EVALUATION OF THE EFFECTIVENESS OF ANTI-LOCK BRAKING SYSTEMS ON MOTORCYCLE SAFETY IN AUSTRALIA

by
Brian Fildes
Stuart Newstead
Matteo Rizzi
Michael Fitzharris
Laurie Budd

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Evaluation of the effectiveness of Anti-Lock Braking Systems on motorcycle safety in Australia

Brian Fildes, Stuart Newstead, Matteo Rizzi, Laurie Budd, and Michael Fitzharris

Sponsoring Organisation(s):
Australian Government Department of Infrastructure and Regional Development and VicRoads

Abstract:

This study sets out to assess the benefits of ABS technology fitted to motorcycles, classification, LC>125cc (no scooters with engine cylinder capacity exceeding 50ml and/or a maximum speed exceeding 50km/h), using Australian crash data, to compare these findings with published international research, and to estimate the likely benefits in reduced crashes and injuries in the years ahead. Importantly, the findings showed that the presence of ABS on these motorcycles resulted in a 33% reduction in all injuries in relevant crash types and a 39% reduction in severe injuries in these crashes.

The benefits varied depending on the type of crash, whether it was a single or multi-vehicle crash, occurred at an intersection, and whether the road was wet or not. There was good consistency in these findings across the various Australian states and similar international findings. Consequently there are marked savings in fewer fatalities as well as severe and minor injuries in these crashes and even further reductions are predicted over the next 10 years. It is predicted that these savings would be enhanced by efforts to increase the fitment rate of ABS on all new LC motorcycles in the coming years. The rate of fitment could be accelerated by mandating the fitment of ABS technology for all new LC>125cc motorcycles with associated reductions in crashes and severe injuries.

Key Words:
crash, injury outcome, reversing camera, data, feasibility, motorcycle anti-lock brakes, motorcycle linked brakes

Disclaimer

This report is disseminated in the interest of information exchange. The views expressed here are those of the authors, and not necessarily those of VicRoads or the Department of Infrastructure and Regional Development or Monash University.
PREFACE

Project Manager / Team Leader:
Professor Brian Fildes
Associate Professor Stuart Newstead

Research Team:
• Matteo Rizzi
• Ms Laurie Budd
• Assoc. Prof. Michael Fitzharris

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Folksam Insurance in Sweden was agreeable to Matteo Rizzi joining the program and spending time in Australia for which we are also most grateful.
## GLOSSARY OF TERMS

<table>
<thead>
<tr>
<th>term</th>
<th>description</th>
</tr>
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<tbody>
<tr>
<td>ABS</td>
<td>Anti-lock Braking Systems</td>
</tr>
<tr>
<td>ASC</td>
<td>Automatic Stability Control</td>
</tr>
<tr>
<td>BITRE</td>
<td>Bureau of Infrastructure, Transport and Regional Economics</td>
</tr>
<tr>
<td>Bikes</td>
<td>Motorcycles</td>
</tr>
<tr>
<td>CBS</td>
<td>Combined Braking Systems</td>
</tr>
<tr>
<td>DIRD</td>
<td>Department of Infrastructure and Regional Development</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>HLDI</td>
<td>Highway Loss Data Institute</td>
</tr>
<tr>
<td>IIHS</td>
<td>Insurance Institute for Highway Safety</td>
</tr>
<tr>
<td>KSI</td>
<td>Killed and Seriously Injured</td>
</tr>
<tr>
<td>LA</td>
<td>Australian Design Rule category for a 2-wheeled motor vehicle, not being a power-assisted pedal cycle, with an engine cylinder capacity not exceeding 50 ml and a maximum speed not exceeding 50 km/h; or a 2-wheeled motor vehicle with a power source other than a piston engine and a maximum speed not exceeding 50 km/h. Sensitive cases where ABS technology is expected to influence the crash outcome.</td>
</tr>
<tr>
<td>LB</td>
<td>Australian Design Rule category for a 3-wheeled motor vehicle, not being a power-assisted pedal cycle, with an engine cylinder capacity not exceeding 50 ml and a maximum speed not exceeding 50 km/h; or a 3-wheeled motor vehicle with a power source other than a piston engine and a maximum speed not exceeding 50 km/h. VicRoads State Government Authority responsible for efficient and safe travel on roads in Victoria.</td>
</tr>
<tr>
<td>LC</td>
<td>Australian Design Rule category for a 2-wheeled motor vehicle with an engine cylinder capacity exceeding 50 ml or a maximum speed exceeding 50 km/h. Vin Vehicle Identification Number assigned to all registered vehicles</td>
</tr>
<tr>
<td>LC&lt;125cc</td>
<td>LC category 2-wheel vehicle with engine capacity less than 125cc TAC Transport Accident Commission of Victoria (Aus)</td>
</tr>
<tr>
<td>LC&gt;125</td>
<td>LC category 2-wheel vehicle with engine capacity greater than 125cc YoM Year of vehicle manufacture</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

EXECUTIVE SUMMARY .................................................................................................................. 1
METHODOLOGY .................................................................................................................................. 1
ABS OVERALL EFFECTIVENESS ........................................................................................................ 1
MOTORCYCLE CRASH TYPES FOR ABS EQUIPPED BIKES AGAINST NON ABS EQUIPPED BIKES ...... 1
FLEET SIZE AND MARKETING TRENDS ............................................................................................. 2
CRASH AND INJURY BENEFITS ......................................................................................................... 2
ASSUMPTIONS AND LIMITATIONS ................................................................................................... 2
CONCLUSIONS .................................................................................................................................. 3

1. INTRODUCTION ............................................................................................................................... 4
   1.1 MOTORCYCLES ............................................................................................................................ 4
   1.2 OTHER BRAKING TECHNOLOGIES ............................................................................................ 4
   1.3 THE MOTORCYCLE PROJECT ................................................................................................... 5

2. PROJECT METHODOLOGY ............................................................................................................... 6
   2.1 ABS/CBS EFFECTIVENESS ....................................................................................................... 6
   2.2 DETAILED ANALYSES ............................................................................................................. 7
   2.3 MODELLING THE EFFECTS OF ABS ON FUTURE CRASHES ..................................................... 7

3. RESULTS .......................................................................................................................................... 8
   3.1 ABS DATA IN AUSTRALIAN STATES ......................................................................................... 8
   3.2 SENSITIVE AND NON-SENSITIVE CRASH TYPES ................................................................. 11
   3.3 EFFECTIVENESS OF ABS AND CBS IN MOTORCYCLE CRASHES IN AUSTRALIA ............... 12
   3.4 EFFECTIVENESS FOR ALL MOTORCYCLE CRASHES ................................................................ 13
   3.5 OTHER FINDINGS .................................................................................................................... 13

   3.5.1 Fatality and Survivable Injury Outcomes ............................................................................. 13
   3.5.2 Motorcycle type and bike age .............................................................................................. 14
   3.5.3 Rider age group and sex ...................................................................................................... 14
   3.5.4 Crash type and road condition ............................................................................................ 15
   3.5.5 Speed Zone and Helmet Use ............................................................................................... 16
   3.5.6 Summary of Findings .......................................................................................................... 16

   3.6 MARKETING AND ROAD SAFETY .......................................................................................... 17

   3.6.1 New vehicles entering the market ...................................................................................... 17
   3.6.2 The Number under RVCS Listing ....................................................................................... 17
   3.6.3 Numbers with ABS and CBS in the fleet ........................................................................... 17
   3.6.4 Market Expectations ........................................................................................................... 17
   3.6.5 Accelerated Growth ............................................................................................................. 18

4. OVERALL BENEFITS OF ABS .......................................................................................................... 20
   4.1 FATAL AND SERIOUS INJURY CRASHES (VICTORIA) ............................................................... 20
   4.2 FATAL AND SERIOUS INJURY CRASHES (AUSTRALIA) ........................................................... 21
5. GENERAL DISCUSSION AND CONCLUSIONS .......................................................... 28
   5.1 EFFECTIVENESS OF ABS (AND CBS) TECHNOLOGIES FOR MOTORCYCLES ............. 28
      5.1.1 ABS Relevance for Motorcycle Crash Types .................................................. 28
   5.2 FLEET SIZE AND MARKETING TRENDS ............................................................. 28
   5.3 CRASH AND INJURY BENEFITS ........................................................................... 29
   5.4 STUDY LIMITATIONS .......................................................................................... 29
   5.5 CONCLUSIONS ..................................................................................................... 30
REFERENCES ............................................................................................................... 30
APPENDIX A – EXTRACTS FROM HLDI (2013) .............................................................. 32
APPENDIX B – DCA CHARTS USED IN THIS ANALYSIS ................................................. 33
APPENDIX C – PROJECTION MODELLING ...................................................................... 46
APPENDIX D – PROJECTED CRASHES UNAFFECTED BY LC>125CC ABS MODELLING ........... 49
EXECUTIVE SUMMARY

This study sets out to address a number of objectives related to the use of ABS (Anti-lock Braking Systems) technology as a safety feature on LC category motorcycles with an engine capacity greater than 125cc. In particular, it examined the effectiveness of ABS in reducing motorcycle crashes and injuries to motorcyclists, both in Australia and within an international context, and the relevance and effectiveness of motorcycle ABS to specific crash types.

In addition, the project sought to identify future trends of motorcycle and ABS fitment growth and the likely benefits in terms of future injury savings and what the economic cost of the technology is expected to be. While it was hoped that the analysis would also include the benefits of CBS (Combined Braking Systems), limited fitment of this technology in the vehicle fleet precluded this task.

Methodology

The project involved a statistical analysis of national road crash data as well as trend data in vehicle sales and ABS fitment for motorcycles. The Vehicle Identification Number (VIN) was used to identify LC motorcycles with the technology fitted and this proved to be somewhat challenging, given the different forms of the recording of VIN adopted in this country. Statistical modelling was also undertaken for predicting future trends based on past and current figures, requiring a number of assumptions.

It was assumed that ABS would be effective for various crash configurations which excluded head-on, overtaking, U-turning, entering and leaving a parking place, collision with a fixed object and cutting in collisions. These crashes were labelled as "non-sensitive" crashes. All other crash types were considered to be sensitive crashes where ABS was expected to be of benefit. The effectiveness analysis involved Induced Exposure measures to help minimise the effects of confounding factors.

ABS Overall Effectiveness

The overall analysis found that ABS technology on LC>125 motorcycles (no scooters) resulted in a 33% reduction in all injury crash severities and a 39% reduction in severe injury crashes for sensitive crashes. This translates to a 31% benefits across all motorcycle crashes in Australia. For the few cases where ABS and CBS were identified together, the effectiveness rose slightly to 44%\(^1\). The effectiveness was further shown to vary depending on single or multi-vehicle crashes, at intersections, and whether the road was wet or not. These findings were roughly equivalent with other published international results.

Motorcycle Crash Types for ABS equipped bikes against non ABS equipped bikes

There were differences in terms of crash type between motorcycles fitted with ABS or not. Those with ABS had slightly fewer intersection crashes and crashes on curves but slightly more rear-end crashes. These findings were not particularly strong and probably influenced by the selection of what was considered to be an ABS sensitive crash type.

Other findings showed some differences between motorcycles with and without ABS by the type of LC motorcycle (sport touring and touring in particular), the age group of the rider, and the speed zone where the crash occurred. It is likely, however, that some of these findings may be subject to other rider influences, such as personality and motivation of the rider. There were no differences between these two groups in terms of helmet use. It was not possible to break these figures down by sealed and unsealed roads as these categories were not consistent across these databases.

\(^1\) 44% was obtained from data interrogation rather than from induced exposure regression, due to the size of the dataset.
Fleet Size and Marketing Trends

The project also called for identifying and predicting the future fleet size of ABS and likely future trends in marketing and ABS fitment rates in Australia. Using registration figures of LC motorcycles dating back to 1998, it was possible to predict the future trend of registrations for the next 10 years. The study team felt that beyond that, it was not really possible as there are likely to be major changes in motorcycle types, consumer interest (especially if ABS fitment becomes mandatory) and general shifts in the whole vehicle industry.

The predicted growth trend for the number of Australian registered motorcycles was a general increase of around 4.7% annually (Australian Bureau of Statistics) of which the proportion of LC>125cc motorcycles was around 62%. In 2014 the five year average annual growth in new LC>125cc vehicles with ABS was 17%. As the proportion of new LC motorcycles with ABS in 2015 is still quite a modest proportion of new vehicle sales (approximately 20%), all-age vehicle fleet fitment is still not likely to rise above 20% by 2025 according to modelled projections of current new-vehicle fitment rates. This might suggest the need for intervention to help accelerate these trends.

Crash and Injury Benefits

Given the difficulty experienced in VIN identification in most Australian states, the analysis necessitated the use of the more reliable figures of ABS fitment in Victoria for predicting the benefits in all Australian states and territories. Trends targeted what the benefits would be if the current increase in ABS fitment was to occur annually, taking into account predicted increases of LC motorcycles over the last 10 years, fitment rates of ABS, and likely crashes and injury savings up until 2025.

The analysis revealed that if increases in ABS fitment trends continue at current rates, it is expected that there would be a net reduction of 643 injury crashes between now and the year 2025 with expected injury savings of 22 fatalities, 345 serious injuries and 367 minor injuries. These savings could be accelerated by introducing legislation for mandatory fitment of ABS in all new LC>125cc motorcycles.

Depending on when such legislation could be introduced, it could lead to an additional 60% reduction over current predicted trends in injury crashes and associated fatalities, and in serious and minor injuries. As the average life of an LC motorcycle is currently around 22 years, these savings would be considerably greater beyond 2025, assuming there are no major changes in vehicle registration patterns and consumer demand.

Achieving these savings will come at a cost of ensuring all motorcycles LC>125cc are produced with anti-lock brakes as standard equipment. The European parliament mandated compulsory fitment of ABS on motorcycles 125cc and above by 2016. In their cost-benefit-analysis, they used a figure of 500 euros per motorcycle, based on manufacturer’s costs. This has been disputed by others who argued that suppliers’ figures (based on what the cost to manufacturers would actually be by suppliers) of 150 euros was more realistic. It seems reasonable, therefore, to assume that the actual cost to OEMs for fitment of ABS technology on all LC>125cc motorcycles would be 150 euros (approx. A$220).

Assumptions and Limitations

Studies of this kind are typically limited in a number of ways. The lack of any consistent available data across the states (especially VIN number irregularities) led to assumptions of what the current situation is regarding motorcycle crashes and ABS fitment in Australia. These really need to be validated if possible in future analyses. In addition, in estimating future trends, it was necessary to make the assumption that the LC motorcycle environment in future will follow current patterns. This is quite a broad assumption as demand for new motorcycles with ABS is quite unknown. For instance, if legislation
were to be introduced mandating ABS, this could possibly lead to significant changes in supply and demand.

**Conclusions**

The findings of the effectiveness of ABS in preventing crashes and injuries identified substantial benefits for LC>125cc motorcyclists from fitment of this technology to their machines. The analysis found that ABS resulted in a 33% reduction of all injuries in sensitive crash types and a 39% reduction in severe injuries in these crashes. These findings were in line with other published international results. In association with these savings, there are expected to be marked savings in fewer fatalities as well as severe and minor injuries. These savings would be enhanced by efforts to increase the fitment rate of ABS on all new LC motorcycles over the coming years.
1. INTRODUCTION

Anti-lock Braking Systems (ABS) were developed many years ago and became a popular fitment on passenger cars during the early 1980s. ABS is a closed-loop braking system that prevents wheel lock during braking resulting in improved vehicle stability and steering and potentially reduced stopping distance. ABS uses speed sensors on both wheels to accurately determine wheel speed, as well as sensors to determine when a wheel is about to lock. Since its introduction, ABS technology has been acclaimed as providing significant improvement in braking performance for passenger cars and consequently reducing crash risk, yet the evidence to support these claims is thin and equivocal at best (Burton et al, 2004). Evans (1998) reported a reduction of 32% in striking the vehicle ahead offset by an increase in being struck from behind by 30%. Burton and his colleagues found a reduction in multi-vehicle rear-end and head-on collisions, but an increase in the number of single-vehicle and rollover crashes. They claimed that its greatest benefit is in improving injury reductions by diverting injurious crashes into less-injurious ones.

1.1 Motorcycles

The effectiveness of ABS in reducing crash risk for motorcycles may be quite different to passenger cars, given that motorcycles have only 2 wheels and are inherently less stable. Swedish research by Matteo Rizzi and his colleagues (Rizzi et al, 2009; 2014) revealed significant crash reduction benefits for ABS on motorcycles in Europe from 34% to 39% for all injury crashes and 42% to 48% for severe crashes using real-world crash analysis. From insurance data, the Insurance Institute for Highway Safety (IIHS 2008) reported considerable benefits for Antilock Braking Systems (ABS) at reducing crashes and injuries among motorcyclists in the USA. Benefits of up to a 34% reduction in the number of crashes and significant reductions in injury claims have been reported. These authors have shown that antilock brakes are more beneficial on motorcycles than they are on cars because they make the bikes more stable by reducing wheel lockup preventing falling or overturning during braking.

These studies show considerable promise for ABS technology to substantially improve motorcycle safety. While these studies have been carried out in Europe and the USA, no equivalent studies were found showing the likely effectiveness of ABS on Australian motorcycles and roads. Such a study would help in determining the need for ABS to be fitted on all new motorcycles sold in this region and show a direct comparison of effectiveness with the overseas reports. Moreover, as there is little evidence of how these benefits accrue, it would also be useful to examine the characteristics of motorcycle crashes in Australia.

1.2 Other Braking Technologies

More recently, other new braking technologies have been introduced for motorcycles. BMW have announced that their S1000R motorcycle is fitted with Race ABS and ASC (automatic stability control) as standard equipment. They claim that these technologies are integral for optimum deceleration, provide clear feedback in the hand lever to detect threshold range, can be deactivated while riding, are ultralight systems and virtually maintenance-free, ensure optimum acceleration on all road surfaces, and together, are perfectly interconnected, and that their regulation response is very simple to adapt via the standard road/rain riding modes (BMW Motorrad USA, 2014).

Honda, too, have looked into enhanced braking systems for their motorcycles, combining controllability, convenience and the sense of confidence for the average rider (Honda 2014). First, they developed a combined brake system (CBS) for their motorcycles, and then an anti-lock brake system
(ABS). Furthermore, they claimed that in developing CBS and ABS, they were able to introduce both together as a way of enhancing their respective effects.

The Highway Loss Data Institute (HLDI) (2013) reported on the benefits of these systems based on US claims analysed using insurance data. Their analysis involved reductions in claims frequency, injury severity and overall losses for a range of 36 motorcycles involving 427,878 claims (see Appendix A). They reported reductions in overall losses for ABS alone on motorcycle crashes in the US at 20.3 percent and for ABS and CBS of 34.2 percent.

While these reductions in motorcycle crashes are impressive, nevertheless, the focus of this Australian research will predominantly emphasise ABS on motorcycles as the introduction of CBS and ASC (automatic stability control) technologies is new and not that widespread in this country to date. It would be useful, however, to include any potential benefits from Combined Braking Systems in this research where possible.

### 1.3 The Motorcycle Project

The project has a number of objectives:

- To examine the effectiveness of ABS and where possible CBS technology to reduce motorcycle crashes and injuries to motorcyclists, both in Australia and within an international context;
- To examine the relevance of motorcycle ABS to specific crash types and the effectiveness of ABS in reducing relevant crash types, as well as account for the use of CBS, particularly on smaller motorcycles, if possible;
- To identify fleet size of ABS and CBS and predict likely future trends in marketing and road trauma in Australia;
- To identify the likely benefits in terms of injury savings and what the economic cost of the technology is expected to be; and
- Prepare a report on the findings of the study, including a recommendation on the likely future of advanced braking technologies and how best to evaluate their likely safety benefits for motorcyclists in Australia.

The Australian Design Rules categorises motorcycles in Australia as either:

- **LA** (mopeds up to 50cc);
- **LB** (A 3-wheeled motor vehicle, not exceeding 50cc and a maximum motor cycle speed not exceeding 50km/h); and
- **LC** (A 2-wheeled motor vehicle with an engine cylinder capacity exceeding 50cc or a maximum motor cycle speed exceeding 50 km/h).

While it would be desirable to identify ABS effectiveness of motorcycles by ADR category and engine capacity, this will depend on the numbers of crash cases available for the analysis. It is highly unlikely that ABS for motorcycles is fitted to mopeds in this country. Where possible, the effectiveness of ABS alone and in combination with CBS will be separated in the analysis. In addition, the effectiveness of ABS on motorcycles in Australia will be compared with published international figures to show relative rates to help guide future interventions.

This project is a jointly-funded collaboration between the Commonwealth Department of Infrastructure and Regional Development (DIRD) and VicRoads (Victoria).
2. PROJECT METHODOLOGY

A number of methodologies were used in this analysis, combining descriptive comparisons of available crash and motorcycle population data with statistical models. Importantly, in judging effectiveness, induced exposure methods were employed for statistical rigor and for comparison with other international findings.

A comprehensive national database from five Australian states (Victoria, NSW, QLD, WA and SA) was compiled for use in this analysis. In addition, other data including Australian Bureau of Statistics (ABS 2014) census data for registered vehicles and VIN analysis (MUARC, 2015) were accessed for modelling future trends and likely benefits. These latter data were necessary to identify what motorcycles had or did not have ABS technology.

2.1 ABS/CBS Effectiveness

In assessing the likely effectiveness of ABS, a statistical analysis was carried out using odds-ratio calculations and an induced exposure approach, as in previous studies (Rizzi et al, 2009; 2014). With this approach, the key point is to identify at least one crash type or situation in which ABS can reasonably be assumed not to be effective (control). If the only noteworthy difference in terms of crash risk is ABS, the relation between motorcycles with and without ABS in that non-sensitive situation would be considered as the true exposure measure. This means that any deviation from the relation in non-sensitive situations is considered to be a result of ABS, as shown below.

\[
R = \frac{A_{ABS}}{N_{ABS}} ÷ \frac{A_{non-ABS}}{N_{non-ABS}} \quad (Eq. 1)
\]

Where:

- \(A_{ABS}\) = number of crashes sensitive to ABS, involving motorcycles with ABS
- \(A_{non-ABS}\) = number of crashes sensitive to ABS, involving motorcycles without ABS
- \(N_{ABS}\) = number of crashes non-sensitive to ABS, involving motorcycles with ABS
- \(N_{non-ABS}\) = number of crashes non-sensitive to ABS, involving motorcycles without ABS

Thus, the effectiveness in reducing sensitive crashes can be expressed as:

\[
E_{sens} = 100 × (1 - R)\% \quad (Eq. 2)
\]

Analyses also included estimation of the induced exposure injury and KSI crash risk associated with ABS using Poisson regression analysis with a Pearson over-dispersion correction. The regression analysis included adjustment for the motorcycle speed (by two zone limit categories: under 80 km/hr or \(≥80\)km/hr) and the differences associated with jurisdictions. Analyses were repeated for all and severe injury crashes on wet roads, at intersections and involving multiple vehicles. Data proved insufficient in power to produce effect estimates for single vehicle crashes under this modelling.

In undertaking this analysis, it is important to identify the sensitive and non-sensitive crash types that ABS is predicted to influence. Sensitive crashes are those such as a motorcycle striking a passenger car in the side or rear-end where the ABS would be expected to either mitigate the severity of the crash or avoid it altogether. Non-sensitive crashes are those where little benefit is expected such as a head-on crash where braking is less likely to occur in time to have any real effect. Using this approach, an estimate of motorcycle effectiveness in Australia was then computed and compared with previous reports.
2.2 Detailed Analyses

Given sufficient cases, the effectiveness analysis can also be broken down by extra factors such as the rider's age and sex, relevant crash types, and severe to less severe crash outcomes. This helps to identify riders and crash vulnerable factors for intervention, and provides additional information for use in other follow-up studies, i.e., cost-benefit analysis (see Appendix B).

2.3 Modelling the effects of ABS on future crashes

Registration and crash datasets up to 2014 were available for modelling the effects of ABS in reducing future crashes in this state. Only crash data with registration plate records matching those in the registration snapshots and only registration data with valid VINs, registration plates and years of manufacture were included in this analysis. VINs were needed to match datasets, uniquely identify vehicles and determine the motorcycle type and ABS status.

Modelling was carried out for vehicles aged up to 22 years beyond their manufactured year. For each crash/registration year and each age of vehicle from 0 to 22 years, unique vehicles and their crashes were counted. From this, proportions of registered vehicles, proportions of ABS fitment in registered vehicles and total registered motorcycle fleet size were projected (see Appendix C). Mopeds and scooters did not have ABS fitted. Scrappage for the fleet was estimated by keeping the vehicle age distribution by type constant at the distribution average for 2013 through 2014 (Appendix C). Vehicles fitted with ABS were assumed not to be scrapped, since they are relatively new and the time projected is relatively short. The ABS proportion of older vehicles at the end of the projected time is small, so failure to meet this assumption is likely to have no significant effect. In addition crash risks by type, crash year and vehicle age were calculated and averaged over the past five years to use in projecting injury, serious injury and other injury crashes. Crashes were projected with the 2014 ABS proportion of new vehicle across all years, with the ABS proportion in new vehicles projected to increase from logistic regression projections depicted in Appendix C for 2018, 2019 and 2020 respectively and a mandate on new vehicles thereafter. Injuries from injury crashes were calculated using average injuries (of type) per crash type from combined jurisdiction crash data.

For this analysis motorcycle types (Off road, LA, LC>125CC road and not a scooter, and LC ≤125CC), engine capacity and Australian Design Rule Grouping (ADG) code were identified for all vehicles with a year of manufacture beyond 2003. Estimations needed for vehicles with a 2003 or earlier year of manufacture were carried out as follows: type was estimated as off-road if the vehicle was VTYPE purpose built or OUTFIT and ADG was estimated as LC unless capacity was less than 50 or VTYPE was a scooter. Scooters with an engine capacity greater than 125CC were not included in any group since none of these were fitted with ABS in the data.
3. RESULTS

There were no LA mopeds or LC ≤ 125cc motorcycles fitted with ABS in the crash data. Of those with an engine capacity >125cc, there were none manufactured prior to 1989. Thus, the analysis focussed on LC motorcycles with a greater than 125cc and greater than 1988 year of manufacture.\(^2\)

3.1 ABS Data in Australian States

To undertake the tasks listed above, it was necessary to put together national police data from as many Australian states as possible. The Centre is currently assembling a 2012 edition to the current vehicle crashworthiness database comprising data from Victoria, NSW, Queensland, Western Australia and South Australia since 2000. These data comprise more than 90% of all road crashes that occur in Australia annually. As there have been difficulties in securing some data for 2012, the analysis will concentrate on ABS and CBS crash performance from 2000 to 2011 to expedite the project.

Tables 1 to 5 show the distribution of cases with ABS, and those without ABS, based on an analysis of the 11 years of data available from these five Australian states.

---

Table 1: Australian ABS Sensitive Motorcycle Crashes of 2000-2011 by Jurisdiction - All Crashes

<table>
<thead>
<tr>
<th>ABS Sensitive Crashes</th>
<th>New South Wales</th>
<th>Victoria</th>
<th>Queensland*</th>
<th>Western Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>All crashes</td>
<td>26,857</td>
<td>2,437</td>
<td>N/A**</td>
<td>17,083</td>
<td>1,109</td>
</tr>
<tr>
<td>All injury crashes</td>
<td>24,501</td>
<td>2,185</td>
<td>21,957</td>
<td>1,910</td>
<td>16,700</td>
</tr>
<tr>
<td>Valid All injury</td>
<td>698</td>
<td>68</td>
<td>4,845</td>
<td>387</td>
<td>3,181</td>
</tr>
<tr>
<td>crashes*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With ABS status</td>
<td>278</td>
<td>23</td>
<td>1,336</td>
<td>122</td>
<td>1,158</td>
</tr>
<tr>
<td>identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ABS Injury</td>
<td>238</td>
<td>17</td>
<td>1,133</td>
<td>96</td>
<td>1,021</td>
</tr>
<tr>
<td>ABS Injury</td>
<td>40</td>
<td>16</td>
<td>203</td>
<td>26</td>
<td>137</td>
</tr>
<tr>
<td>No ABS KSI</td>
<td>238</td>
<td>17</td>
<td>483</td>
<td>53</td>
<td>595</td>
</tr>
<tr>
<td>ABS KSI(^{f})</td>
<td>40</td>
<td>6</td>
<td>80</td>
<td>16</td>
<td>78</td>
</tr>
</tbody>
</table>

*Valid VIN, year of manufacture and capacity
** Non-injury crashes are not reported in official crash statistics in Victoria
*Valid with ABS status identified (NSW injury crashes assumed serious)
\(^{f}\) incomplete 2011 data

---

\(^2\) In addition, only motorcycle data with a valid VIN could be adequately identified, and only those with ABS status identified could be used in the analysis. A valid VIN consisted of at least 11 of the appropriate alpha-numeric characters.
**Table 2**: Australian ABS Sensitive Motorcycle Crashes during 2000-2011 - No Injury Crashes by engine capacity, year of manufacture and jurisdiction*

<table>
<thead>
<tr>
<th>Crash Sensitive to ABS</th>
<th>New South Wales</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Capacity ≤125 cc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valid VIN and valid YOM</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Unknown engine capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No valid VIN</td>
<td>1,947</td>
<td>214</td>
<td>176</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2,518</td>
<td>238</td>
<td>186</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>443</td>
<td>19</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>No valid YOM</td>
<td>332</td>
<td>30</td>
<td>194</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1,683</td>
<td>149</td>
<td>218</td>
<td>19</td>
</tr>
<tr>
<td>No valid VIN and YOM</td>
<td>271</td>
<td>29</td>
<td>76</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1,569</td>
<td>137</td>
<td>129</td>
<td>13</td>
</tr>
<tr>
<td>Valid VIN and valid YOM</td>
<td>271</td>
<td>29</td>
<td>129</td>
<td>13</td>
</tr>
<tr>
<td>Engine Capacity &gt;125 cc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No valid VIN</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No valid YOM</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Valid VIN and valid YOM</td>
<td>73</td>
<td>8</td>
<td>54</td>
<td>2</td>
</tr>
</tbody>
</table>

*Victoria does not record non-injury crashes in their database

**Table 3**: Australian ABS Sensitive Motorcycle Crashes during 2000-2011 - All Injury Crashes by engine capacity, year of manufacture and jurisdiction

<table>
<thead>
<tr>
<th>Crash Sensitive to ABS</th>
<th>New South Wales</th>
<th>Victoria</th>
<th>Queensland</th>
<th>West. Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Capacity ≤125 cc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No valid VIN</td>
<td>20,410</td>
<td>1,810</td>
<td>3,778</td>
<td>382</td>
<td>4,458</td>
</tr>
<tr>
<td></td>
<td>4,455</td>
<td>333</td>
<td>4,959</td>
<td>237</td>
<td>1,435</td>
</tr>
<tr>
<td>No valid YOM</td>
<td>4,688</td>
<td>433</td>
<td>3,755</td>
<td>403</td>
<td>5,495</td>
</tr>
<tr>
<td></td>
<td>5,495</td>
<td>393</td>
<td>2,973</td>
<td>157</td>
<td>1,241</td>
</tr>
<tr>
<td>No valid VIN &amp; YOM</td>
<td>4,114</td>
<td>385</td>
<td>2,489</td>
<td>289</td>
<td>4,455</td>
</tr>
<tr>
<td></td>
<td>4,455</td>
<td>333</td>
<td>2,735</td>
<td>148</td>
<td>965</td>
</tr>
<tr>
<td>Valid VIN and YOM</td>
<td>2,751</td>
<td>250</td>
<td>11,675</td>
<td>1,011</td>
<td>7,465</td>
</tr>
<tr>
<td></td>
<td>7,465</td>
<td>452</td>
<td>2,793</td>
<td>77</td>
<td>3,193</td>
</tr>
<tr>
<td>Unknown capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No valid vin</td>
<td>20,410</td>
<td>1,810</td>
<td>3,778</td>
<td>382</td>
<td>4,458</td>
</tr>
<tr>
<td></td>
<td>4,455</td>
<td>333</td>
<td>4,959</td>
<td>237</td>
<td>1,435</td>
</tr>
<tr>
<td>No valid YOM</td>
<td>4,688</td>
<td>433</td>
<td>3,755</td>
<td>403</td>
<td>5,495</td>
</tr>
<tr>
<td></td>
<td>5,495</td>
<td>393</td>
<td>2,973</td>
<td>157</td>
<td>1,241</td>
</tr>
<tr>
<td>No valid VIN &amp; YOM</td>
<td>4,114</td>
<td>385</td>
<td>2,489</td>
<td>289</td>
<td>4,455</td>
</tr>
<tr>
<td></td>
<td>4,455</td>
<td>333</td>
<td>2,735</td>
<td>148</td>
<td>965</td>
</tr>
<tr>
<td>Valid VIN and YOM</td>
<td>2,751</td>
<td>250</td>
<td>11,675</td>
<td>1,011</td>
<td>7,465</td>
</tr>
<tr>
<td>Engine Cap. &gt;125 cc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No valid vin</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No valid YOM</td>
<td>9</td>
<td>2</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No valid vin and no YOM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Valid VIN and YOM</td>
<td>698</td>
<td>68</td>
<td>4,845</td>
<td>378</td>
<td>3,181</td>
</tr>
<tr>
<td></td>
<td>3,181</td>
<td>212</td>
<td>1,098</td>
<td>42</td>
<td>1,123</td>
</tr>
</tbody>
</table>

*Victoria does not record non-injury crashes in their database*
Table 4: Crash Severity for Motorcycle Injury Crashes of 2000-2011 by jurisdiction

<table>
<thead>
<tr>
<th>Sensitive to ABS</th>
<th>New South Wales*</th>
<th>Victoria</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity of Injury</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Fatal</td>
<td>615</td>
<td>163</td>
<td>460</td>
<td>141</td>
<td>536</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>23,886*</td>
<td>2022*</td>
<td>9,935</td>
<td>955</td>
<td>8,956</td>
</tr>
<tr>
<td>Minor Injury</td>
<td>11,562</td>
<td>814</td>
<td>7,208</td>
<td>377</td>
<td>5528</td>
</tr>
</tbody>
</table>

*New South Wales do not differentiate between serious and minor injury in their database

Table 5: Crash Severity for known ABS status Motorcycle Injury Crashes of 2000-2011 by jurisdiction

<table>
<thead>
<tr>
<th>Sensitive to ABS</th>
<th>New South Wales*</th>
<th>Victoria</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity of Injury</td>
<td>With ABS</td>
<td>Without ABS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>78</td>
<td>16</td>
<td>75</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Minor Injury</td>
<td>123</td>
<td>10</td>
<td>59</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Fatal</td>
<td>4</td>
<td>2</td>
<td>17</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>466</td>
<td>44</td>
<td>562</td>
<td>23</td>
<td>105</td>
</tr>
<tr>
<td>Minor Injury</td>
<td>234*</td>
<td>15*</td>
<td>465</td>
<td>43</td>
<td>426</td>
</tr>
</tbody>
</table>

*New South Wales do not differentiate between serious and minor injury in their database

These findings show that over all states, 15% (10%-23%) of motorcycles involved in injury crashes with ABS status known and a valid VIN, year of manufacture YPOM and an engine capacity >125 CC were equipped with ABS. In addition, it was also possible to assess ABS with and without CBS, where 45% (17%-58%) of ABS motorcycles that crashed (in injury crashes with valid VIN, YOM and >125CC) were also fitted with CBS technology. Killed and Serious Injury (KSI) crashes on average comprised 48% (34%-57%) of injury crashes from jurisdictions excluding NSW (where serious injuries could not be distinguished), while crashes at intersections accounted for 42% (39%-50%) of all injury crashes. It should be noted that there were many instances when it was not possible to identify whether the vehicle had ABS or not in the relevant motorcycle crashes, but this seemed unlikely to have any marked influence on the findings for most states, apart from NSW where the absence of VIN was more evident compared to the other states.

The distribution of ABS and Non-ABS motorcycles used in the analysis of ABS effectiveness is shown in Table 6 below. Not all motorcycle crashes were relevant and many were excluded if they were not represented motorcycle categories (there were no cases for LA mopeds or LC motorcycles with an engine capacity ≤ 125cc), if they were not matched cases to those with ABS, or where ABS could not be identified from the VIN. This meant that only 4% of all injury motorcycle crashes were used in the analysis.
### Table 6: Crashed motorcycles available for the ABS Effectiveness Analysis

<table>
<thead>
<tr>
<th>Make</th>
<th>ABS - Cases</th>
<th>Percent</th>
<th>Non-ABS Cases</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aprilia</td>
<td>0</td>
<td>0%</td>
<td>7</td>
<td>0%</td>
</tr>
<tr>
<td>BMW</td>
<td>402</td>
<td>75%</td>
<td>513</td>
<td>16%</td>
</tr>
<tr>
<td>Honda</td>
<td>83</td>
<td>15%</td>
<td>1,144</td>
<td>36%</td>
</tr>
<tr>
<td>Kawasaki</td>
<td>14</td>
<td>3%</td>
<td>314</td>
<td>10%</td>
</tr>
<tr>
<td>Suzuki</td>
<td>33</td>
<td>6%</td>
<td>867</td>
<td>28%</td>
</tr>
<tr>
<td>Triumph</td>
<td>5</td>
<td>1%</td>
<td>181</td>
<td>6%</td>
</tr>
<tr>
<td>Yamaha</td>
<td>2</td>
<td>0.4%</td>
<td>113</td>
<td>4%</td>
</tr>
<tr>
<td>MBK</td>
<td>0</td>
<td>0%</td>
<td>13</td>
<td>0.4%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>622</td>
<td>100%</td>
<td>3,556</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### 3.2 Sensitive and Non-Sensitive Crash Types

In using induced exposure methods, it is necessary, when assessing the effectiveness of ABS and CBS technologies, to identify crashes where these technologies are likely to work or not. These are called sensitive (technology design should operate in these crash types) and non-sensitive (technology unlikely to work in these crash types). This was done using a group consensus approach and examining the Definition of Crashes (DCA) records from each state. For example, non-sensitive crash types for ABS technology using Victorian DCAs included head-on, manoeuvring and some overtaking crash types. The DCA coding sheets for the 5-states showing the individual codes used in the analysis for sensitive and non-sensitive crash types are included in Appendix B to this report. Also in Appendix B are frequency tables for all motorcycle and all injury motorcycle crashes tabled for each crash type code by jurisdiction. The results showing the sensitive and non-sensitive crash numbers for ABS fitted motorcycles are shown in Table 7, along with injury crash numbers for ABS and ABS+CBS motorcycles.

### Table 7: Number of motorcycle sensitive and non-sensitive crash types with ABS and injury crashes with ABS and/or CBS from the 5-states in Australia (2000 to 2011)

<table>
<thead>
<tr>
<th>Crash Sensitive to ABS</th>
<th>New South Wales</th>
<th>Victoria</th>
<th>Queensland</th>
<th>Western Australia</th>
<th>South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>All Crashes</td>
<td>26,857</td>
<td>2,437</td>
<td>21,961</td>
<td>1,910</td>
<td>17,083</td>
</tr>
<tr>
<td>Valid Injury crash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS+CBS</td>
<td>6</td>
<td>2</td>
<td>87</td>
<td>12</td>
<td>78</td>
</tr>
<tr>
<td>ABS Only</td>
<td>34</td>
<td>4</td>
<td>116</td>
<td>14</td>
<td>59</td>
</tr>
<tr>
<td>No ABS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+CBS</td>
<td>11</td>
<td>1</td>
<td>119</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>no CBS</td>
<td>227</td>
<td>16</td>
<td>1014</td>
<td>89</td>
<td>989</td>
</tr>
</tbody>
</table>

The results in Table 7 show that 93% of the ABS motorcycle injury crashes occurred in those judged to be sensitive crash types for the technology (NOT head-on, NOT manoeuvring and some overtaking crash types). The equivalent figures for all crashes with and without injury (shown in Table 1) were also 93%.
3.3 Effectiveness of ABS and CBS in Motorcycle Crashes in Australia

The effectiveness analysis of the 3,691 available ABS and non-ABS vehicle crashes across Australia between 2000 and 2011 is shown in Table 8 below, along with published international comparisons. With the exception of the ABS+CBS result, Australian effectiveness estimates are derived from the Poisson regression analysis. The findings show point-value estimates from the analysis as well as 95th percentile values. From these figures, it is possible to calculate the statistical significance of these values, assuming a p<.05 value of significance.

Table 8: Effectiveness of motorcycle ABS (and CBS) in Australia and International

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Australia</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Point</td>
<td>Effective</td>
</tr>
<tr>
<td>ABS (all injury crash)</td>
<td>33%</td>
<td>(19-45)</td>
</tr>
<tr>
<td>ABS (severe injury crash)</td>
<td>39%</td>
<td>(21-53)</td>
</tr>
<tr>
<td>ABS +CBS</td>
<td>44%²</td>
<td>±20%</td>
</tr>
<tr>
<td>Multi-vehicle crash ABS (all injury)</td>
<td>31%</td>
<td>(12-46)</td>
</tr>
<tr>
<td>Multi-vehicle crash ABS (severe injury crash)³</td>
<td>31%</td>
<td>(1-52)</td>
</tr>
<tr>
<td>Intersection crash ABS (severe injury crash)³,⁴</td>
<td>65%</td>
<td>(42-79)</td>
</tr>
<tr>
<td>Wet road crash ABS (all injury)</td>
<td>57%</td>
<td>(8-80)</td>
</tr>
<tr>
<td>Wet road crash ABS (severe injury crash)³</td>
<td>60%</td>
<td>(9-83)</td>
</tr>
</tbody>
</table>

1. Crashes with all injuries and severe and fatal crashes
2. Overall insurance loss claims
3. NSW excluded
4. A non-significant estimate was obtained for injury crashes at intersections
5. Not a regression result involving very few numbers

These results show that motorcycles fitted with ABS technology have a significant 33% reduction in the likelihood of being involved in an injury crash across Australian states, and a significant 39% reduction in being involved in a serious or fatal injury crash. These findings are remarkably similar to those previous reported by Rizzi et al (2014) for Sweden and marginally higher than those for Italy, Spain and the USA. In addition, the benefits in Australia for motorcycles fitted with both ABS and CBS was higher than ABS by itself and also higher than that based on insurance loss claims published by HLDI (2013).
3.4 Effectiveness for all Motorcycle Crashes

The previous section focuses on the effectiveness of ABS for motorcycles in sensitive crash types (those crashes for which ABS was expected to be beneficial). Table 9 below shows the proportions of sensitive and non-sensitive crashes (with and without injury) and what the benefits would be for all motorcycle crashes (both sensitive and non-sensitive crash types).

Table 9: Proportions of sensitive and non-sensitive crashes and effectiveness for all motorcycle crashes

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>All crashes</th>
<th>Injury crashes</th>
<th>Effectiveness Sensitive crashes</th>
<th>Effectiveness All crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive</td>
<td>88,703</td>
<td>78,929</td>
<td>33%</td>
<td>30.7%</td>
</tr>
<tr>
<td>Proportion - sensitive</td>
<td>93%</td>
<td>93%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total – Sensitive and non-sensitive crashes</td>
<td>95,390*</td>
<td>84,745*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Figures from Table 1 on page 13

3.5 Other Findings

A number of other findings for ABS and non-ABS fitted motorcycles are shown below.

3.5.1 Fatality and Survivable Injury Outcomes

Comparison of ABS effectiveness among fatal and all injury cases is shown in Table 10. Over 2000 to 2011, 48% of all injuries to motorcycle riders in crashes in Australia (excluding NSW) were fatal or severe injuries. These proportions varied across the states (from 34% in SA to 57% in QLD) probably reflecting differences between the data bases and coding differences in each of the states. The proportion of motorcycles fitted with ABS in fatal and serious injury crashes, to all injury crashes, was remarkably similar across the 5 states.

Table 10: Motorcycle KSI and all injuries from 5-states in Australia (2000 to 2011) for ABS and controls

<table>
<thead>
<tr>
<th>Comparison5</th>
<th>NSW</th>
<th>VIC</th>
<th>QLD</th>
<th>WA</th>
<th>SA</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Total KSI</td>
<td>563</td>
<td>80</td>
<td>673</td>
<td>123</td>
<td>99</td>
<td>9</td>
</tr>
<tr>
<td>KSI with ABS</td>
<td>563</td>
<td>80</td>
<td>673</td>
<td>123</td>
<td>99</td>
<td>9</td>
</tr>
<tr>
<td>KSI without ABS</td>
<td>483</td>
<td>53</td>
<td>595</td>
<td>107</td>
<td>76</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Total injuries</td>
<td>278</td>
<td>40</td>
<td>1,336</td>
<td>373</td>
<td>317</td>
<td>15</td>
</tr>
<tr>
<td>Injuries with ABS</td>
<td>278</td>
<td>40</td>
<td>1,336</td>
<td>373</td>
<td>317</td>
<td>15</td>
</tr>
<tr>
<td>Injuries without ABS</td>
<td>238</td>
<td>17</td>
<td>1,133</td>
<td>137</td>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

5 = Severe and fatal injuries, and all injuries for crashes with ABS and without (controls)
3.5.2 Motorcycle type and bike age

Table 11: Motorcycle type and model years for ABS and Non-ABS motorcycles in injury crashes (2000-2011)

<table>
<thead>
<tr>
<th>Motorcycle Type</th>
<th>ABS Motorcycles</th>
<th>Non-ABS Motorcycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Naked</td>
<td>80</td>
<td>15%</td>
</tr>
<tr>
<td>On/Off Road</td>
<td>155</td>
<td>29%</td>
</tr>
<tr>
<td>Sport/Touring</td>
<td>69</td>
<td>13%</td>
</tr>
<tr>
<td>Touring</td>
<td>232</td>
<td>43%</td>
</tr>
<tr>
<td>Others/unknown</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>539</td>
<td>100%</td>
</tr>
</tbody>
</table>

The findings in Table 11 show that there were differences in the percentage of motorcycles fitted with or without ABS (especially sport-touring and touring) with similar median model year ranges. This most probably reflects differences in the way sport-touring and touring motorcycles are coded in each state. These differences, however, are unlikely to make much impact on the effectiveness outcome.

3.5.3 Rider age group and sex

Table 12 shows the rider’s age and sex distribution for ABS and Non-ABS crash cases listed on the states’ injury crash databases. Of interest, those riders crashing on an ABS fitted bike tended to be slightly older than similar controls (15% c.f. 35% at 34 years) whereas riders of non-ABS fitted control motorcycles had a more general and wider age distribution. Males overwhelmingly dominated riders of motorcycles in the crash databases (95% c.f. 5%), with practically no differences across both groups of motorcycles.

Table 12: Motorcycle rider’s age group for ABS and Non-ABS motorcycles in injury crashes (2000-2011)

<table>
<thead>
<tr>
<th>Riders Age Group</th>
<th>ABS Motorcycles</th>
<th>Cum %</th>
<th>Non-ABS Motorcycles</th>
<th>Cum %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
<td></td>
<td>Count</td>
</tr>
<tr>
<td>≤15 years</td>
<td>1</td>
<td>0%</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>16-24 years</td>
<td>12</td>
<td>2%</td>
<td>3%</td>
<td>262</td>
</tr>
<tr>
<td>25-34 years</td>
<td>65</td>
<td>13%</td>
<td>15%</td>
<td>815</td>
</tr>
<tr>
<td>35-54 years</td>
<td>331</td>
<td>64%</td>
<td>80%</td>
<td>1671</td>
</tr>
<tr>
<td>55-64 years</td>
<td>79</td>
<td>15%</td>
<td>95%</td>
<td>288</td>
</tr>
<tr>
<td>65-74 years</td>
<td>23</td>
<td>4%</td>
<td>99%</td>
<td>63</td>
</tr>
<tr>
<td>75+ years</td>
<td>3</td>
<td>1%</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>514</td>
<td>100%</td>
<td>100%</td>
<td>3107</td>
</tr>
</tbody>
</table>
3.5.4 Crash type and road condition

**Table 13:** Crash type for ABS and Non-ABS motorcycles in injury crashes (2000-2011)

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>ABS Motorcycles</th>
<th>Non-ABS Motorcycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Intersection</td>
<td>164</td>
<td>30%</td>
</tr>
<tr>
<td>Rear-end crash</td>
<td>78</td>
<td>14%</td>
</tr>
<tr>
<td>Single vehicle - straight</td>
<td>75</td>
<td>14%</td>
</tr>
<tr>
<td>Single vehicle - curve</td>
<td>72</td>
<td>13%</td>
</tr>
<tr>
<td>Other</td>
<td>40</td>
<td>7%</td>
</tr>
<tr>
<td>Head-on</td>
<td>25</td>
<td>5%</td>
</tr>
<tr>
<td>Maneoeuvring</td>
<td>20</td>
<td>4%</td>
</tr>
<tr>
<td>Turning</td>
<td>17</td>
<td>3%</td>
</tr>
<tr>
<td>U-turn</td>
<td>17</td>
<td>3%</td>
</tr>
<tr>
<td>Animal on road</td>
<td>12</td>
<td>2%</td>
</tr>
<tr>
<td>Overtaking</td>
<td>11</td>
<td>2%</td>
</tr>
<tr>
<td>Vulnerable Road User</td>
<td>8</td>
<td>1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>539</td>
<td>100%</td>
</tr>
</tbody>
</table>

Crash types in Table 13 have been assigned in an exclusive manner with the hierarchy assigning multi-vehicle crashes before single vehicle crash types, in this order: rear-end, head-on, overtaking, U-turn, other manoeuvring, other intersection, turning, vulnerable road user (pedestrians and bicycles), animal on the road, single vehicle curve, and then single vehicle curve. The results show that the top 5-crash types account for 80% of all crashes with ABS motorcycles and 84% of motorcycle crashes without ABS. There were slight differences between motorcycles fitted or not fitted with ABS. This further confirms the importance of having ABS fitted to motorcycles as a likely cost-effective intervention, given that these crash types captured the bulk of the sensitive crashes in the effectiveness analysis.

**Table 14:** Road condition in injury crashes for ABS and Non-ABS motorcycles (2000-2011)

<table>
<thead>
<tr>
<th>Road Conditions</th>
<th>ABS Motorcycles</th>
<th>Non-ABS Motorcycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Dry road</td>
<td>441</td>
<td>82%</td>
</tr>
<tr>
<td>Wet road</td>
<td>93</td>
<td>17%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5</td>
<td>1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>539</td>
<td>100%</td>
</tr>
</tbody>
</table>

The findings in Table 14 for road condition at the time of the crash shows that the majority of crashes occurred on dry roads and that while there was a higher proportion of ABS fitted motorcycle crashes on wet roads, this is unlikely to be of any real concern in the analysis. It was not possible to break these figures down by road finish (sealed or unsealed) as these conditions were unreliable in some datasets.
3.5.5 Speed Zone and Helmet Use

Tables 15 and 16 show the findings for speed zone in which the crash happened and whether the rider was wearing a helmet or not. Unfortunately, it was only possible to analyse helmet wearing using Victorian data as these details were not freely available in the other states databases.

### Table 15: Speed zone of the crash site for ABS and Non-ABS motorcycles in injury crashes (Victoria, 2000-2011)

<table>
<thead>
<tr>
<th>Speed Zone</th>
<th>ABS Motorcycles</th>
<th>Non-ABS Motorcycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>30-40km/h</td>
<td>10</td>
<td>2%</td>
</tr>
<tr>
<td>50km/h</td>
<td>56</td>
<td>10%</td>
</tr>
<tr>
<td>60km/h</td>
<td>214</td>
<td>40%</td>
</tr>
<tr>
<td>70km/h</td>
<td>28</td>
<td>5%</td>
</tr>
<tr>
<td>80-90 km/h</td>
<td>68</td>
<td>13%</td>
</tr>
<tr>
<td>100 plus km/h</td>
<td>139</td>
<td>26%</td>
</tr>
<tr>
<td>Unknown</td>
<td>24</td>
<td>4%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>539</td>
<td>100%</td>
</tr>
</tbody>
</table>

The results in Table 15 reveal two peaks in the distribution; one at 60km/h and a second at 100km/h suggesting a difference between urban and rural crashes in Victoria. Assuming urban crashes occur between 30km/h and 60km/h and rural crashes between 70km/h and 100km/h and above then it is apparent that there are roughly equal numbers of crashes in urban and rural areas and with slightly fewer urban crashes (52% c.f. 56%) for motorcycles fitted with ABS.

### Table 16: Helmet wearing for ABS and Non-ABS motorcycle riders in injury crashes (Victoria, 2000-2011)

<table>
<thead>
<tr>
<th>Helmet Use</th>
<th>ABS Motorcycles</th>
<th>Non-ABS Motorcycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Helmet worn</td>
<td>448</td>
<td>83%</td>
</tr>
<tr>
<td>Helmet not worn</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>Not appropriate</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Not known</td>
<td>86</td>
<td>16%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>539</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 16 reveals that the vast proportions of motorcyclists in Victoria, both with and without ABS or CBS, were wearing their helmet at the time of the crash.

3.5.6 Summary of Findings

The findings from this analysis of Australian motorcycle crashes between 2000 and 2011 found that ABS (with and without CBS) provides a benefit in injury reductions of 33%, ranging from 19% to 45%, with higher benefit in the more severe injury outcomes of 39% (21% to 53%) for sensitive crash types. Given a 93% predominance of ABS fitted motorcycles, the overall fleet benefit for all motorcycles crashes was still a substantial 31%. Moreover, these findings are reasonably consistent with figures published in
Europe, and slightly higher than US equivalents. While there were some differences observed between the motorcycles and rider distributions across the states and between those fitted with ABS and CBS in these crashes, these effects were not expected to have had much influence on the effectiveness outcome reported here, given the use of induced exposure in the calculations.

3.6 Marketing and Road Safety

Objective 3 was to identify fleet size of ABS and CBS and predict likely future trends in marketing and road trauma in Australia. Specifically, to identify the number of new vehicles that enter the market, the number of these under the Commonwealth’s RVCS database, the number of new vehicles entering the market with ABS or CBS fitted, and what are expected in the coming years. These are discussed separately below.

3.6.1 New vehicles entering the market

The project brief calls for the number of new motorcycles that currently enter the market. Trend data were obtained from the Australian Bureau of Statistics (2014), showing motorcycle registrations from 1998 to 2013, with an average increase in the Australian motorcycle fleet over this period of 4.86%. These results are shown in Table 16.

3.6.2 The Number under RVCS Listing

The number of certified motorcycle models under the Commonwealth’s RVCS representing these vehicles was also computed from the Federal Government statistics. The RVCS system allows vehicle manufacturers to electronically certify that the vehicles they supply to the Australian market meet the Australian Design Rules (ADRs). It was not possible to reliably identify ABS or CBS fitment for motorcycles, both categories LA and LC, from the RVCS data. Consequently it was not possible to compute precisely how many vehicles in the fleet had ABS/CBS fitted from this data source.

3.6.3 Numbers with ABS and CBS in the fleet

An analysis of the number of new vehicles that are currently supplied to the market with ABS or CBS fitted was computed using the crash data proportions applied to motorcycle registrations outlined above. An estimate of the number of new vehicles that are expected to be supplied to the market over the next ten years was also computed from these data. These figures are shown in Table 18a (p. 24).

3.6.4 Market Expectations

The project brief also called for an estimate of the likely number of new motorcycles with ABS and/or CBS over the next 30 years. Given the obvious difficulty in predicting so far ahead in an environment of emerging and changing motorcycle technologies, a predicted 10-year trend from 2015 to 2025 was computed using various data available.
Figure 1: Past and future trends of motorcycles listed on the Victorian Vehicle Register (vehicles aged 0-22 only)

The upper BLUE line shows the observed (2004-2014) and predicted growth (2015-2025) in all LC >125cc motorcycles (not including scooters), while the lower BLUE line shows those with ABS over the same period. The predicted growth in both all LC>125cc motorcycles (no scooters) and those with ABS were derived from the modelling described earlier. Predicted growth figures show what is expected with only natural growth in current fitment rates for ABS technologies. Figure 1 shows that while there is some expected reduction in the gap between expected new motorcycles and those likely to be fitted with ABS, it is at best only a modest improvement or gap reduction expected over the next 10 years, based on current fitment rates.

3.6.5 Accelerated Growth

As noted above, the predicted “natural” increase in fitment of ABS by motorcycle manufacturers is not expected to be overwhelming over the coming 10 years. By mandating ABS fitment, manufacturers of this category of motorcycles (LC >125cc) would be required to fit this technology, and this gap would be reduced as a result. If, for instance, legislation could be introduced by say 2018 to this effect, then obviously all new motorcycles of this category after 2018 would have a zero gap in fitment. It would however, have any little effect on the predicted trends for the other motorcycles shown in Figure 1.
It should be remembered, though, that with an average vehicle service life of 22 years, it will take some time until which the full effects in reduced crashes will be apparent. Current crash figures for motorcycles show that 50% of crashes are for motorcycles less than six years old, with a long tail showing 95% of crashes are for vehicles less than 23 years. This will help ensure that the benefits flow through more quickly than a linear increase in benefits from the technology. For ease of calculation, however, it was assumed that the cumulative distribution was close to linear as this was not expected to make much of an effect on the modelling process to follow in the next chapter. Further research is warranted in later years to confirm this assumption.

There are little data available on the suitability of fitting ABS to all motorcycles, mopeds, and scooters of all categories. Obviously, if this is technically feasible, the advantages of ensuring all motorcycles enjoy the ABS benefits shown earlier would be greater. However, for this report, the widespread use of ABS for motorcycles (LC >125cc) was the immediate focus.

![Figure 2: Cumulative distribution of motorcycle crashes (source: VicRoads 2015)](image-url)
4. OVERALL BENEFITS OF ABS

This chapter sets out to identify what the likely benefits of widespread fitment of ABS on motorcycles in terms of crash and injury savings will be and what the likely economic cost of the technology will be for having all motorcycles fitted out with ABS technology.

Previous chapters have shown that widespread use of ABS technology will substantially reduce the number of motorcycle crashes. This Chapter therefore focusses on what these benefits amount to in terms of injury and death reductions, resulting from the technology. Given difficulties experienced in VIN identification in most Australian states, the figures for Victoria that were reliable have been used in predicting the benefits in all Australian states.

4.1 Fatal and Serious Injury Crashes (Victoria)

The charts in Figure 2 below depict the potential Victorian injury crash savings (all injury plus killed and serious injury (KSI) only) for LC>125cc road motorcycles (excluding scooters) under three scenarios, assuming: (i) the uptake of ABS remains at 2014 rates, (ii) the ABS uptake continues to increase according to current trends and (iii) ABS uptake is accelerated by introducing a mandate.

The graphs in Figure 2 show the predicted reductions in both all injuries and killed and serious injury crashes from now until 2025 in Victoria for the no projected increase in ABS fitment (PURPLE), the modelled prediction based on previous trends (RED) and for accelerated increases in ABS fitment rates expected for various ABS mandated dates of 2018, 2019, and 2020. These rates were then used to compute figures for the whole of Australia weighted by motorcycle registrations across each state and territory. They are shown below.
4.2 Fatal and Serious Injury Crashes (Australia)

The Australian Bureau of Statistics ([http://www.abs.gov.au/ausstats/abs@.nsf/mf/9309.0/](http://www.abs.gov.au/ausstats/abs@.nsf/mf/9309.0/)) 2014 motor vehicle census places the growth in registered motorcycles at 4.8% from 2013 to 2014 and the average annual growth at 4.7% over 2009 to 2014. Over the same five year period, Western Australia and Tasmania have the largest total growth at 41.3% and 34.5% respectively.

![Motorcycle registrations by jurisdiction over 2009 and 2014 (Australian Bureau of Statistics)](image)

Using the Australian Bureau of Statistics 2014 registered Australian Fleet in Figure 3 and their 4.7% projected annual growth, the Victorian modelling was used to predict potential injury crash savings for LC >125cc road motorcycles (excluding scooters) across all Australia (Table 18a and 18b). Figure 4 shows the predicted probability that all new LC>125cc motorcycles (excluding scooters) from 2004 up until 2025 had or will have ABS fitted.

![Probability of new LC >125cc road bike with ABS](image)

From these data, it was possible to compute the likelihood of all injury and KSI injuries between 2015 and 2025 across Australia from crashes involving an LC>125cc (excl. scooters) based on the modelled data listed in Tables 18a and 18b. These findings are then shown graphically in Figure 5.
Table 18a: Projected Australian Motorcycle Crash Savings for road bikes >125 CC (not a scooter) based on the Australian Bureau of Statistics 2014 Registered Fleet Size

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycle Fleet -2014</td>
<td>780,174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>projected @4.7% rise</td>
<td>816,842</td>
<td>855,234</td>
<td>895,430</td>
<td>937,515</td>
<td>981,578</td>
<td>1,027,712</td>
<td>1,076,015</td>
<td>1,126,587</td>
<td>1,179,537</td>
<td>1,234,975</td>
<td>1,293,019</td>
</tr>
<tr>
<td>Percentage of vehicles aged 22 years and under</td>
<td>92.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion LC &gt;125</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>0.61</td>
<td>0.61</td>
<td>0.61</td>
<td>0.61</td>
<td>0.61</td>
<td>0.61</td>
</tr>
<tr>
<td>LC&gt;125 not a scooter, road fleet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion with ABS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 mandate</td>
<td>0.0731</td>
<td>0.0787</td>
<td>0.0857</td>
<td>0.1003</td>
<td>0.1148</td>
<td>0.1292</td>
<td>0.1435</td>
<td>0.1579</td>
<td>0.1722</td>
<td>0.1864</td>
<td>0.1999</td>
</tr>
<tr>
<td>2019 mandate</td>
<td>0.0731</td>
<td>0.0787</td>
<td>0.0857</td>
<td>0.0941</td>
<td>0.1086</td>
<td>0.1231</td>
<td>0.1375</td>
<td>0.1519</td>
<td>0.1662</td>
<td>0.1805</td>
<td>0.1940</td>
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<tr>
<td>2020 mandate</td>
<td>0.0731</td>
<td>0.0787</td>
<td>0.0857</td>
<td>0.0941</td>
<td>0.1037</td>
<td>0.1182</td>
<td>0.1327</td>
<td>0.1471</td>
<td>0.1615</td>
<td>0.1757</td>
<td>0.1893</td>
</tr>
<tr>
<td>Modelled</td>
<td>0.0731</td>
<td>0.0787</td>
<td>0.0857</td>
<td>0.0941</td>
<td>0.1037</td>
<td>0.1144</td>
<td>0.1260</td>
<td>0.1383</td>
<td>0.1511</td>
<td>0.1643</td>
<td>0.1771</td>
</tr>
<tr>
<td>Observed</td>
<td>0.0737</td>
<td>0.0786</td>
<td>0.0836</td>
<td>0.0887</td>
<td>0.0937</td>
<td>0.0988</td>
<td>0.1038</td>
<td>0.1089</td>
<td>0.1140</td>
<td>0.1191</td>
<td>0.1234</td>
</tr>
<tr>
<td>Number with ABS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 mandate</td>
<td>34,292</td>
<td>38,569</td>
<td>43,863</td>
<td>53,569</td>
<td>64,024</td>
<td>75,281</td>
<td>87,398</td>
<td>100,436</td>
<td>114,457</td>
<td>129,469</td>
<td>145,115</td>
</tr>
<tr>
<td>2019 mandate</td>
<td>34,292</td>
<td>38,569</td>
<td>43,863</td>
<td>50,273</td>
<td>60,612</td>
<td>71,746</td>
<td>83,734</td>
<td>96,635</td>
<td>110,513</td>
<td>125,374</td>
<td>140,860</td>
</tr>
<tr>
<td>2020 mandate</td>
<td>34,292</td>
<td>38,569</td>
<td>43,863</td>
<td>50,273</td>
<td>57,865</td>
<td>68,901</td>
<td>80,785</td>
<td>93,576</td>
<td>107,338</td>
<td>122,077</td>
<td>137,435</td>
</tr>
<tr>
<td>Modelled</td>
<td>34,292</td>
<td>38,569</td>
<td>43,863</td>
<td>50,273</td>
<td>57,865</td>
<td>66,673</td>
<td>76,709</td>
<td>87,975</td>
<td>100,473</td>
<td>114,152</td>
<td>128,604</td>
</tr>
<tr>
<td>Observed</td>
<td>34,574</td>
<td>38,528</td>
<td>42,785</td>
<td>47,363</td>
<td>52,281</td>
<td>57,561</td>
<td>63,226</td>
<td>69,299</td>
<td>75,805</td>
<td>82,712</td>
<td>89,621</td>
</tr>
<tr>
<td>@2014 Observed ABS uptake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury Crashes</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg Risk (no ABS)</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
<td>0.0112</td>
</tr>
<tr>
<td>(ABS 0.67% reduction)</td>
<td>5,142</td>
<td>5,359</td>
<td>5,586</td>
<td>5,823</td>
<td>6,071</td>
<td>6,331</td>
<td>6,602</td>
<td>6,886</td>
<td>7,183</td>
<td>7,494</td>
<td>7,820</td>
</tr>
<tr>
<td>Serious Injury and Fatal Crashes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg Risk (no ABS)</td>
<td>0.0052</td>
<td>0.0052</td>
<td>0.0052</td>
<td>0.0052</td>
<td>0.0052</td>
<td>0.0052</td>
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<tr>
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<td>1</td>
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<td>2</td>
<td>3</td>
<td>4</td>
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<td>6</td>
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</tr>
<tr>
<td>Potential Serious injuries prevented</td>
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<td>75</td>
<td>92</td>
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<td>Potential Minor injuries prevented</td>
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<td>14</td>
<td>23</td>
<td>34</td>
<td>48</td>
<td>63</td>
<td>79</td>
<td>97</td>
<td></td>
</tr>
</tbody>
</table>

**MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE**
4.3 Fatal and Serious Injury Benefits

In assessing the likely injury saved from these crashes, the results for fatal, serious and minor injuries were computed from the modelling results found in Tables 18a and 18b above. Figures 6 to 8 depict the Australian injury reductions expected under combinations of current growth in ABS mandated fitment scenarios (2018, 2019, 2020). The total injuries saved are detailed in Table 18a and 18b.
These plots show what the potential savings would be depending on whether there would be legislation to mandate ABS and what implementing strategy would be adopted up until 2025. Table 19 shows the actual values for these options, from 2015 to 2025.
**Table 19: Accumulated injury reductions for various ABS update scenarios**

<table>
<thead>
<tr>
<th>Injuries Saved</th>
<th>Modelled savings*</th>
<th>Mandatory Introduction Dates</th>
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<tr>
<td></td>
<td>2018</td>
<td>2019</td>
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<tr>
<td>Injury crashes</td>
<td>643</td>
<td>1029</td>
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<tr>
<td>Fatalities</td>
<td>22</td>
<td>35</td>
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<tr>
<td>Serious Injuries</td>
<td>345</td>
<td>553</td>
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<tr>
<td>Minor Injuries</td>
<td>367</td>
<td>587</td>
</tr>
</tbody>
</table>

* Modelled savings assumes normal growth in ABS fitment rates from 2014

### 4.4 Societal Cost Savings (Australia)

The 2006 costs of crashes by crash injury level (BITRE) updated with the current CPI (Australian Bureau of Statistics) were used to estimate the savings to society for the crashes. They are presented in Table 18b. Victorian crash data were used to estimate the proportions of injury crashes and those involving fatal and serious injury crashes so that the BITRE costs could be applied. These estimates are presented in Table 20 along with the average annual saving over the ten year period covering 2016 to 2025 (inclusive) and the 2015 present value for the average savings carried over the ten year period with a 6.5% discount.

**Table 20: Cost Savings to Society over 2016 to 2025 (million dollars)**

<table>
<thead>
<tr>
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<th>Modelled savings</th>
<th>Mandatory Introduction Dates</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>2020</td>
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<td>Average Annual Savings</td>
<td>Injury Crashes</td>
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<td>Fatal and Serious Injury crashes</td>
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<tr>
<td>2015 Present Value for ten year period</td>
<td>Injury Crashes</td>
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<td>164.8</td>
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<tr>
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<td>Fatal and Serious Injury crashes</td>
<td>117.7</td>
<td>188.5</td>
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</tbody>
</table>

### 4.5 Societal Benefit Costs (Australia)

Achieving the savings listed above will come at a cost of ensuring all motorcycles LC>125cc are produced with anti-lock brakes as standard equipment. While many of today’s relevant motorcycles have ABS as standard, not all of them do.

The European Union (EU) voted in favour of mandatory ABS for motorcycles over 125cc from 2016 (Visordown News, 2012). While they would have preferred compulsory fitment of ABS for all motorcycles, they finally agreed not to mandate below 125cc as the proportional increase in cost for smaller motorcycles and the 4-wheeled quad bikes or quadricycles could not be substantiated.
The figure the European Parliament used in computing the cost-benefit analysis by the European Parliament's Committee on Internal Market and Consumer Affairs (European Parliament 2012) was a figure of 500 euros per motorcycle. This was based on what they report as “Manufacturer's Costs”. The Federation Internationale De L’Automobile (FIA, 2012) argued that the European Parliament’s cost-benefit analysis was flawed. They claimed that the manufacturers’ 2011 figures (based on manufacturers’ estimates) used inappropriate methodology in generating these costs and that using suppliers’ figures (based on what the cost to manufacturers would actually be by suppliers) of 150 euro gave a more realistic estimate of the real costs.

Baum (2008) in his cost-benefit analysis used costs determined by interviewing three most important OEMs which were also 150 euros. He argued that the benefit-cost ratios for what he described as a high effectiveness scenario ranged between 4.6 and 4.9 to one. He further claimed that benefit-cost-ratios for less effective scenarios were all above 3:1.

It seems reasonable, therefore, to assume that a cost to the manufacturers for fitment of ABS technology on all LC>125cc motorcycles would be 150 euros (approx. A$220).

4.6 Summary

The findings from this Chapter are quite impressive, as shown in Table 19. If the modelled trends are achieved and current fitment rates increase as predicted from past patterns through logistic regression, there would be a net reduction of 643 injury crashes between the start of 2015 and end of year 2025 with expected injury savings of 22 fatalities, 345 serious injuries, and 367 minor injuries. Should ABS be mandated for all new registered LC>125cc motorcycles, these savings could be increased by up to 60% between 2018 and 2025. These savings would, of course, be even greater if the current trend in motorcycle sales continues beyond 2025.
5. GENERAL DISCUSSION AND CONCLUSIONS

This study set out with a number of objectives which have been addressed above. The results for each of these are summarised below.

5.1 Effectiveness of ABS (and CBS) technologies for Motorcycles

The first thing to note was that there were very few cases of CBS fitment on LC>125cc motorcycles in Australia among the crash data. Thus, all subsequent analyses have mainly focussed on ABS only although where possible, both ABS and CBS were considered as a group. The analyses were conducted on 2000 to 2011 crash data across the 5 Australian states of NSW, Vic, Qld, WA and SA on valid injury crashes with and without ABS fitment. It was assumed that ABS would be effective on various crash configurations excluding head-on, overtaking, U-turning, entering and leaving a parking place, collision with a fixed object and cutting in collisions. These were labelled as “non-sensitive” crashes. All other crash types were considered sensitive crashes.

The effectiveness analysis was conducted using LC>125cc (no scooters) motorcycles with ABS as case vehicles and those without ABS as controls. Induced exposure was used to help minimise the effects on confounding factors. Non-sensitive crash situations were used as a true exposure measure.

Based on these parameters, the analysis found that ABS technology resulted in a 33% reduction in all relevant crash and injury severities and a 39% reduction in relevant severe injury crashes. For the few cases where ABS and CBS were identified together, the effectiveness rose slightly to 44%. However, this result was not derived from regression analysis due to insufficient data. The effectiveness was further shown to vary depending on single or multi-vehicle crashes, at intersections, and whether the road was wet or not. These findings were roughly equivalent with other published international results. There was good consistency in these findings across the various Australian states.

5.1.1 ABS Relevance for Motorcycle Crash Types

There were some differences in terms of crash type between cases and controls. Those with ABS had slightly fewer intersection crashes and crashes on curves but slightly more rear-end crashes. These findings were not particularly strong and probably influenced by the selection of sensitive and non-sensitive crash types. Other findings showed some differences between motorcycles with and without ABS by the type of LC motorcycle (sport touring and touring in particular), the age group of the rider, and the speed zone where the crash occurred. It is likely, however, that these findings may be subject to other rider influences, such as personality and motivation of the rider. There were no differences between these two groups in terms of helmet use.

5.2 Fleet Size and Marketing Trends

The project also identified and predicted the future fleet size of ABS (and CBS) and predicted likely future trends in marketing and road trauma in Australia. Again, because of small numbers, it was not possible to predict future trends of CBS, with or without ABS, so only ABS fitted LC>125cc motorcycles (without scooters) were included here.

Chapter 3 showed that using sales figures of these motorcycles dating back to 1998, it was possible to predict the future trend of sales for the next 10 years. The study team felt that beyond that, it was not really possible as there are likely to be major changes in motorcycle types, consumer interest (especially if ABS fitment becomes mandatory) and general shifts in the whole vehicle industry.
The predicted growth trend for all Australian motorcycles was a general increase of 4.7% annually (Australian Bureau of Statistics) of which the proportion of LC>125 motorcycles alone would be 62%. Of those new motorcycles, the predicted trend of those with ABS was estimated, based on previous trends across Australia from 2004. As the interpretation of new ABS fitted motorcycles relied on Vehicle Identification Number (VIN) and that the interpretation of VIN was more reliable in Victoria, these proportions were subsequently used across all Australian States in the modelling conducted here.

In 2014 the five-year average annual growth in new LC>125 cc vehicles with ABS was 17%. As the proportion of new LC motorcycles with ABS in 2015 is still quite a modest proportion of new vehicle sales (approximately 20%), total fleet fitment is still not likely to rise above 20% by 2025 at current rates. This suggests there is scope for intervention in the market to help accelerate these trends.

5.3 Crash and Injury Benefits

Chapter 4 set out to assess what the benefits would be in terms of crashes and injury reductions, resulting from the fitment of ABS technology for LC>125cc (excluding scooters). Given the difficulties experienced in VIN identification in most Australian states, the analysis necessitated the use of reliable figures of ABS fitment in Victoria for predicting the benefits in all Australian states and territories. Four scenarios were investigated based on what the benefits would be if the current increase in ABS fitment was to continue to occur, taking into account predicted increases of LC>125cc motorcycles over the last 10 years, fitment rates of ABS, and likely crashes and injury savings up until 2025.

The findings showed an increasing trend in LC motorcycles fitted with ABS with corresponding expected reductions in the number of crashes, shown earlier in Chapter 3. Using these figures and those in Chapter 2, it was possible to estimate what the associated injury savings were likely to be from 2015 to 2025. In essence, if increases in ABS fitment trends continue at current rates, it is expected that there would be a net reduction of 643 injury crashes between now and the year 2025 with expected injury savings of 22 fatalities, 345 serious injuries and 367 minor injuries.

These savings could be accelerated by mandating the fitment of ABS in all new LC>125cc motorcycles. Depending on implementation timing, such a mandate could generate up to an additional 60% reduction in injury crashes and associated fatalities, and serious and minor injuries. As the average life of an LC motorcycle is currently around 22 years, these savings would be considerably greater beyond 2025, assuming there are no major changes in vehicle registration patterns and consumer demand.

5.4 Study Limitations

Studies of this kind are typically limited in a number of ways.

- First, the lack of any consistent available data across the states (especially VIN irregularities) limits what is the real situation regarding motorcycle crashes and ABS fitment in Australia. There is clearly a need for more harmonious databases nationwide to facilitate such analyses as this one.

- As such, many of the assumptions made in the modelling process, while necessary for the analysis, really need to be validated to ensure that the predictions outlined for future LC>125cc motorcycles sales and ABS fitment rates are confirmed.

- In estimating future trends, we were forced to make the assumption that the LC motorcycle environment in future will follow current patterns. However, this is quite a broad assumption as future demand for new motorcycles with ABS is quite unknown. Should ABS was mandated, for instance, this could lead to significant changes in supply and demand.
5.5 Conclusions

The findings of the effectiveness of ABS in preventing crashes and injuries identified substantial benefits for LC>125cc motorcyclists from fitment of this technology to their machines. The analysis found that ABS resulted in a 33% reduction of all injuries in relevant sensitive crash types and a 39% reduction in severe injury in these sensitive crashes. The benefits varied depending on the type of crash, whether it was a single or multi-vehicle crash, occurred at an intersection, and whether the road was wet or not. There was good consistency in these findings across the various Australian states. These findings were roughly equivalent with other published international results.

In association with these savings, marked savings are expected to result in fewer fatalities as well as severe and minor injuries. These savings would be enhanced by efforts to increase the fitment rate of ABS on all new LC motorcycles over the coming years. Based on current trends, an increase in the fitment of ABS is expected over the next 10 year period, both in terms of an increase in registered motorcycles as well as a general increase in the rate of fitment of ABS. The rate of fitment could be accelerated by mandating the fitment of ABS technology for all new LC>125cc motorcycles with associated reductions in crashes and severe injuries.
References


Baum H. Cost-benefit analysis for ABS of motorcycles, Institute for transport economics, University of Cologne, Germany (BASt Fahrzeugtechnik Heft, F68, July 2008.


## Appendix A – Extracts from HLDI (2013)

### Table A1: Distribution of exposure for antilock and combined control brake systems, collision coverage (Source: HLDI 2013)

<table>
<thead>
<tr>
<th>Make and series</th>
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<th>Percent ABS</th>
<th>Percent Non-ABS</th>
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</thead>
<tbody>
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<td>494</td>
<td>20%</td>
<td>80%</td>
</tr>
<tr>
<td>Aprilia Scarabeo 500</td>
<td>1,406</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>Honda Gold Wing</td>
<td>217,874</td>
<td>22%</td>
<td>78%</td>
</tr>
<tr>
<td>Honda Interceptor 800</td>
<td>14,806</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Honda NT700V</td>
<td>1,300</td>
<td>21%</td>
<td>79%</td>
</tr>
<tr>
<td>Honda Reflex</td>
<td>15,070</td>
<td>13%</td>
<td>87%</td>
</tr>
<tr>
<td>Honda Silver Wing</td>
<td>18,258</td>
<td>17%</td>
<td>83%</td>
</tr>
<tr>
<td>Honda ST1300</td>
<td>22,596</td>
<td>36%</td>
<td>64%</td>
</tr>
<tr>
<td>Kawasaki Ninja 1000</td>
<td>88</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>Kawasaki Ninja 650R</td>
<td>16</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>Kawasaki Ninja ZX-10R</td>
<td>138</td>
<td>20%</td>
<td>80%</td>
</tr>
<tr>
<td>Suzuki Bandit 1250</td>
<td>4,382</td>
<td>23%</td>
<td>77%</td>
</tr>
<tr>
<td>Suzuki B-King</td>
<td>1,873</td>
<td>3%</td>
<td>97%</td>
</tr>
<tr>
<td>Suzuki Burgman 400</td>
<td>1,075</td>
<td>24%</td>
<td>76%</td>
</tr>
<tr>
<td>Suzuki Burgman 650</td>
<td>20,333</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>Suzuki SV650</td>
<td>11,113</td>
<td>6%</td>
<td>94%</td>
</tr>
<tr>
<td>Suzuki V-Strom 650</td>
<td>12,525</td>
<td>23%</td>
<td>77%</td>
</tr>
<tr>
<td>Triumph Rocket III</td>
<td>1,773</td>
<td>21%</td>
<td>79%</td>
</tr>
<tr>
<td>Triumph Speed Triple</td>
<td>290</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>Triumph Sprint ST</td>
<td>6,232</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>Triumph Thunderbird</td>
<td>1,953</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Triumph Tiger</td>
<td>6,093</td>
<td>28%</td>
<td>72%</td>
</tr>
<tr>
<td>Triumph Tiger 800</td>
<td>910</td>
<td>84%</td>
<td>16%</td>
</tr>
<tr>
<td>Victory Cross Country</td>
<td>340</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>Yamaha FJR1300</td>
<td>18,723</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>379,660</strong></td>
<td><strong>24%</strong></td>
<td><strong>76%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Make and series</th>
<th>Exposure</th>
<th>Percent ABS/CCBS</th>
<th>Percent Non-ABS/CCBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honda CBR1000RR</td>
<td>4,091</td>
<td>8%</td>
<td>92%</td>
</tr>
<tr>
<td>Honda CBR600RR</td>
<td>8,985</td>
<td>8%</td>
<td>92%</td>
</tr>
<tr>
<td>Honda Fury</td>
<td>7,660</td>
<td>2%</td>
<td>98%</td>
</tr>
<tr>
<td>Honda Interstate</td>
<td>441</td>
<td>1%</td>
<td>99%</td>
</tr>
<tr>
<td>Honda NC700X</td>
<td>122</td>
<td>18%</td>
<td>82%</td>
</tr>
<tr>
<td>Honda Shadow Aero 750</td>
<td>99</td>
<td>41%</td>
<td>59%</td>
</tr>
<tr>
<td>Honda Stateline</td>
<td>916</td>
<td>5%</td>
<td>95%</td>
</tr>
<tr>
<td>Kawasaki Concours 14</td>
<td>14,553</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td>Kawasaki Vulcan 1700 Voyager</td>
<td>3,374</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>Victory Vision</td>
<td>7,638</td>
<td>15%</td>
<td>85%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>47,878</strong></td>
<td><strong>26%</strong></td>
<td><strong>74%</strong></td>
</tr>
</tbody>
</table>
Appendix B – DCA Charts used in this analysis

The following descriptive Charts of DCAs and RUMs used in determining sensitive and non-sensitive crash types in the induced exposure computations are enclosed. It should be noted that while there is no consistent and agreed coding between the states for crash type, they are nevertheless quite consistent in the codes they have used individually for each crash type. South Australia do not publish a DCA/RUM Chart so other criteria were used for assessing in this state.

<table>
<thead>
<tr>
<th>State</th>
<th>DCA and RUM Codes identified for the ABS sensitive crash types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria</td>
<td>120 140 142 143 144 145 146 150 153</td>
</tr>
<tr>
<td>New South Wales</td>
<td>201 207 401 402 403 404 405 501 504</td>
</tr>
<tr>
<td>Queensland</td>
<td>20 40 42 43 44 45 46 50 54</td>
</tr>
<tr>
<td>Western Australia</td>
<td>21 27 42 43 44 45 46 51 54</td>
</tr>
<tr>
<td>South Australia</td>
<td>No DCA/RUM Chart available – used 5 (CTY-Type Codes)</td>
</tr>
</tbody>
</table>

Table B1: Australian ABS Sensitive Motorcycle Crashes of 2000-2011 -All Crashes by Crash type, NSW, Queensland, Victoria and Western Australia

<table>
<thead>
<tr>
<th></th>
<th>NSW</th>
<th>Queensland</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
<td>Crash Sensitive to ABS</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Pedestrian</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ped nearside</td>
<td>208</td>
<td>62</td>
<td>49</td>
</tr>
<tr>
<td>Ped emerging</td>
<td>37</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Ped far side</td>
<td>123</td>
<td>72</td>
<td>28</td>
</tr>
<tr>
<td>Ped playing</td>
<td>31</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Pedest: Walking With Traffic</td>
<td>13</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Pedest: Walking Against Traffic</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedest: On Footway</td>
<td>32</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Pedest: In Driveway</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Pedest: Struck Boarding / Alighting</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Ped other</td>
<td>11</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Intersection-Adjacent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross traffic</td>
<td>1645</td>
<td>823</td>
<td>658</td>
</tr>
<tr>
<td>Right far</td>
<td>294</td>
<td>168</td>
<td>181</td>
</tr>
<tr>
<td>Left far</td>
<td>67</td>
<td>29</td>
<td>32</td>
</tr>
<tr>
<td>Right near</td>
<td>1096</td>
<td>1100</td>
<td>904</td>
</tr>
<tr>
<td>2 right turning</td>
<td>30</td>
<td>69</td>
<td>91</td>
</tr>
<tr>
<td>Right/left far</td>
<td>8</td>
<td>46</td>
<td>26</td>
</tr>
<tr>
<td>Left near</td>
<td>187</td>
<td>189</td>
<td>186</td>
</tr>
<tr>
<td>Left/right far</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 left turning</td>
<td>1</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Other adjacent</td>
<td>8</td>
<td>92</td>
<td>69</td>
</tr>
<tr>
<td>Opposite Direction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head on</td>
<td></td>
<td></td>
<td>1135</td>
</tr>
<tr>
<td>Right through</td>
<td>2738</td>
<td>1832</td>
<td>1297</td>
</tr>
<tr>
<td>Left through</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
### Same Direction

<table>
<thead>
<tr>
<th>Category</th>
<th>Right/left</th>
<th>Right/right</th>
<th>Opposite Dirn: Left - Left</th>
<th>Other opposing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear end</td>
<td>22</td>
<td>30</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left rear</td>
<td>216</td>
<td>257</td>
<td>649</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right rear</td>
<td>550</td>
<td>424</td>
<td>503</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane sideswipe</td>
<td>502</td>
<td>356</td>
<td>426</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane change right</td>
<td>560</td>
<td>251</td>
<td>377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane change left</td>
<td>829</td>
<td>328</td>
<td>333</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right turn sideswipe</td>
<td>276</td>
<td>683</td>
<td>245</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left turn sideswipe</td>
<td>443</td>
<td>283</td>
<td>198</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other same direction</td>
<td>91</td>
<td>72</td>
<td>31</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Manoeuvring

| Category                           | Opposite Dirn: U - Turn | Same Dirn: Same Lane U - Turn | U turn into object | Leaving parking | Entering parking | Parking vehicles | Reversing | Reversing into obj | Emerging from drive | From footpath | Manoeuv: Loading Bay | Other manoeuvring | Overtaking | Head on (overtake) | Overtaking: Out Of Control: | Pulling out | Overtaking: Into Right Turn | Cutting in | Overtaking: Pull Out - Rear End | Other overtaking | On Path | Parkerd | Double parked | Accident | Vehicle door | Perm obstruction | Temp roadworks | Object on road | Struck animal | Other on path | Off path-Straight | Off road to left | Off rd left => obj | Off road to right | Off rd right => obj | On road-out => obj | Off end of road | Loss Of Control: Left Turn - Intx |
|------------------------------------|-------------------------|-----------------------------|-------------------|----------------|-----------------|-----------------|-----------|-------------------|---------------------|--------------|-------------------|-----------------|------------|-----------------|-----------------------------|-------------|------------------------|-------------|------------------|----------------|---------|---------|--------------|-----------|----------------|----------------|----------------|----------------|---------------|-----------------|------------------|------------------|--------------------------|
|                                    | 819                    | 170                        | 52                | 20             | 313             | 10              | 95        | 39                | 34                 | 43           | 26                | 8               | 12         | 362             | 56                          | 52          | 8                      | 7            | 24              | 16           | 16     | 62      | 1            | 67        | 114        | 8             | 21           | 348          | 732            | 34              | 458                  | 458              | 79          | 109                 | 512                  | 295          | 283             | 151            | 294          | 3526         | 1332            | 1514           | 81                 | 164              | 373         |
Loss Of Control: Right Turn - Intx 186 395
Other straight 27 390 93

**Off Path-Curve**

<table>
<thead>
<tr>
<th>Crash Description</th>
<th>NSW</th>
<th>Victoria</th>
<th>Queensland</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off Path On Curve: Off Cway Right Bend</td>
<td>883</td>
<td>206</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Off Path On Curve: Off Right Bend In Obj</td>
<td>235</td>
<td>591</td>
<td>420</td>
<td></td>
</tr>
<tr>
<td>Off Path On Curve: Off Cway Left Bend</td>
<td>474</td>
<td>103</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Off Path On Curve: Off Left Bend In Obj</td>
<td>716</td>
<td>347</td>
<td>328</td>
<td></td>
</tr>
<tr>
<td>Off Path On Curve: Lost Control On Cway</td>
<td>2955</td>
<td>967</td>
<td>316</td>
<td></td>
</tr>
<tr>
<td>Off Path On Curve: Other</td>
<td>18</td>
<td>282</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous**

<table>
<thead>
<tr>
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<th>Victoria</th>
<th>Queensland</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fell in/from vehicle</td>
<td>6</td>
<td>297</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Misc: Load Struck Veh</td>
<td>14</td>
<td>28</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Struck train</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Misc: Struck Rail Xing Furniture</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Misc: Parked Car Ran Away</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Misc: Hit Animal Off Cway</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>33</td>
<td>75</td>
<td>15</td>
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</table>

Table B2: Australian ABS Sensitive Motorcycle Crashes of 2000-2011 -All Injury Crashes by Crash type, NSW, Queensland, Victoria and Western Australia
<table>
<thead>
<tr>
<th></th>
<th>Left near</th>
<th>158</th>
<th>180</th>
<th>183</th>
<th>128</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left/right far</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 left turning</td>
<td>1</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Other adjacent</td>
<td>7</td>
<td>44</td>
<td>89</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>

**Opposite Direction**

<table>
<thead>
<tr>
<th></th>
<th>Head on 1029</th>
<th>843</th>
<th>694</th>
<th>205</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right through 2425</td>
<td>1787</td>
<td>1797</td>
<td>1012</td>
<td></td>
</tr>
<tr>
<td>Left through 2</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Right/left 20</td>
<td>26</td>
<td>30</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Right/right 3</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Opposite Dirn: Left - Left</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other opposing 21</td>
<td>27</td>
<td>28</td>
<td>10</td>
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**Same Direction**

<table>
<thead>
<tr>
<th></th>
<th>Rear end 2077</th>
<th>1269</th>
<th>1449</th>
<th>838</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left rear 190</td>
<td>162</td>
<td>252</td>
<td>276</td>
<td></td>
</tr>
<tr>
<td>Right rear 485</td>
<td>301</td>
<td>414</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td>Lane sideswipe 458</td>
<td>320</td>
<td>347</td>
<td>164</td>
<td></td>
</tr>
<tr>
<td>Lane change right 498</td>
<td>338</td>
<td>246</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>Lane change left 748</td>
<td>409</td>
<td>320</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td>Right turn sideswipe 231</td>
<td>286</td>
<td>674</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>Left turn sideswipe 395</td>
<td>262</td>
<td>278</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>Other same direction 86</td>
<td>105</td>
<td>70</td>
<td>18</td>
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</table>

**Manoeuvring**

<table>
<thead>
<tr>
<th></th>
<th>Opposite Dirn: U - Turn 740</th>
<th>775</th>
<th>165</th>
<th>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Dirn: Same Lane U -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn</td>
<td></td>
<td>33</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>U turn into object</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving parking 16</td>
<td>281</td>
<td>5</td>
<td>95</td>
<td>10</td>
</tr>
<tr>
<td>Entering parking 2</td>
<td>35</td>
<td>8</td>
<td>99</td>
<td>26</td>
</tr>
<tr>
<td>Parking vehicles 3</td>
<td>1</td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Reversing 1</td>
<td>24</td>
<td>2</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Reversing into obj 3</td>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Emerging from drive</td>
<td></td>
<td>681</td>
<td>494</td>
<td>441</td>
</tr>
<tr>
<td>From footpath 104</td>
<td>69</td>
<td>189</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>Maneouev: Loading Bay</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Other manoeuvring 105</td>
<td>69</td>
<td>375</td>
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<td>71</td>
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</tbody>
</table>

**Overtaking**

<table>
<thead>
<tr>
<th></th>
<th>Head on (overtake) 54</th>
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### Table B3: Australian ABS Sensitive Motorcycle Crashes of 2000-2011
All and injury Crashes by Crash Type, South Australia

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<th>Injury Crashes</th>
<th>Type of crash</th>
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<td>Left Road - Out of Control</td>
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### Definitions for Classifying Accidents

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<tr>
<th>Pedestrian on foot or in trolley</th>
<th>Vehicles from adjacent directions (intersections only)</th>
<th>Vehicles from opposite directions</th>
<th>Maneuvering</th>
<th>Overtaking</th>
<th>On path</th>
<th>Off path on straight</th>
<th>Off path on curve</th>
<th>Passenger and miscellaneous</th>
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<td><strong>170</strong></td>
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</table>

**Notes:**
1. Definition for classifying accidents (DCA) should be determined by first selecting a column using the text above each column and then by diagrammatic sub-division.
2. The sub-division chosen should describe the general movement of vehicles involved in the initial event; it does not assign a cause to the accident.
3. Supplementary codes have been defined for most sub-division; these codes give further detail of the initial event.
4. The number 1, 2 identify individual vehicles involved when the DCA is linked with other vehicle/driver information.
5. These codes were used for 1987 accidents and replace the road movement (RM) code.
VALUATION OF MOTORCYCLE ABS IN AUSTRALIA
### Fig. 46 - Definitions for coding crashes - left hand version (1994)

<table>
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<tr>
<th>PEDESTRIAN</th>
<th>INTERSECTION VEHICLES FROM ADJACENT APPROACHES</th>
<th>VEHICLES FROM OPPOSING DIRECTIONS</th>
<th>VEHICLES FROM ONE DIRECTION</th>
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<td>THRU-RIGHT 202</td>
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<td>U-TURN 304</td>
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<td>LEFT TURN S/S 309</td>
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Version 1.2  Page 97  Date: 31 August 1996
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Fig. 47 - Definitions for coding crashes - left hand version (1994)
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<td>EVT_DIRECTION</td>
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</table>

<table>
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<tr>
<th>EVT_VEH_MOVEMENT</th>
<th>Code</th>
<th>Description</th>
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<td>1 Stopped: By Traffic Control</td>
</tr>
<tr>
<td>EVT_VEH_MOVEMENT</td>
<td>2</td>
<td>2 Stopped: By Congestion</td>
</tr>
<tr>
<td>EVT_VEH_MOVEMENT</td>
<td>3</td>
<td>3 Stopped: By Prior Acc</td>
</tr>
<tr>
<td>EVT_VEH_MOVEMENT</td>
<td>4</td>
<td>4 Stopped: By Mechanical Failure</td>
</tr>
<tr>
<td>EVT_VEH_MOVEMENT</td>
<td>5</td>
<td>5 Stopped: To Avoid Veh</td>
</tr>
</tbody>
</table>
Appendix C – Projection Modelling

The Age Distribution of Victorian Registered Motorcycles used in the modelling is depicted below. Figure 7 displays the proportion by age for the fleet of all motorcycle types aged 0 to 22 years. Figure 8 shows the age distribution of LC >125CC road motorcycles (excluding scooters) over all ages.

Figure 7: Average 2013-2014 Age Distribution of Victorian Motorcycles by vehicle type (from 0 to 22 years)

Figure 8: Average 2013-2014 Age Distribution of Victorian LC>125CC road (excl. scooters) Motorcycles (all years)

Figure 9 charts the proportion of motorcycle types within the 0-22 year old Victorian registered motorcycle fleet. Only two wheeled vehicles were considered in this study. The proportion of scooters and off road vehicles were observed to increase. It is possible that the off-road vehicle distribution is an artefact of the way it was defined. For vehicles manufactured before 2003 and not identified by VIN as a particular type, the off road type was designated if the registration type was listed as a purpose built motorcycle. These motorcycles represent a larger proportion in earlier registration years. However the purpose built label was strongly associated with identified off road vehicles.

The changes in fleet moped, scooter and off road proportions over time were modelled using Figure 10. The proportion of LC >125 was considered as the difference from unity.
Figure 9: Proportion vehicle type of registered Victorian motorcycle fleet (aged 0 to 22 years only)

Figure 10: Projected proportion vehicle type of registered Victorian motorcycle fleet (vehicles aged 0 to 22 years only)

0=2004, 23=2025

Figure 11 depicts the future modelling of the entire Victorian motorcycle fleet.
Figure 11: Projected registered Victorian motorcycle fleet (vehicles aged 0-22 years only)

0=2004, 23=2025
Appendix D – Projected crashes unaffected by LC>125CC ABS modelling

**Figure 12:** Projected crashes of Victorian motorcycle fleet unaffected by ABS (vehicles aged 0-22 only)

**Figure 13:** Projected crashes of Victorian off road fleet (vehicles aged 0-22 only)