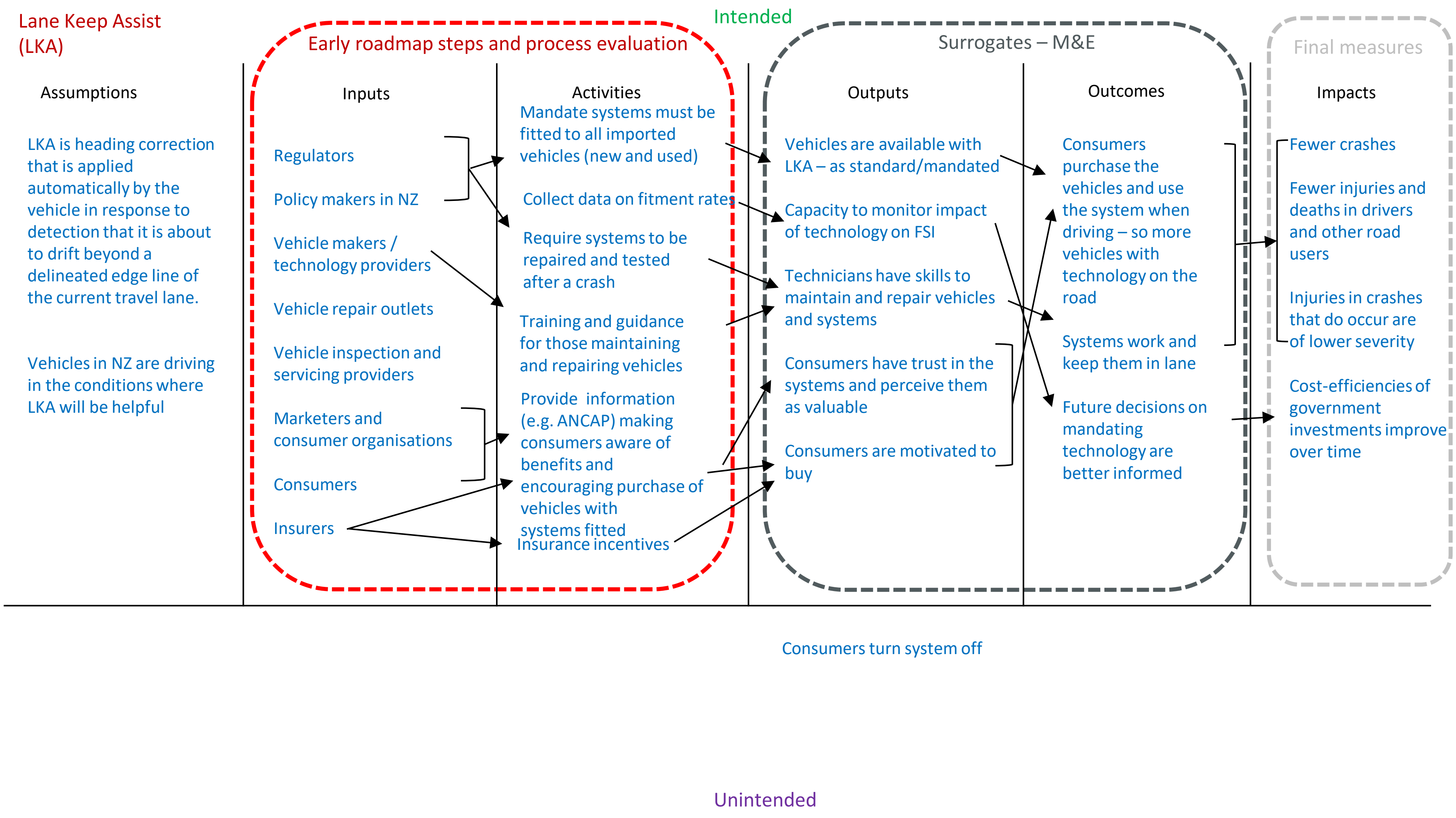
Factor ID	Name	Factor ID	Name	Factor ID	Name
100	Other alcohol	432	Playing chicken	602	Headlights fail suddenly, inadequate/no headlights
101	Alcohol suspected	433	Wheelspins/wheelies/ doughnuts/drifting	604	Brake-lights or indicators faulty or not fitted
103	Alcohol test above limit or test refused	434	Intimidating driving	605	Tail-lights inadequate or no tail-lights
108	Drugs suspected	503	Defective vision	606	Reflectors inadequate or no reflectors
109	Drugs proven	506	Attempted suicide	665	Inadequate tow coupling
200	Forbidden movements	510	Other intentional or criminal	666	Inadequate or no safety chain
201	Wrong way in one-way street, motorway or roundabout	511	Homicide/suicide (successful)	680	Load
202	Non-compliance with regulatory device with sign	512	Intentional collision	681	Load interferes with driver
220	Other drugs	514	Evading enforcement	682	Load not well secured, or load moved
313	To emergency vehicle	515	Object thrown (at/by/from)	683	Load overhanging
359	Attention diverted by cell phone	517	Stolen vehicle	684	Load obscured vision
426	Lights not switched on	521	Intentionally leaving/ boarding moving vehicle	686	Over-dimension vehicle or load
429	Trailer coupling or safety chain not secured	532	Casualty thrown from vehicle	687	Load too heavy
430	Other intentional actions	536	Unsecured child seat	688	Towed vehicle or trailer too heavy or incompatible
431	Racing	537	Child restraint failure/ inappropriate		

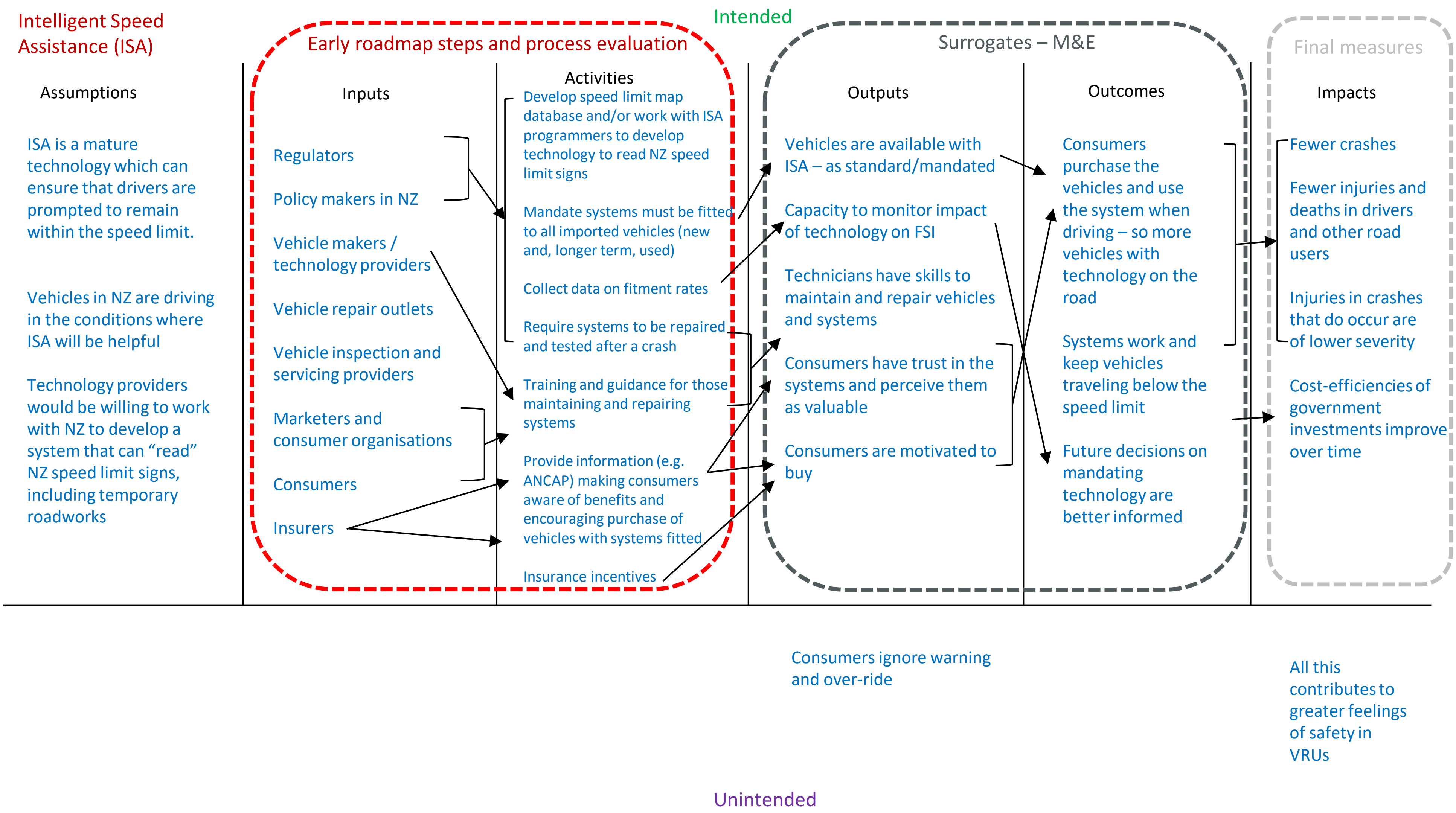
Appendix G: Workshop logic models

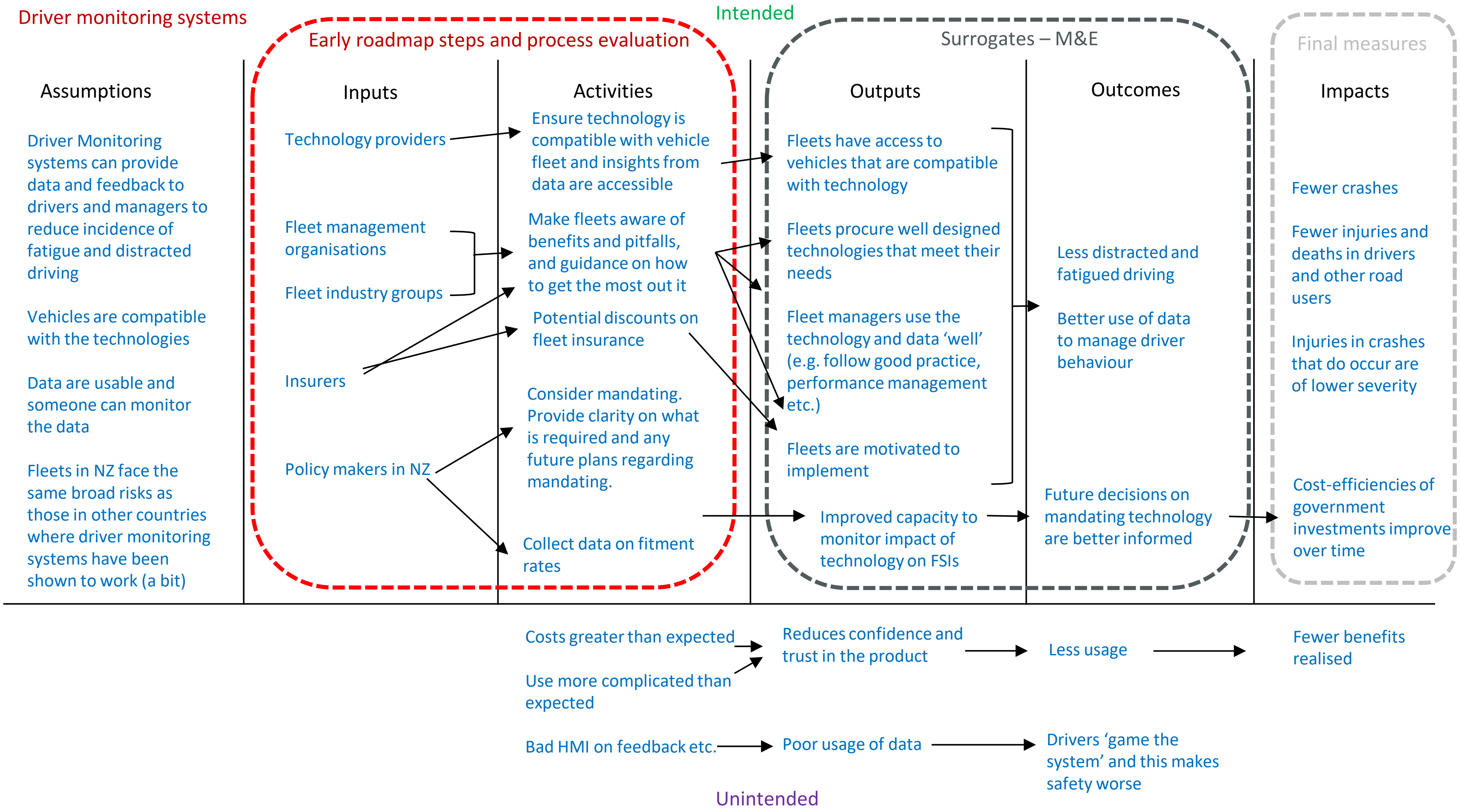


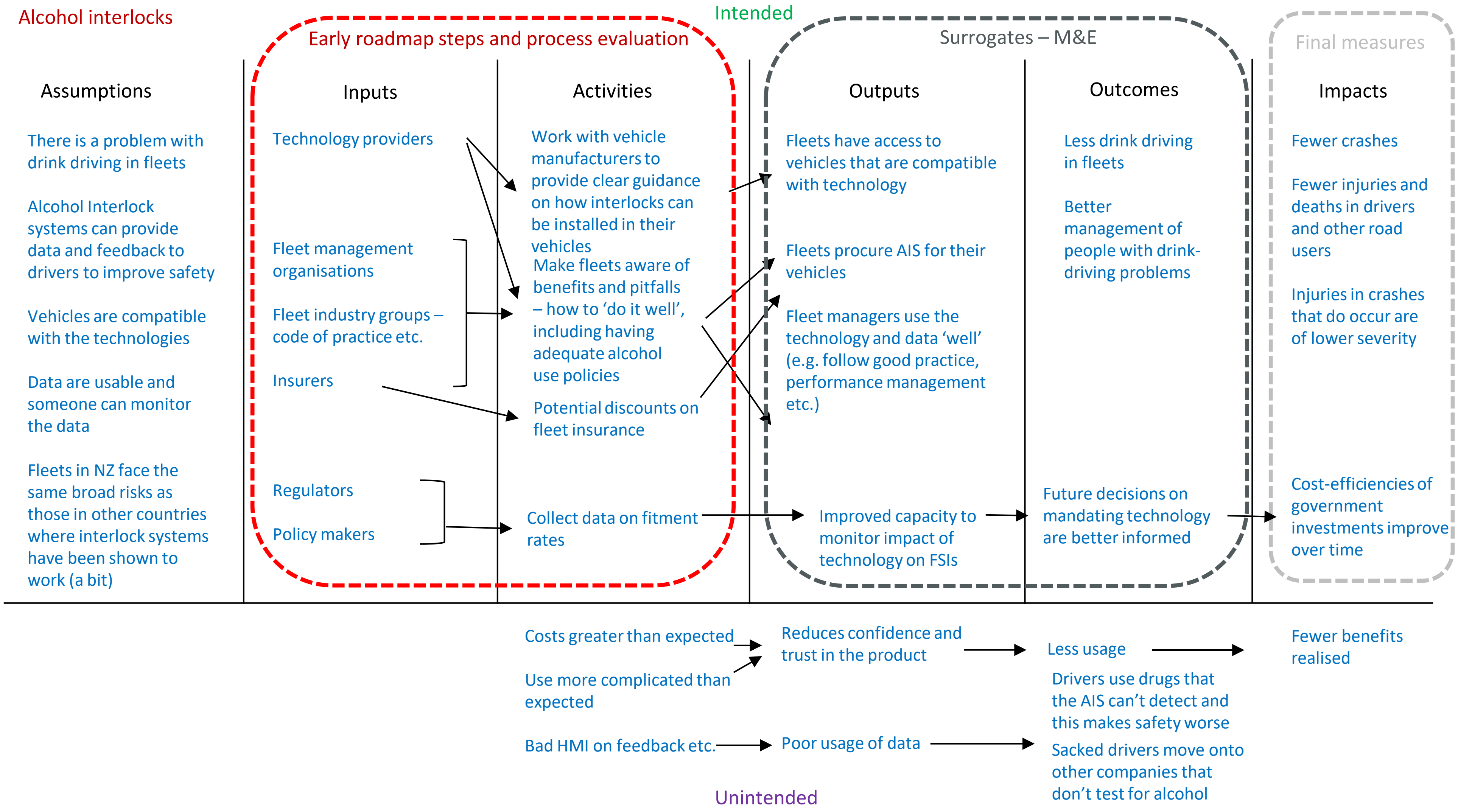

Rear collision warning (RCW)
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
RCW is a mature technology which can ensure that drivers are aware of what is in their blind spot.
Vehicles in NZ are driving in the conditions where RCW will be helpful
Regulators
Policy makers in NZ
Vehicle makers / technology providers
Vehicle repair outlets
Vehicle inspection and servicing providers
Marketers and consumer organisations
Consumers
Insurers
Mandate systems must be fitted to all imported vehicles (new and used)
Collect data on fitment rates
Require systems to be repaired and tested after a crash
Training and guidance for those maintaining and repairing vehicles
Provide information (e.g. ANCAP) making consumers aware of benefits and encouraging purchase of vehicles with systems fitted
Insurance incentives
Vehicles are available with RCW – as standard/mandated
Improved capacity to monitor impact of technology on FSI
Technicians have skills to maintain and repair vehicles and systems
Consumers have trust in the systems and perceive them as valuable
Consumers are motivated to buy
Consumers purchase the vehicles and use the system when driving – so more vehicles with technology on the road
Systems work and prevent collisions while reversing
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in other road users
Cost-efficiencies of government investments improve over time
Consumers ignore warning and over-ride
Unintended

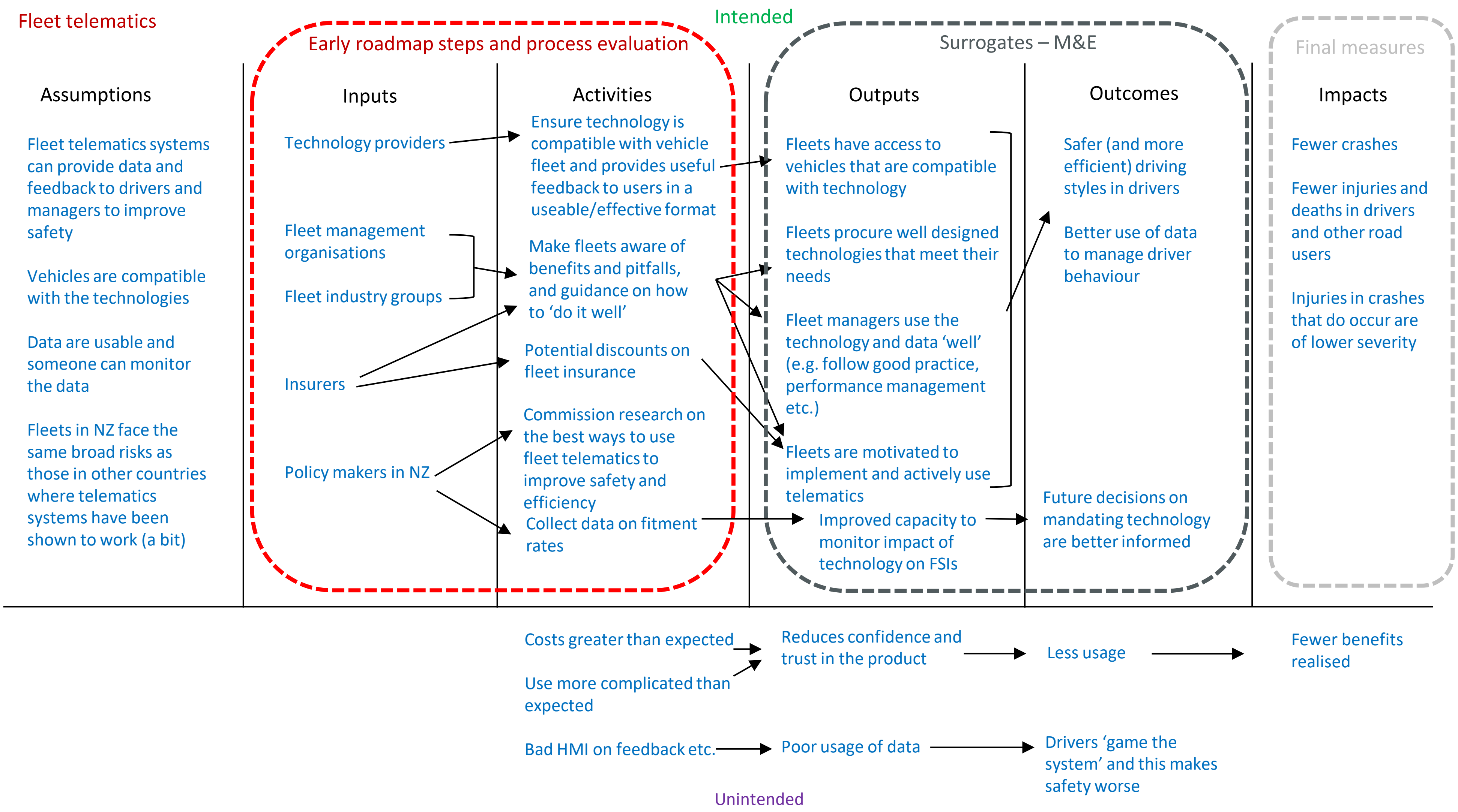

Autonomous Emergency Braking (AEB)
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
AEB is a mature technology which can automatically apply the brakes in response to the detection of a likely collision to reduce the vehicle speed and potentially avoid the collision.
Vehicles in NZ are driving in the conditions that AEB will be helpful
(*Vehicle to vehicle; vehicle to pedestrian; and eventually vehicle to cyclist)
Regulators
Policy makers in NZ
Vehicle makers / technology providers
Vehicle repair outlets
Vehicle inspection and servicing providers
Marketers and consumer organisations
Consumers
Insurers
Mandate systems must be fitted to all imported vehicles (new and used)
Collect data on fitment rates
Require systems to be repaired and tested after a crash
Training and guidance for those maintaining and repairing vehicles
Provide information (e.g. ANCAP) making consumers aware of benefits and encouraging purchase of vehicles with systems fitted
Insurance incentives
Vehicles are available with AEB – as standard/mandated
Capacity to monitor impact of technology on FSI
Technicians have skills to maintain and repair vehicles and systems
Consumers have trust in the systems and perceive them as valuable
Consumers are motivated to buy
Consumers purchase the vehicles and use the system when driving – so more vehicles with technology on the road
Systems work and stop vehicles early
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Cost-efficiencies of government investments improve over time
Consumers turn system off
Depending on type of AEB this can:
• Vehicle to vehicle AEB - reduce front to rear crashes, associated injuries and insurance costs, especially for low speed impacts
• Vehicle to VRU – reduce VRU casualties
Unintended

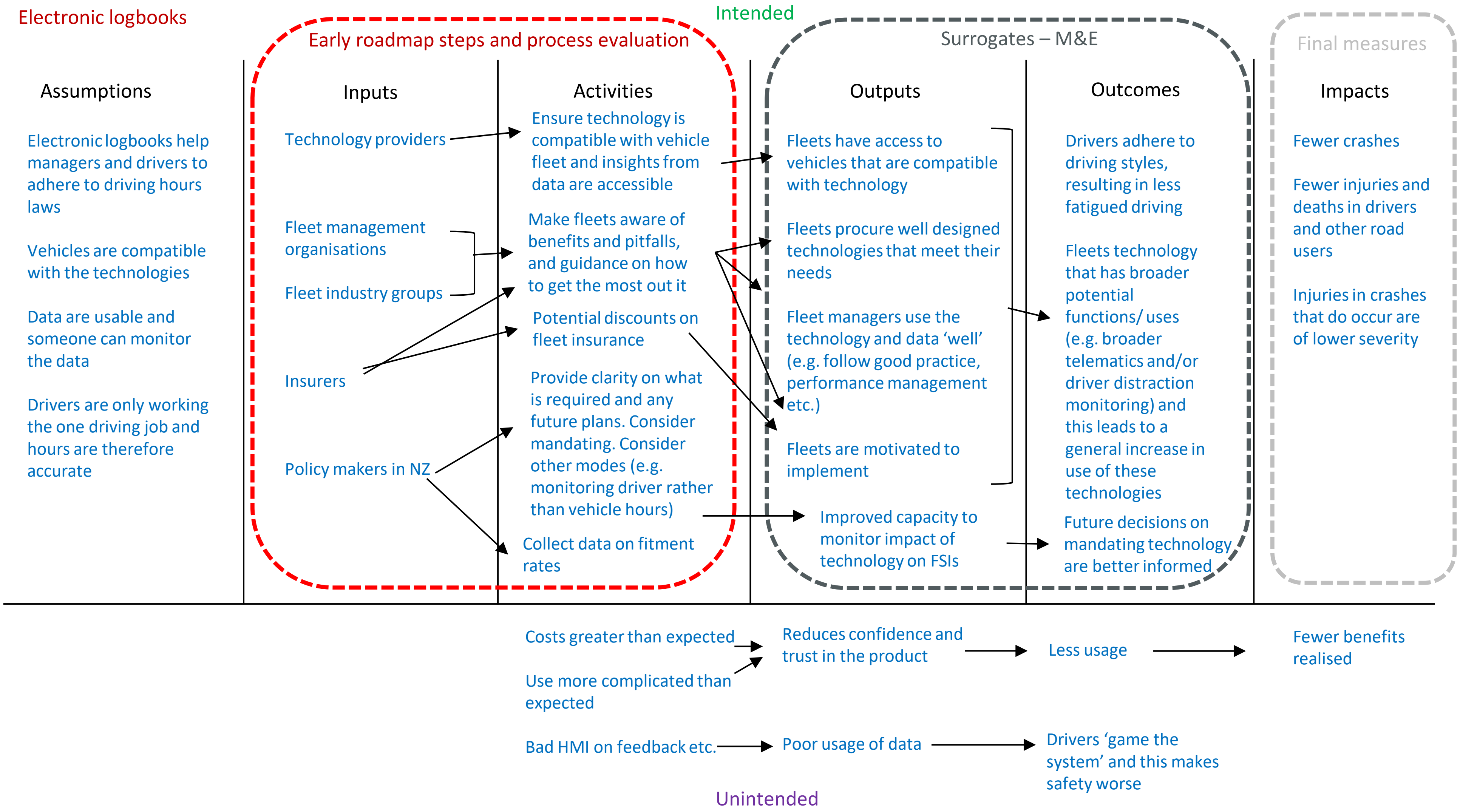

Lane Keep Assist (LKA)
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
LKA is heading correction that is applied automatically by the vehicle in response to detection that it is about to drift beyond a delineated edge line of the current travel lane.
Vehicles in NZ are driving in the conditions where LKA will be helpful
Regulators
Policy makers in NZ
Vehicle makers / technology providers
Vehicle repair outlets
Vehicle inspection and servicing providers
Marketers and consumer organisations
Consumers
Insurers
Mandate systems must be fitted to all imported vehicles (new and used)
Collect data on fitment rates
Require systems to be repaired and tested after a crash
Training and guidance for those maintaining and repairing vehicles
Provide information (e.g. ANCAP) making consumers aware of benefits and encouraging purchase of vehicles with systems fitted
Insurance incentives
Vehicles are available with LKA – as standard/mandated
Capacity to monitor impact of technology on FSI
Technicians have skills to maintain and repair vehicles and systems
Consumers have trust in the systems and perceive them as valuable
Consumers are motivated to buy
Consumers purchase the vehicles and use the system when driving – so more vehicles with technology on the road
Systems work and keep them in lane
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Cost-efficiencies of government investments improve over time
Consumers turn system off
Unintended


Intelligent Speed Assistance (ISA)
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
ISA is a mature technology which can ensure that drivers are prompted to remain within the speed limit.
Vehicles in NZ are driving in the conditions where ISA will be helpful
Technology providers would be willing to work with NZ to develop a system that can “read” NZ speed limit signs, including temporary roadworks
Regulators
Policy makers in NZ
Vehicle makers / technology providers
Vehicle repair outlets
Vehicle inspection and servicing providers
Marketers and consumer organisations
Consumers
Insurers
Develop speed limit map database and/or work with ISA programmers to develop technology to read NZ speed limit signs
Mandate systems must be fitted to all imported vehicles (new and, longer term, used)
Collect data on fitment rates
Require systems to be repaired and tested after a crash
Training and guidance for those maintaining and repairing systems
Provide information (e.g. ANCAP) making consumers aware of benefits and encouraging purchase of vehicles with systems fitted
Insurance incentives
Vehicles are available with ISA – as standard/mandated
Capacity to monitor impact of technology on FSI
Technicians have skills to maintain and repair vehicles and systems
Consumers have trust in the systems and perceive them as valuable
Consumers are motivated to buy
Consumers purchase the vehicles and use the system when driving – so more vehicles with technology on the road
Systems work and keep vehicles traveling below the speed limit
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Cost-efficiencies of government investments improve over time
Consumers ignore warning and over-ride
All this contributes to greater feelings of safety in VRUs
Unintended


Driver monitoring systems
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
Driver Monitoring systems can provide data and feedback to drivers and managers to reduce incidence of fatigue and distracted driving
Vehicles are compatible with the technologies
Data are usable and someone can monitor the data
Fleets in NZ face the same broad risks as those in other countries where driver monitoring systems have been shown to work (a bit)
Technology providers
Fleet management organisations
Fleet industry groups
Insurers
Policy makers in NZ
Ensure technology is compatible with vehicle fleet and insights from data are accessible
Make fleets aware of benefits and pitfalls, and guidance on how to get the most out it
Potential discounts on fleet insurance
Consider mandating. Provide clarity on what is required and any future plans regarding mandating.
Collect data on fitment rates
Fleets have access to vehicles that are compatible with technology
Fleets procure well designed technologies that meet their needs
Fleet managers use the technology and data 'well' (e.g. follow good practice, performance management etc.)
Fleets are motivated to implement
Improved capacity to monitor impact of technology on FSIs
Less distracted and fatigued driving
Better use of data to manage driver behaviour
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Cost-efficiencies of government investments improve over time
Costs greater than expected
Use more complicated than expected
Reduces confidence and trust in the product
Less usage
Fewer benefits realised
Bad HMI on feedback etc.
Poor usage of data
Drivers 'game the system' and this makes safety worse
Unintended


Alcohol interlocks
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
There is a problem with drink driving in fleets
Alcohol Interlock systems can provide data and feedback to drivers to improve safety
Vehicles are compatible with the technologies
Data are usable and someone can monitor the data
Fleets in NZ face the same broad risks as those in other countries where interlock systems have been shown to work (a bit)
Technology providers
Fleet management organisations
Fleet industry groups – code of practice etc.
Insurers
Regulators
Policy makers
Work with vehicle manufacturers to provide clear guidance on how interlocks can be installed in their vehicles
Make fleets aware of benefits and pitfalls – how to 'do it well', including having adequate alcohol use policies
Potential discounts on fleet insurance
Collect data on fitment rates
Fleets have access to vehicles that are compatible with technology
Fleets procure AIS for their vehicles
Fleet managers use the technology and data 'well' (e.g. follow good practice, performance management etc.)
Improved capacity to monitor impact of technology on FSIs
Less drink driving in fleets
Better management of people with drink-driving problems
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Cost-efficiencies of government investments improve over time
Costs greater than expected
Use more complicated than expected
Bad HMI on feedback etc.
Reduces confidence and trust in the product
Poor usage of data
Less usage
Drivers use drugs that the AIS can't detect and this makes safety worse
Sacked drivers move onto other companies that don't test for alcohol
Fewer benefits realised
Unintended


Fleet telematics
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
Fleet telematics systems can provide data and feedback to drivers and managers to improve safety
Vehicles are compatible with the technologies
Data are usable and someone can monitor the data
Fleets in NZ face the same broad risks as those in other countries where telematics systems have been shown to work (a bit)
Technology providers
Fleet management organisations
Fleet industry groups
Insurers
Policy makers in NZ
Ensure technology is compatible with vehicle fleet and provides useful feedback to users in a useable/effective format
Make fleets aware of benefits and pitfalls, and guidance on how to 'do it well'
Potential discounts on fleet insurance
Commission research on the best ways to use fleet telematics to improve safety and efficiency
Collect data on fitment rates
Fleets have access to vehicles that are compatible with technology
Fleets procure well designed technologies that meet their needs
Fleet managers use the technology and data 'well' (e.g. follow good practice, performance management etc.)
Fleets are motivated to implement and actively use telematics
Improved capacity to monitor impact of technology on FSIs
Safer (and more efficient) driving styles in drivers
Better use of data to manage driver behaviour
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Costs greater than expected
Use more complicated than expected
Reduces confidence and trust in the product
Less usage
Fewer benefits realised
Bad HMI on feedback etc.
Poor usage of data
Drivers 'game the system' and this makes safety worse
Unintended


Electronic logbooks
Intended
Early roadmap steps and process evaluation
Surrogates – M&E
Final measures
Assumptions
Inputs
Activities
Outputs
Outcomes
Impacts
Electronic logbooks help managers and drivers to adhere to driving hours laws
Vehicles are compatible with the technologies
Data are usable and someone can monitor the data
Drivers are only working the one driving job and hours are therefore accurate
Technology providers
Fleet management organisations
Fleet industry groups
Insurers
Policy makers in NZ
Ensure technology is compatible with vehicle fleet and insights from data are accessible
Make fleets aware of benefits and pitfalls, and guidance on how to get the most out it
Potential discounts on fleet insurance
Provide clarity on what is required and any future plans. Consider mandating. Consider other modes (e.g. monitoring driver rather than vehicle hours)
Collect data on fitment rates
Fleets have access to vehicles that are compatible with technology
Fleets procure well designed technologies that meet their needs
Fleet managers use the technology and data 'well' (e.g. follow good practice, performance management etc.)
Fleets are motivated to implement
Improved capacity to monitor impact of technology on FSIs
Drivers adhere to driving styles, resulting in less fatigued driving
Fleets technology that has broader potential functions/ uses (e.g. broader telematics and/or driver distraction monitoring) and this leads to a general increase in use of these technologies
Future decisions on mandating technology are better informed
Fewer crashes
Fewer injuries and deaths in drivers and other road users
Injuries in crashes that do occur are of lower severity
Costs greater than expected
Use more complicated than expected
Reduces confidence and trust in the product
Less usage
Fewer benefits realised
Bad HMI on feedback etc.
Poor usage of data
Drivers 'game the system' and this makes safety worse
Unintended