The impact of airbags, electronic stability control and autonomous

emergency braking on Australian light vehicle fatalities:

methodology and findings

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Abstract

This paper presents estimates of the current and potential impact of airbags, electronic stability control, and autonomous emergency braking on fatalities in light vehicle crashes. This analysis draws on a number of sources to provide estimates and projections of the proportion of the light vehicle fleet equipped with these technologies. It combines these with estimates of the impact of each technology to provide estimates and projections of the impact on fatalities. It is estimated that frontal airbags have reduced light vehicle fatalities by 13%, side airbags by 4%, and electronic stability control by 6% to 2014. It is also predicted that the impacts of side airbags and electronic stability control will increase significantly as newer vehicles filter through the fleet, and that autonomous emergency braking will begin to lead to significant fatality reductions. Combined, these technologies are predicted to reduce fatalities a further 30% by 2033. This paper draws on the underlying research in BITRE Information Sheet 68 and Report 140 and provides a more in-depth description of the data and research methodology. The paper will be of relevance to those engaged with road safety policy, and to other researchers.

Introduction

From 1990 to 2014, the number of road fatalities in Australia halved (BITRE 2015, BITRE 2014a), and the fatality rate per vehicle kilometre fell by two thirds from 1990 to 2012 (BITRE 2014b). This is attributable to a number of factors, including safer vehicles, safer roads, and improved law enforcement. To some extent there are likely to be offsetting factors, particularly increased driver distraction (BITRE 2010).

BITRE (2010) estimated the impacts of seatbelts, speed cameras, and random breath tests. BITRE (2015) estimated the impacts of two more recent measures: airbags and electronic stability control (ESC). BITRE (2014c) projected the future impacts of airbags and ESC, as well as the future impacts of autonomous emergency braking (AEB), which is now in the early stages of adoption. This paper consolidates the analysis of airbags, ESC, and AEB, and provides more detail on the methodology used for the estimates and projections. Altogether seven specific technologies were analysed: front driver airbags, passenger airbags, side airbags, ESC, 'basic' AEB, AEB with vulnerable road user protection, and all-speeds AEB. These are described more fully in the section on background and assumptions.

Methodology

For each technology, the methodology consisted of the following steps: **Adoption in new vehicles:**

Firstly, estimates were made of the number of new light vehicles equipped with these technologies each year. These standard feature estimates are based on matching vehicle information from Glass's Research Data (GRD, 2014), which lists specifications and characteristics of vehicles, with new light passenger vehicle sales figures from various VFACTS issues (FCAI, various issues). The number of new light vehicles that include each technology as an optional feature was also estimated.

The method of projecting uptake in new vehicles to 2033 differed for each technology. For airbags and ESC, which are already mandated, it was assumed that all new vehicles will have these technologies. For AEB, future uptake was assumed to follow a logistic diffusion process, similar to that of earlier technologies (see the next section).

Fleet estimates: In order to estimate the impact on fatalities, it is necessary to transform estimates of uptake in new vehicles to estimates of the proportion of the fleet that is equipped with each technology. That is, it is necessary to estimate the rate at which vehicles without each technology are removed from the vehicle fleet. This was done using data from the ABS Motor Vehicle Census (ABS 2014). Fleet-level projections to 2033 were produced using past rates of removal from the fleet.

Fatality reductions for each crash class: Drawing on published estimates, assumptions were made about the likely reductions in fatalities from each technology, for the particular classes of crashes in which the technologies are effective. The studies drawn on, and the assumptions used, are detailed in the next section. Effort was made to ensure that the estimates were as relevant to the Australian context as possible. For example, it was not possible to use estimates of the impact of airbags from the United States, as the implementation of airbags is somewhat different to that in Australia.

Frequency of fatalities by crash class: The frequency of fatalities in light vehicle crashes of each crash type was estimated using data provided to BITRE from jurisdictions. For future years, it was generally assumed that the proportions of light vehicle fatalities in each crash type remain unchanged. The exception was for fatalities in front-impact crashes, which are the class most likely to be reduced by airbags. For this class of crashes, the estimated reduction in fatalities from airbags was taken as a baseline for the analysis of AEB. Finally, the assumptions about the impact in each crash class were combined with the estimates of the frequency of fatalities in each class, and the share of the light vehicle fleet equipped with the technology, to produce estimates of the fatality reduction in each year. All results presented here are proportional reductions relative to a 'base case' in which the technologies did not exist, rather than in terms of the number of lives saved. In BITRE 2014c it was assumed that fatality rates per vehicle kilometre travelled would remain constant in the absence of these technologies, which is consistent with the impacts of other measures (notably seatbelts) already being fully realised, and other improvements (such as improved infrastructure) being offset by increased driver inattention.

Background and assumptions

This section provides a brief background to each of the technologies analysed, including the Australian context, estimates of the impacts from other literature, and the assumptions used for this analysis. The assumptions are also tabulated in Table 1.

Airbags: Frontal airbags began to be introduced as a standard feature in light vehicles in around 1990, and by 2006 were a standard feature in over 90% of new light vehicles. Passenger airbags were taken up at a slower rate, but were also a standard feature in over 90% of new vehicles by 2007. Frontal airbags are most effective at reducing trauma in front-impact crashes. Paine (2002), drawing on estimates by Langwieder, K., Hummel, T. and Anselm, D. (1998) and MUARC (1992), assumed that driver airbags reduced fatalities by 25% in front-impact crashes, and that passenger airbags reduced fatalities by 20% in frontal crashes in which a passenger was involved. These figures have been assumed in our analysis.

Side airbags began to be introduced as a standard feature in around 1995 (D'Elia, A., Scully, J. and Newstead, S. 2012). By 2014 over 75% of new light vehicles were equipped, and 36% of the light vehicle fleet. Side airbags are most effective at reducing trauma in side-impact crashes, which account for approximately 20% of fatalities in Australia (UN 2013). D'Elia et al (2012), analysing side impact crashes, found that combination airbags were associated with a reduction of 51% in the odds of death and injury to all body regions. In our analysis it was assumed that side airbags reduced fatalities in side-impact crashes by 51%.

ESC: ESC involves an on-board computer detecting when loss of control is imminent then restoring control through reducing power and applying individual braking to each wheel (FCAI 2015). ESC began to be included as a standard feature in vehicles sold in Australia in around 1999, and by 2014 nearly all new light vehicles were equipped with ESC. ESC was mandated for all new passenger cars in 2013 (FCAI 2015) and will be mandated for all new light commercial vehicles in 2017 (DPMC 2013). ESC is most effective at reducing singlevehicle crashes, particularly 'run-off-road' crashes, in which a vehicle leaves the roadway. Single-vehicle crashes accounted for 47% of Australian road fatalities in 2013 (BITRE 2014a) and BITRE estimates that run-off-road crashes accounted for 38% of road fatalities in 2008-2012 (BITRE 2014c). Scully et. al. (2007) cite international findings that fatal single vehicle (car) crashes are reduced by 53% by ESC, and that run-off-road crashes are reduced by 54.5%. Here, we assumed a 53% reduction in fatalities from run-off-road crashes. Note that airbags reduce the fatality risk in some of the crashes that will be avoided by ESC, meaning that the impact of ESC on fatalities will be slightly lower than it would be in the absence of airbags. This effect has not been taken into account in this analysis, and doing so would require more detail on crash type than is available. Based on the estimated impact of airbags, and the proportion of ESC-equipped vehicles that also have airbags, this could potentially reduce the estimate of the impact of ESC alone by up to 0.7 percentage points in 2014, and 3 percentage points in the 2033 projections.

AEB: AEB systems improve safety in two ways: firstly, they help to avoid accidents by avoiding critical situations early and warning the driver; and secondly they reduce the severity of crashes by lowering the speed of collision and, in some cases, by preparing the vehicle and restraint systems for impact. AEB first started appearing in sales figures as a standard feature in new light passenger vehicles in around 2010. By 2013 AEB was appearing as a standard feature in a number of the premium light passenger models. A large proportion of AEB systems appearing as a standard feature in new light passenger vehicles are the basic AEB system intended to mitigate urban crashes at lower speeds, notably rear-end crashes at intersections in stop-start traffic.

Anderson, Doecke, Mackenzie and Ponte (2013) looked at the potential benefits from AEB from crash reconstructions and simulation and found overall reductions in risk produced by the various AEB systems were predicted to reduce fatal crashes by 20-25 per cent, but noted 'the differences in the way that systems operate will make a material difference to their effectiveness, in terms of either speed reductions or injury risk.'

In order to model the impact of AEB, we made the following assumptions about different subsets of crashes in two different speed contexts (using speed zone as a proxy). Basic AEB systems, with and without vulnerable road user protection, are assumed to be effective in reducing collision crashes and crashes involving pedestrians and pedal cyclists in speed zones of 60 km/hr or less. High speed AEB systems are assumed to be effective in all speed zones (including where the speed zone is unknown) for collision crashes, including pedestrian and pedal cyclist crashes. It was assumed that all levels of AEB reduced relevant subsets of fatal crashes by 20% and injury crashes by 25% (the lower bound of the effectiveness found by Anderson et al (2013)).

The adoption of each of these three AEB technologies in new vehicles was assumed to follow a logistic diffusion process. Basic AEB, without vulnerable road user protection, was assumed to reach 90% of new vehicles by 2022. AEB with vulnerable road user protection was assumed to reach 90% of new vehicles by 2027, and all-speed AEB with vulnerable road user protection was assumed to reach 90% of new vehicles by 2039.

By the time AEB becomes common, many of the fatalities that it would have saved will have already been saved by airbags. This was accounted for in the assumed proportion of fatalities from crashes of those classes.

Findings

This section highlights some of the notable findings. Findings are also tabulated in Table 1, which summarises the assumptions used, the estimated uptake and crash type shares, and the resulting reduction in fatality risk in 2014 and 2033. Figure 1 shows the estimated, and projected, proportions of the light vehicle fleet equipped with each technology from 1990 to 2033. Figure 2 shows the estimated proportional reduction in fatalities from airbags and ESC from 1990 to 2014. Figure 3 shows the fatality rate per safety weighted vehicle kilometre from 1990 to 2014, and includes the predicted contributions of earlier measures considered by BITRE (2010): seatbelts, random breath testing, and speed cameras. ('Safety-weighted' vehicle kilometres account for changes in traffic composition, by converting vehicle kilometres to light vehicle equivalent units. See BITRE (2014) for more detail.) In total, airbags and ESC, combined with the continuing impacts of random breath testing and speed cameras, can account for much of the observed reduction in the fatality rate since 1990. However, reductions in the fatality rate could also be driven by infrastructure improvements, speed limit reductions, improved enforcement, or other vehicle improvements. The impacts of a range of other potential measures are discussed in BITRE 2014c. As discussed in BITRE 2010, some of these reductions may have been offset by increases in distraction due to mobile devices. While over the long term the actual fatality rate has fallen by roughly the same proportion as predicted by this analysis, in some years it has fallen faster and in others slower.

As of 2014, airbags were found to have had the greatest impact, collectively reducing fatalities by 17%. This is explained by the relatively high proportion of the fleet already equipped with airbags, and the high proportion of crashes that are front-impact. The impact of airbags is expected to double by 2033, as almost all vehicles without airbags are scrapped. (Note that the analysis implicitly attributes some saved fatalities to airbags, which would have also been avoided by AEB). It is notable that despite airbags having been standard in new vehicles for over 20 years, they are still driving a year-on-year reduction in the fatality rate. This is because there are a significant number of light vehicles still not equipped with airbags (around 21% of the fleet), which are gradually being removed from the fleet. The impact of ESC was estimated to be only around 6% in 2014, due to its more recent uptake in new vehicles, and consequently the large proportion of the fleet without the technology. By 2033, it is expected to be in almost all light vehicles, leading to fatalities 18% lower than otherwise. While the impact of ESC in relevant crashes is higher than for airbags (in part because ideally the crashes are avoided altogether), the number of relevant crashes is lower, as ESC is less useful at avoiding fatalities in frontal collision crashes. The impact of AEB was insignificant in 2014, and was also estimated to be lower than the other technologies in 2033. This is partly because the technology will take a long time to filter through the vehicle fleet, but also because the assumed impacts per crash are lower. However, due to the early stage of development of AEB compared with the other technologies analysed, the uncertainty surrounding the impacts is greater.

Technology	Relevant crash types	Share of fatalities	Fatality reduction.	Fatality reduction.	Share of LV fleet	Total fatality	Share of LV fleet	Total fatality
		accounted for by relevant	relevant crashes (%)	equipped vehicles (%)	equipped, 2014 (%)	reduction, 2014 (%)	equipped, 2033 (%)	reduction, 2033 (%)
		crash types (%)						
Driver airbags	Front impact	60ª	25ª	15	79	12	99	15
Passenger airbags	Front impact with passenger	12ª	20ª	2	55	1	97	2
Side airbags	Side impact	20 ^b	51 ^c	10	36	4	95	10
ESC	Run-off-road	380	53 ^e	20	29	6	94	18
Basic AEB	Low speed collisions	10	20	2	3	0	78	1
AEB protection for vulnerable road users	Low speed collisions involving cyclists and pedestrians	10	20	2	1	0	72	2
High speed AEB	Higher speed collisions (including cyclists and pedestrians)	34	20	7	0	0	52	5

Table 1 Summary of assumptions and estimates

(a) Paine 2002, citing Langwieder et al (1998) and MUARC (1992) (b) United Nations 2013 (c) D'Elia, Scully and Newstead 2012 (d) BITRE unpublished data (e) Scully and Newstead 2007, citing US research



Figure 1 Proportion of light vehicle fleet with airbags and electronic stability control. Source: BITRE estimates derived from VFACTS (various years) Glass's (2014), ABS (2014)







Figure 3 Estimated impacts of measures on fatalities per billion safety weighted vehicle kilometres travelled. Sources: BITRE 2014b, BITRE analysis

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