In-car safety technology
Literature review and expert opinion

Introduction
This review of literature and experts forms part of a broader investigation into in-car safety technology and older drivers. This work was carried out by Rica and funded by Motability.

Here we review the key literature contributions from academia and position them alongside expert opinions from industry and the third sector. In reviewing in-car safety technology we used 5 overarching research questions to explore attitudes about user centred design (UCD) practices, older people and the automobile industry. These research questions were:

RQ 1. What research exists about the usage of existing in-car safety technology and older drivers?
RQ 2. To what extent have older drivers’ needs and abilities been considered in the design and development of in-car safety equipment?
RQ 3. What are the opinions and attitudes of older people towards these systems?
RQ 4. Is in-car safety technology solving safety problems for older people?
RQ 5. What gaps exist in the research of in-car safety technology and older people?

Our investigation was informed through searching academic, industrial and 3rd sector literature and contacting c30 experts from the automotive industry as well as academics in the field.

Background
There has been plenty of discussion over the past decade concerning the shifting population age demographic in developed western economies. This is illustrated by the European figures that show an increase in the percent of the population over 65 from 17.5% in 2011 projected to be 30% by 2050 [1, 2]. This shift is often framed negatively as a burden on resources of a seemingly non-productive section of society. However, it is increasingly the case that the over 65s are being recognised as a market opportunity for suppliers of products and services. This is perhaps not so surprising when considering 80% of the nation’s wealth is being held by the over 50s [3].

Alongside this we are all living longer, in 2012 the mean life expectancy of a 65 year old man is to live a further 18 years or until he is 83 and a woman to the age of 86. By 2062 a 65 year old man can expect to live until 90 and a woman to 92 years old [4]. These later years will increasingly be lived managing health concerns, seeing a 32% increase in older people with moderate or severe disability and a 32%-50% rise in over 65s with chronic diseases [5].

The role of the car in supporting everyday activities such as going to the supermarket, visiting a friend or travelling to work is woven into the fabric of 21st century life and as such is difficult to give

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1 The technology cited in this review is listed in Appendix A.
up. This applies to older people as it does to younger people, so it is of no surprise people are driving for longer into their later years. This is supported by work from Sivak and Schoettle [28] which shows a clear increase in the percentage of older people holding a driver’s licence. As mentioned above older people are more likely to have physical or sensory impairments. Additionally we know that older drivers will regulate their driving behaviour to avoid stressful times of the day or potentially dangerous situations. This further supports the conclusion that many older people are driving whilst experiencing reduced physical or cognitive functions [31].

In the UK when a driver reaches the age of 70 years old they are obliged to reapply for their driving licence. This they can do by filling out a form and declaring that they meet the minimum eyesight requirements. The new licence is only valid for 3 years after which the driver will need to reapply again. There is currently no legal age at which a driver must stop driving. However, certain medical conditions or disabilities may affect the ability to drive safely. It is the driver’s responsibility to ensure they can safely continue to drive.

When viewed internationally the rules governing licences for older people vary widely; from doctor signed medical certificate every 3 years from 65 years old in Singapore, to the use of testing centres in some Canadian States, and doctor signed medical certificates every year after 75 years old in Australia.

Automobile technology is seeing a period of rapid development fuelled by the advances made in informatics, particularly in the fields of infrastructure, data management and ubiquitous computing. The potential for fully automated vehicles is slowly being realised with many manufacturers declaring this as their goal achievable within the next decade. However the path towards this goal is being achieved through the development of a myriad of in-car safety technologies. These technologies are in turn being used as building blocks towards the future design of fully automated vehicles [26, 27].

These technologies span: passive information systems to alert the driver of potential hazards (night vision or blind spot detection), semi-autonomous systems which assist the driver by offering to take control (assistive parking or automated cruise control), through to fully autonomous systems that take direct control from the driver to avoid or minimise the effect of accidents (Intelligent speed adaption or collision avoidance).

What research exists about the usage of existing in-car safety technology and older drivers? (RQ 1)
Research has shown that older people are at an elevated risk of being involved in and responsible for accidents in which they themselves die [6]. However the actual public health impact on other road users is relatively small. Drivers in the USA under the age of 20 are responsible for more than twice as many deaths of occupants of other vehicles and non-motorists as drivers aged 70 or over. When looking at the figures a little closer it becomes clear that this comparatively favourable statistic is as much to do with how deaths are recorded, per driver, per miles driven or per number of trips taken. To further compound this, older people have a greater degree of frailty and are more likely to suffer greater harm following an accident than a younger person.
What can be said is there is an increase in accidents for the over 70s. That increase is more significant after reaching 80. These accidents occur often at low speeds and are most common at road intersections, suggesting vision and cognitive issues as a possible cause. It is noted however by the Insurance Institute for Highway Safety [6], that even though there are more drivers 70 years old and over today, they crash less often than they used to do.

Other studies undertaken by Insurance Institute for Highway Safety [7, 8, 9] take a particular look at advanced crash avoidance and related technologies in the latest car models from Volvo, Toyota, Acura, Mazda, Mercedes and Infiniti. Eichelberger and McCart [8] interviewed 472 current Volvo car owners with fitted in-car safety equipment and explored their everyday experiences with this technology.

They found acceptance of the technology quite high except for lane departure warning, with over 80% of the owners stating that they would want it in their next car purchase, and most owners leaving their systems switched on. Notably though, of the 472 drivers interviewed only 44 were over 70 years old and only 8 over 80 years old.

The success of these types of systems especially forward collision avoidance systems and adaptive headlights, have been correlated with insurance loss data in the USA to show real reductions in car accidents [10].

**To what extent have older drivers’ needs and abilities been considered in the design and development of in-car safety equipment? (RQ 2)**

When looking for evidence in the literature of involvement of the older community in the design of in-car technology the emerging picture is not very clear. It is reasonable to assume that some user testing would have happened within the design process of these in-car safety technologies; however it has been difficult to obtain detail about these tests from the manufacturers.

Information concerning usability and user experience of these systems is closely guarded and hard to come by. We contacted c30 car manufacturers and OEMs (original equipment manufacturers), and enquired about any information they might have concerning older people being used in the design process. The responses were in the main polite but without much substance. We were told by just under half of the companies we approached that they do carry out usability tests and user centred design, but not specifically for older people.

A typical position taken is “we as **** do not develop any cars or systems exclusively for older users. However, we are considering restrictions the elderly might have, especially in terms of the interior design concept of our cars”. It is not clear from this what is meant by older people: 65-74? 75-84? or 85+?

Another approach taken by the automobile industry is to have younger designers use age simulators such as the Third Age Suit [11] which provides the designer a visceral glimpse into the lived perspective of an older person.
Euro NCAP (European New Car Assessment Programme) have gone some way to recognising older people as needing consideration when designing safe car environments. They state in their strategic road map [32] recognition of an increasingly older (and female) driving population in terms of dummy stature and biomechanical limits as well as the state-of-the art in crash avoidance technologies. Further to this, in their latest strategic roadmap [33] they highlight “Safety critical HMI guidelines and assessment of the quality of warning and distraction (consistent for and applicable to all ADAS protocols). The behavioural aspects of the older population need specific attention.

Whilst there has been recognition of the need to include older people in the design of in-car safety technology features [12, 13], there has been little evidence of user centred design or usability tests, designed and undertaken specifically for this user group.

On the other hand there has been work with older people and in-car technology within academia. Older people have been used in research projects to look at the relationship between new in-car technology and the wants and needs of older people. Musselwhite used a mixture of grounded theory and participatory design to uncover the driving needs of older people [14]. This work cited the key driving issues for older drivers to be distraction, keeping to the speed limit, fatigue/tiredness, reactions, glare and luminance.

**What are the opinions and attitudes of older people towards these systems? (RQ 3)**

Musselwhite and Haddad [15] took a participatory design approach in their study “to critically examine whether new technological advances in Advanced Control and Safety Systems have the capacity to aid driver safety and prolong driving for older drivers in the UK”. This work seeks to add context to the in-car technology debate for older people, putting the needs and perspectives of this group at the centre.

Their research found that older people were quite willing to accept in-vehicle technologies that help their driving, with a slight preference for technologies that aid feedback rather than reduce workload, which were felt to also reduce control. Three systems were cited as potential targets for future testing: head-up display (with optional audible cues) of current vehicle speed, intelligent speed adaptation and head-up and dashboard display of road signs. These finding were broadly in line with Bradley et al [13] who also found speeding of concern and put emphasis on reverse parking being of particular interest.

Musselwhite [15] examined the perceived acceptance of in-car safety technology by older people, noting their preference for information systems rather than autonomous or semi-autonomous systems which is recorded in work by Meadows and Stradling [16]. Meadows and Stradling [17] go on to highlight a gender differentiator with more support for “take over” systems seen from women rather than men.
Is in-car safety technology solving safety problems for older people? (RQ 4)

Although there is evidence that older drivers will self-regulate their driving habits to support safer driving [18], they are nonetheless at an elevated risk of being involved in an accident after the age of 70. This risk is more significant after 80 years old [19].

Studies in the USA [20] show older drivers are commonly involved in collisions at junctions, often through the misjudgement of speed and distance of other vehicles. Although these accidents often happen at low speed, due to their more fragile health and physical condition, older drivers are more likely to suffer injuries when they crash.

It would seem a reasonable assumption that the technology which supports older people making safer choices about their driving will reduce the number and severity of vehicle accidents. However this view is challenged by a number of key researchers and policy makers in Europe [21] who point towards the design and complexity of the HMI (Human Machine Interface) as a place where the safety benefits of ADASs can be compromised by driver distraction and poor learnability design.

Mark Fowkes, senior consultant at MIRA states; “We have technology roadmaps which consider increasing levels of ADAS all the way up to fully autonomous vehicles but we need to look at the effects of multiple systems being in operation at the same time. The effects can be counter-intuitive” [21].

Another issue highlighted in this report is that of driver engagement and how people can move from driving with the system being in control through to driver intervention. Fowkes [21] points to this hazard with ADAS: “Potentially, the person in the driving seat has to change, instantly, from relaxing to controlling a vehicle doing 80mph. It’s not just speed we have to consider – there’s lateral control, acceleration and so on”.

Further older driver concerns include unintentional speeding and reverse parking, as well as driver training in the use of the HMIs especially when the vehicle is sold second hand [13, 21, 22].

What gaps exist in the research of in-car safety technology and older people? (RQ 5)

The research landscape of in-car safety technology is not very clear, with contributions from industry often being guarded. Car manufacturers seek to sustain any advantage their technology might provide over their competitors and as such will keep performance data to themselves. Likewise car manufacturers are also sensitive to protecting the marketing position of their brands, few of which wish to be seen as producers of an older person’s car.

This position is most visible when enquiring about the age demographics of participants used in usability studies. Some car manufacturers and OEM’s informed us that they do undertake usability trials of their equipment. However they are keen to point out that they use representative samples of the population and don’t consider older people as a mutually exclusive group for these tests.

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2 Advanced Driver Assistance Systems. See table in Annex 1 for examples
On the other hand there is emerging data from the insurance industry in the USA [6, 10] which indicates that certain in-car safety technologies are having a positive impact and reducing the number of accidents. It is noted however, that this correlation between technology and a reduced risk of accident holds true for forward collision systems and adaptive headlights, but not for lane departure warning which see a small negative impact. Unfortunately this report [10] does not examine the impact that age has on the data.

Academia has started to explore the relationship between older people and in-car safety technology. MIT AgeLab [23] and The Hartford [24] undertook a survey of over 900 drivers in the US aged 50+ and placed the results alongside an expert panel to identify technologies which promote capacity, confidence, and convenience for drivers as they age. Of particular note were the concerns of mature drivers about distractions within the vehicle such as music and phone calls. Other work at MIT AgeLab [25] argues the need to adopt these new technologies in a structured and considered way. It highlights the need for vehicle interfaces to be optimised to support driver attention and not fight for it.

The need for more visible research into the usability of in-car safety technology HMIs and older people is widely recognised [18, 21, 25]. However any usability investigation would need to recognise older people as a mutually exclusive group containing a potentially diverse set of driving problems [21]. This might be seen as a challenge for any proposed usability study design, but one that can be met through including in the user samples people of different ages with different frailties.

**Summary**

In-car safety technology is experiencing a period of rapid development. These developments are well placed to support older people driving for longer in later life. Although older people are quite accepting of these technologies, the design of their associated HMIs can be seen to be distracting. This is a significant cause for concern when considering older drivers.

The needs and requirements of older people are both diverse and specific encompassing, any or all of, a gradual decline in cognition, vision or dexterity. There seems little evidence of older people being considered as a group in their own right to inform the design and effectiveness of these system control interfaces.

This literature review and expert opinion supports a broader investigation into in-car safety technology and older people. This further work includes a survey of c.471 older motorists. The report can be found online [http://www.rica.org.uk/in-car-tech](http://www.rica.org.uk/in-car-tech) and in print.

We believe there is a need to better understand the performance of in-vehicle information systems and the older population and propose usability evaluations as a means to achieve this.

**Rica**

Rica is a national research charity dedicated to providing independent information of value to disabled and older consumers. It researches and publishes consumer reports, based on rigorous research and providing practical information for disabled and older consumers. It

[www.rica.org.uk](http://www.rica.org.uk)
also works with manufacturers, service providers, regulators and policy makers to improve products and services. Rica's aim is to increase their awareness of the needs of disabled and older consumers through specialist research. Rica published a consumer guide called Driving safely for life; aimed at keeping older people mobile and safe for longer. Find out more Rica research services

Bibliography

18. Dr Craig Berry. Older drivers and behavioural change. ILC-UK policy brief. November 2011


23. AgeLab MIT http://agelab.mit.edu/ Last accessed 26/8/14


28. Sivak, M. Schoettle, B. Recent changes in the age composition of drivers in 15 countries. 2011 UMTRI.


Annex 1.

1. Table of in-car safety technologies *

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Night Vision (NV)</td>
<td>✓</td>
<td></td>
<td>Displays an increased visibility of the road ahead – typically using heat or infra-red</td>
</tr>
<tr>
<td>Blind Spot Detection / Motoring (BSD, BSM)</td>
<td>✓</td>
<td></td>
<td>Detect other vehicles located to the driver’s side and rear blind spots - can give audio alarm</td>
</tr>
<tr>
<td>Parking Assist Systems (PAS)</td>
<td>✓</td>
<td></td>
<td>This will allow the car to steer itself into a parking space with little input from the user</td>
</tr>
<tr>
<td>Lane Change Assistance (LCA)</td>
<td>✓</td>
<td></td>
<td>When changing lanes. The system monitors the areas to the left and right of the car and up to 50 metres behind it and warns you of potential hazards, by means of flashing warning lights in the exterior mirrors.</td>
</tr>
<tr>
<td>Automatic Emergency Call (AEC)</td>
<td>✓</td>
<td></td>
<td>Gives an automatic message to an emergency call centre in case of a crash of the vehicle</td>
</tr>
<tr>
<td>Pedestrian Detection (PD)</td>
<td>✓</td>
<td>✓</td>
<td>Uses sensors to detect presence of people (and animals) This can be tied to other systems to minimise impact</td>
</tr>
<tr>
<td>Lane Departure Warnings (LDW)</td>
<td>✓</td>
<td>✓</td>
<td>Used on major arterial routes. Warns a driver when the vehicle begins to move unintentionally out of its lane. Some systems take control to stay in lane.</td>
</tr>
<tr>
<td>Autonomous Emergency Braking</td>
<td>✓</td>
<td>✓</td>
<td>Uses sensors to protect a potential collision.</td>
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<tr>
<td>(AEB) (Intelligent) Collision Avoidance systems (ICAS,CAS)</td>
<td></td>
<td></td>
<td>Some systems will issue an audio alarm first. Prevents, or reduces severity of, imminent accident – typically through taking control of steering and braking systems.</td>
</tr>
<tr>
<td>Curve Speed Warning (CSW)</td>
<td>✓</td>
<td>✓</td>
<td>Uses sensors, road map information and rain detection information to evaluate the speed of vehicle for upcoming curve in the road. Will issue warnings to the driver if vehicle is outside safe envelope.</td>
</tr>
<tr>
<td>Driver Drowsiness Detection / Driver Impairment Monitoring / Attention Monitoring (DDD, DIM, AM)</td>
<td>✓</td>
<td>✓</td>
<td>Monitors driver and alerts them when driver behaviour indicates drowsiness. Some systems apply brake if no driver reaction is detected</td>
</tr>
<tr>
<td>Electronic Stability Control. (ESC)</td>
<td></td>
<td>✓</td>
<td>Wheel sensors detect the beginning of a slide, small amounts of braking might be applied automatically to individual wheels to regain stability, preventing slide.</td>
</tr>
<tr>
<td>Adaptive Cruise Control (ACC)</td>
<td></td>
<td>✓</td>
<td>Helps to avoid accidents by always keeping the vehicle at a safe distance from the traffic ahead.</td>
</tr>
<tr>
<td>Intelligent speed adaptation (ISA)</td>
<td></td>
<td>✓</td>
<td>Monitors the local speed limit and adjusts the cars speed accordingly.</td>
</tr>
</tbody>
</table>

*It is noted that many of the technologies named in the above table can come as isolated elements fitted to vehicles or as part of a more sophisticated integrated in-car safety solution.*
## 2. Industry / Trade and Academic Associations used in this report.

<table>
<thead>
<tr>
<th>Association</th>
<th>Description</th>
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<tbody>
<tr>
<td>ERTICO</td>
<td>Network of Intelligent Transport Systems and Services stakeholders in Europe</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transport Systems</td>
</tr>
<tr>
<td>EAMA</td>
<td>European Automotive Manufacturers Association</td>
</tr>
<tr>
<td>FIA</td>
<td>International Automobile Federation – Consumer Association</td>
</tr>
<tr>
<td>ICRT</td>
<td>International Consumer Research and Testing</td>
</tr>
<tr>
<td>Euro NCAP</td>
<td>European New Car Assessment Programme (Star rating)</td>
</tr>
<tr>
<td>MIRA</td>
<td>Motor Industry Research Association</td>
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<tr>
<td>TRL</td>
<td>Transport Research Laboratory</td>
</tr>
<tr>
<td>IAM</td>
<td>Institute of Advanced Motorists - Road Safety Charity</td>
</tr>
<tr>
<td>IME</td>
<td>Institute of Mechanical Engineers</td>
</tr>
<tr>
<td>AA</td>
<td>Automobile Association</td>
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<tr>
<td>RAC</td>
<td>Royal Automobile Club (foundation)</td>
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<tr>
<td>PACTS</td>
<td>Parliamentary Advisory Council for Transport Safety</td>
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<tr>
<td>AgeLab MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>ICRT</td>
<td>International Consumer Research Testing</td>
</tr>
<tr>
<td>SMMT</td>
<td>Society of Motor Manufacturers &amp; Traders</td>
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