MONASH University
Accident Research Centre

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

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

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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

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PREFACE

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GLOSSARY OF TERMS

ABS	Anti-lock Braking Systems	Moped	LA or LB category vehicle
ASC	Automatic Stability Control	MUARC	Monash University Accident Research Centre.
BITRE	Bureau of Infrastructure, Transport and Regional Economics	Non-ABS	A motorcycle without ABS technology.
Bikes	Motorcycles	Non-sensitive	Crashes where ABS technology is unlikely to influence the crash outcome.
CBS	Combined Braking Systems	NSW	The state of New South Wales, Australia.
DIRD	Department of Infrastructure and Regional Development	Off-road	A motorcycle designed to travel off a sealed roadway.
EU	European Union	QLD	The state of Queensland, Australia.
HLDI	Highway Loss Data Institute	RVCS	Road Vehicle Certification System database.
IIHS	Insurance Institute for Highway Safety	SA	The state of South Australia
KSI	Killed and Seriously Injured	Scooter	LC category vehicle with an automatic transmission (not manual or clutch-less), and a 'step through' construction type (as defined by VicRoads)
LA	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 crases	Crashes where ABS technology is expected to influence the crash outcome.
LB	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.
LC	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
LC<125cc	LC category 2-wheel vehicle with engine capacity less than 125cc	TAC	Transport Accident Commission of Victoria (Aus)
LC>125	LC category 2-wheel vehicle with engine capacity greater than 125cc	YoM	Year of vehicle manufacture

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

4.3 FATAL AND SERIOUS INJURY BENEFITS 24
4.4 SOCIETAL COST SAVINGS (AUSTRALIA) 26
4.5 SOCIETAL BENEFIT COSTS (AUSTRALIA) 26
4.6 SUMMARY 27

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 31
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 then 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.

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[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 euro 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 ultra-light 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.

$$R = \frac{A_{ABS}}{N_{ABS}} \div \frac{A_{non-ABS}}{N_{non-ABS}} \quad \text{(Eq. 1)}$$

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:

$$E_{sens} = 100 \times (1 - R)\% \quad \text{(Eq. 2)}$$

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 ≥80km/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

	New South Wales		Victoria		Queensland‡		Western Australia		South Australia	
ABS Sensitive Crashes	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
All crashes	26,857	2,437	N/A**	N/A**	17,083	1,109	14,301	887	8,501	344
All injury crashes	24,501	2,185	21,957	1,910	16,700	1,085	9,523	378	6,248	258
Valid All injury crashes*	698	68	4,845	378	3,181	212	1,098	42	1,123	49
With ABS status identified	278	23	1,336	122	1,158	60	373	9	317	15
No ABS Injury †	238	17	1,133	96	1,021	50	333	9	243	12
ABS Injury †	40	6	203	26	137	10	40	0	74	3
No ABS KSI †	238	17	483	53	595	29	107	3	76	7
ABS KSI†	40	6	80	16	78	6	16	0	23	2

*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)

‡ 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*

	New South Wales		Queensland		Western Australia		South Australia	
Crash Sensitive to ABS	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Engine Capacity ≤125 cc								
Valid VIN and valid YOM	3	0	5	0	186	22	47	2
Unknown engine capacity								
No valid VIN	1,947	214	176	6	2,518	238	443	19
No valid YOM	332	30	194	9	1,683	149	373	19
No valid VIN and YOM	271	29	76	6	1,569	137	280	17
Valid VIN and valid YOM	271	29	129	13	1321	179	1235	38
Engine Capacity >125 cc								
No valid VIN	-	-	-	-	-	-	-	-
No valid YOM	1	0	1	0	1	1	3	0
Valid VIN and valid YOM	73	8	54	2	638	57	432	25

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

	New South Wales		Victoria		Queensland		West. Australia		South Australia	
Crash Sensitive to ABS	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Engine Capacity. ≤125 cc										
No valid VIN	-	-	-	-	-	-	-	-	-	-
No valid YOM	-	-	1	-	-	-	-	-	1	-
valid vin and YOM	59	7	383	25	550	27	432	13	220	4
Unknown capacity										
No valid vin	20,410	1,810	3,778	382	4,458	333	4,959	237	1,435	73
No valid YOM	4,688	433	3,755	403	5,495	393	2,973	157	1,241	65
No valid VIN & YOM	4,114	385	2,489	289	4,457	333	2,735	148	965	54
Valid VIN and YOM	2,751	250	11,675	1,011	7,465	452	2,793	77	3,193	121
Engine Cap. >125 cc										
No valid vin	-	-	1	-	-	-	-	-	-	-
No valid YOM	9	2	8	-	8	1	3	-	-	-
No valid vin and no valid YOM	-	-	-	-	-	-	-	-	-	-
valid VIN and YOM	698	68	4,845	378	3,181	212	1,098	42	1,123	49

Table 4: Crash Severity for Motorcycle Injury Crashes of 2000-2011 by jurisdiction

	New South Wales*		Victoria		Queensland		Western Australia		South Australia	
Sensitive to ABS	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Severity of Injury										
Fatal	615	163	460	141	536	110	289	52	195	26
Serious Injury	23,886*	2022*	9,935	955	8,956	598	3,706	163	1,848	115
Minor Injury			11,562	814	7,208	377	5528	163	4,205	117

**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

	New South Wales*		Victoria		Queensland		Western Australia		South Australia	
Sensitive to ABS	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Severity of Injury *With ABS*										
Fatal	3	0	2	0	3	2	0	0	1	1
Serious Injury	37	6	78	16	75	4	16	0	22	1
Minor Injury			123	10	59	4	24	0	51	1
Without ABS										
Fatal	4	2	17	9	33	6	2	1	7	1
Serious Injury	234*	15*	466	44	562	23	105	2	69	6
Minor Injury			650	43	426	21	226	6	167	5

** 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 motor cycle 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

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

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)

	New South Wales		Victoria		Queensland		Western Australia		South Australia	
Crash Sensitive to ABS	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
All Crashes	26,857	2,437	21,961	1,910	17,083	1,109	14,301	887	8,501	344
Valid Injury crash										
ABS+CBS	6	2	87	12	78	7	17	0	33	2
ABS Only	34	4	116	14	59	3	23	0	41	1
No ABS										
+CBS	*11*	*1*	*119*	*7*	*32*	*3*	*28*	*0*	*12*	*0*
no CBS	227	16	1014	89	989	47	305	9	231	12

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

	Australia			International				
	As computed here			Rizzi et al (2009)[1]	Rizzi et al (2014)[1]			HLDI (2013)[2]
Comparison	Point Effective	95th Confidence	$P>X^2$		SWE	ESP	IT	
ABS (all Injury crash)	33%	(19-45)	<0.0001	39%	34%	29%	24%	20.3%
ABS (severe injury crash)[3]	39%	(21-53)	0.0001	48%	42%	34%	-	-
ABS +CBS	44%[5]	±20%		-	-	-	-	34.2%
Multi-vehicle crash ABS (all injury)	31%	(12-46)	0.003					
Multi-vehicle crash ABS (severe injury crash) [3]	31%	(1-52)	0.043					
Intersection crash ABS (severe injury crash) [3,4]	65%	(42-79)	<0.0001					
Wet road crash ABS (all injury)	57%	(8-80)	0.03					
Wet road crash ABS (severe injury crash) [3]	60%	(9-83)	0.030					

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 focus 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

Crash Type	All crashes	Injury crashes	Effectiveness Sensitive crashes	Effectiveness All crashes
Sensitive	88,703	78,929	33%	30.7%
Proportion - sensitive	93%	93%		
Total – Sensitive and non-sensitive crashes	95,390*	84,745*		

* *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

Comparison[5]	NSW		VIC		QLD		WA		SA		TOTAL	
	Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Total KSI			563	69	673	35	123	3	99	9	1,458	116
KSI with ABS			80	16	78	6	16	0	23	2	197	24
KSI without ABS			483	53	595	29	107	3	76	7	1,261	92
Total injuries	278	23	1,336	122	1,158	60	373	9	317	15	3,462	229
Injuries with ABS	40	6	203	26	137	10	40	0	74	3	494	45
Injuries without ABS	238	17	1,133	96	1,021	50	333	9	243	12	2,968	184

[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)

Motorcycle Type	ABS Motorcycles			Non-ABS Motorcycles		
	Count	Percent	Median MY	Count	Percent	Median MY
Naked	80	15%	2003	736	23%	2005
On/Off Road	155	29%	2004	603	19%	2004
Sport/Touring	69	13%	2005	1393	44%	2001
Touring	232	43%	2001	398	13%	2000
Others/unknown	3	1%	2006	22	1%	1998
Total	539	100%	2003	3152	100%	2002

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 34years) 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)

Riders Age Group	ABS Motorcycles			Non-ABS Motorcycles		
	Count	Percent	Cum %	Count	Percent	Cum %
≤15 years	1	0%	0%	1	0%	0%
16-24 years	12	2%	3%	262	8%	8%
25-34 years	65	13%	15%	815	26%	35%
35-54 years	331	64%	80%	1671	54%	88%
55-64 years	79	15%	95%	288	9%	98%
65-74 years	23	4%	99%	63	2%	100%
75+ years	3	1%	100%	7	0%	100%
Total	514	100%	100%	3107	100%	100%

3.5.4 Crash type and road condition

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

Crash Type	ABS Motorcycles		Non-ABS Motorcycles	
	Count	Percent	Count	Percent
Intersection	164	30%	1055	33%
Rear-end crash	78	14%	354	11%
Single vehicle - straight	75	14%	460	15%
Single vehicle - curve	72	13%	495	16%
Other	40	7%	295	9%
Head-on	25	5%	98	3%
Manoeuvring	20	4%	108	3%
Turning	17	3%	108	3%
U-turn	17	3%	61	2%
Animal on road	12	2%	38	1%
Overtaking	11	2%	58	2%
Vulnerable Road User	8	1%	22	1%
TOTAL	539	100%	3,152	100%

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)

Road Conditions	ABS Motorcycles		Non-ABS Motorcycles	
	Count	Percent	Count	Percent
Dry road	441	82%	2,739	87%
Wet road	93	17%	370	12%
Unknown	5	1%	43	1%
TOTAL	539	100%	3,152	100%

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)

Speed Zone	ABS Motorcycles		Non-ABS Motorcycles	
	Count	Percent	Count	Percent
30-40km/h	10	2%	54	2%
50km/h	56	10%	391	12%
60km/h	**214**	**40%**	**1,309**	**42%**
70km/h	28	5%	203	6%
80-90 km/h	68	13%	381	12%
100 plus km/h	**139**	**26%**	**675**	**21%**
Unknown	24	4%	139	4%
TOTAL	539	100%	3,152	100%

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)

Helmet Use	ABS Motorcycles		Non-ABS Motorcycles	
	Count	Percent	Count	Percent
Helmet worn	448	83%	2,605	83%
Helmet not worn	3	1%	32	1%
Not appropriate	2	0%	4	0%
Not known	86	16%	511	16%
TOTAL	539	100%	3,152	100%

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).

Table 17: Motorcycle fleet size Australia

1998-2013 (source: ABS 2014 & FCAI 2013)

Year	Number	Percent Increase	FCAI new road, off-road and scooter sales
1998	335,000		
1999	340,000	1.50%	
2000	342,000	0.60%	
2001	351,000	2.60%	
2002	370,000	5.40%	
2003	377,000	1.90%	
2004	399,000	5.80%	
2005	422,000	5.80%	
2006	466,983	10.70%	
2007	511,966	9.60%	
2008	567,569	10.90%	114,289
2009	624,090	10.00%	95,618
2010	660,107	5.80%	86,899
2011	678,790	2.80%	86,639
2012	709,288	4.50%	92,267
2013	744,732	5.00%	92,215

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.

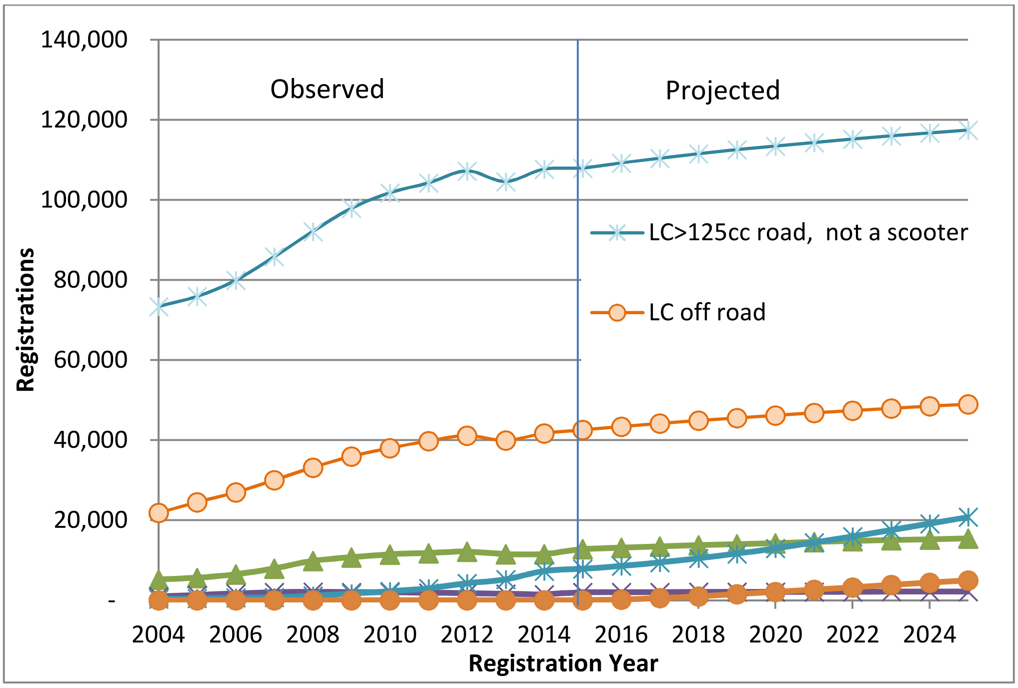

Figure 1: *Past and future trends of motorcycles listed on the Victorian Vehicle Register (vehicles aged 0-22 only)*

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.

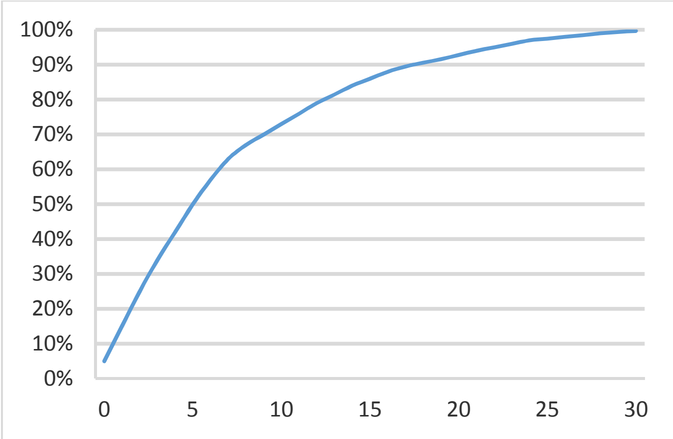

Figure 2: Cumulative distribution of motorcycle crashes (source: VicRoads 2015)

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.

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.

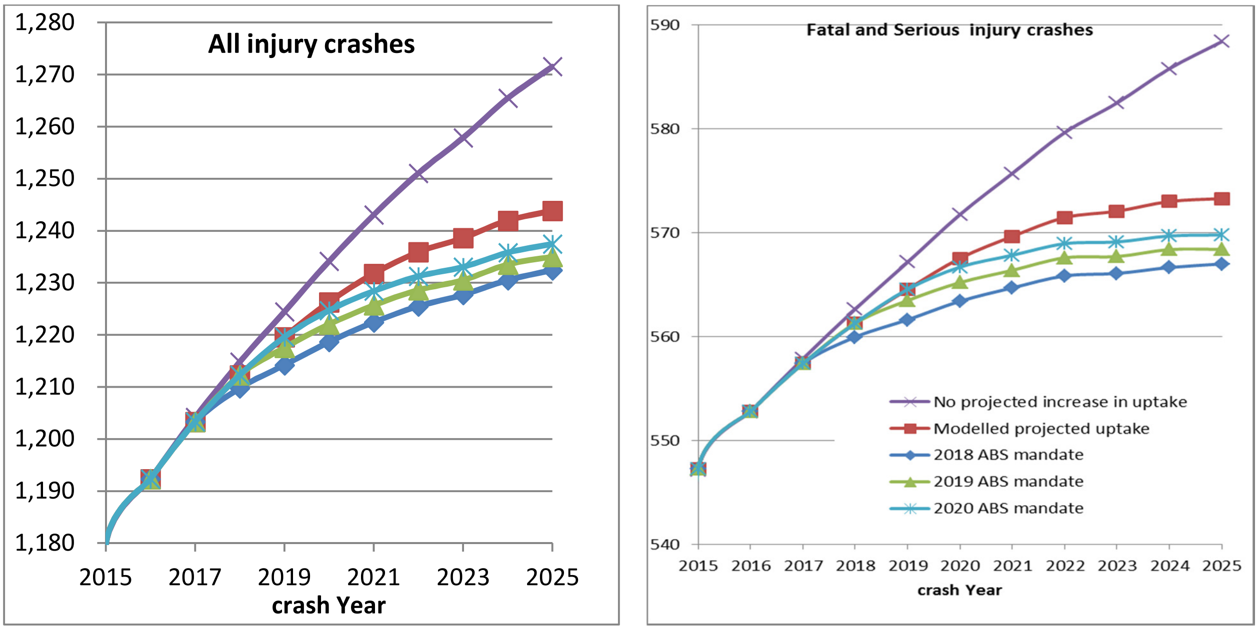

Figure 2: *Future trends of LC>125CC road motorcycle (excluding scooters) injury crashes in Victoria with under various ABS uptake scenarios (vehicles aged 0-22 only)*

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/) 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.

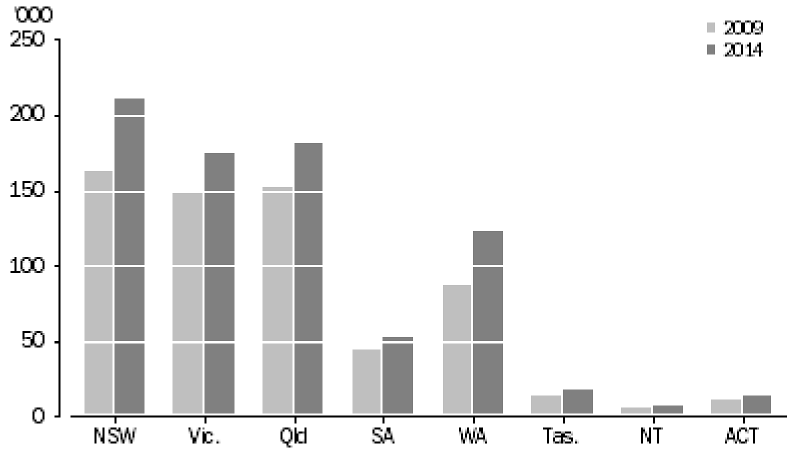

Figure 3: *Motorcycle registrations by jurisdiction over 2009 and 2014 (Australian Bureau of Statistics)*

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.

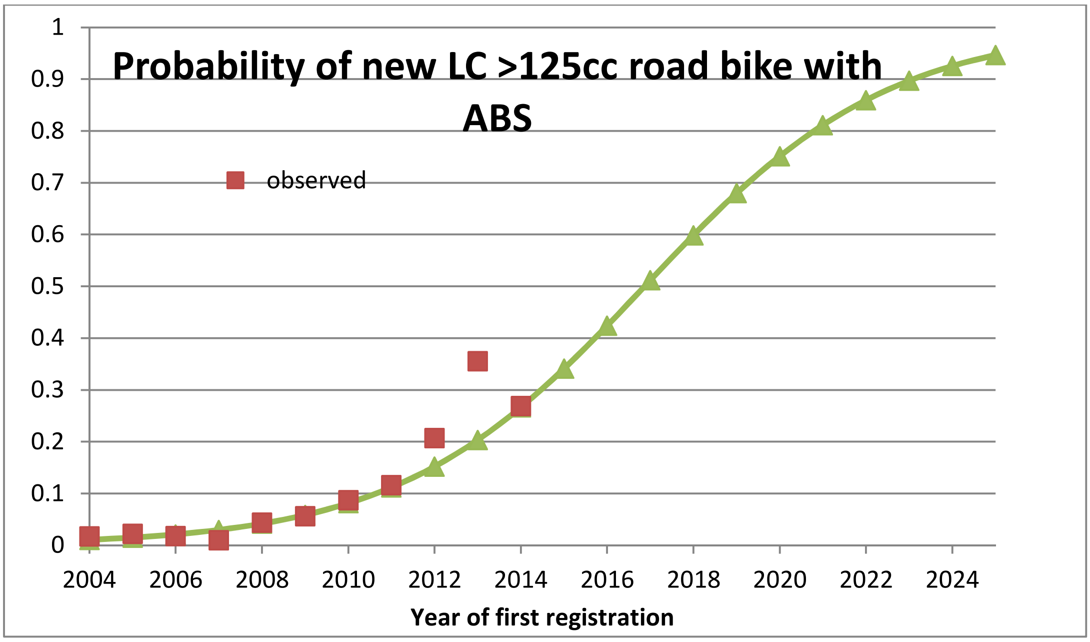

Figure 4: Predicted probability that a new m*otorcycle* LC >125cc will have ABS fitted *2004 to 2025*

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

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Motorcycle Fleet -2014 **780,174** projected @4.7% rise											
	816,842	855,234	895,430	937,515	981,578	1,027,712	1,076,015	1,126,587	1,179,537	1,234,975	1,293,019
Percentage of vehicles aged 22 years and under 92.2%											
Proportion LC >125	0.62	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61	0.61
LC>125 not a scooter , road fleet											
	469,386	489,964	511,555	534,196	557,931	582,804	608,863	636,160	664,748	694,686	726,033
Proportion with ABS											
2018 mandate	0.0731	0.0787	0.0857	0.1003	0.1148	0.1292	0.1435	0.1579	0.1722	0.1864	0.1999
2019 mandate	0.0731	0.0787	0.0857	0.0941	0.1086	0.1231	0.1375	0.1519	0.1662	0.1805	0.1940
2020 mandate	0.0731	0.0787	0.0857	0.0941	0.1037	0.1182	0.1327	0.1471	0.1615	0.1757	0.1893
Modelled	0.0731	0.0787	0.0857	0.0941	0.1037	0.1144	0.1260	0.1383	0.1511	0.1643	0.1771
Observed	0.0737	0.0786	0.0836	0.0887	0.0937	0.0988	0.1038	0.1089	0.1140	0.1191	0.1234
Number with ABS											
2018 mandate	34,292	38,569	43,863	53,569	64,024	75,281	87,398	100,436	114,457	129,469	145,115
2019 mandate	34,292	38,569	43,863	50,273	60,612	71,746	83,734	96,635	110,513	125,374	140,860
2020 mandate	34,292	38,569	43,863	50,273	57,865	68,901	80,785	93,576	107,338	122,077	137,435
Modelled	34,292	38,569	43,863	50,273	57,865	66,673	76,709	87,975	100,473	114,152	128,604
Observed	34,574	38,528	42,785	47,363	52,281	57,561	63,226	69,299	75,805	82,712	89,621
@2014 Observed ABS uptake											
Injury Crashes											
Avg Risk (no ABS)	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112
(ABS **0.67** %redctn)											
	5,142	5,359	5,586	5,823	6,071	6,331	6,602	6,886	7,183	7,494	7,820
Serious Injury and Fatal Crashes											
Avg Risk (no ABS)	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
(ABS **0.61%** reduction)											
	2,372	2,471	2,574	2,683	2,796	2,915	3,039	3,169	3,304	3,446	3,595

Table 18b: Projected Australian Motorcycle Crash Savings for road bikes >125 CC (not a scooter) based on the Australian Bureau of Statistics 2014 Registered Fleet Size

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Proportion reduction compared with observed uptake											
All Injury											
2018 mandate	1.000	1.000	0.999	0.996	0.992	0.987	0.983	0.980	0.976	0.972	0.969
2019 mandate	1.000	1.000	0.999	0.998	0.994	0.990	0.986	0.982	0.978	0.975	0.971
2020 mandate	1.000	1.000	0.999	0.998	0.996	0.992	0.988	0.984	0.980	0.977	0.973
Modelled	1.000	1.000	0.999	0.998	0.996	0.994	0.991	0.988	0.985	0.981	0.978
Serious Injury											
2018 mandate	1.000	1.000	0.999	0.995	0.990	0.985	0.981	0.976	0.972	0.967	0.964
2019 mandate	1.000	1.000	0.999	0.998	0.993	0.989	0.984	0.979	0.975	0.970	0.966
2020 mandate	1.000	1.000	0.999	0.998	0.995	0.991	0.986	0.982	0.977	0.973	0.968
Modelled	1.000	1.000	0.999	0.998	0.995	0.993	0.989	0.986	0.982	0.978	0.974
Absolute reduction compared with observed uptake											
Potential Injury Crashes Saved											
2018 mandate		0	4	24	51	80	109	141	172	207	240
2019 mandate		0	4	12	34	62	92	124	156	189	225
2020 mandate		0	4	12	24	49	78	109	142	176	210
Modelled		0	12	4	24	40	60	83	110	139	170
Potential KSI Crashes Saved											
2018 mandate		0	2	13	27	43	58	75	93	113	131
2019 mandate		0	2	6	18	33	49	66	84	102	122
2020 mandate		0	2	6	13	26	42	58	76	95	114
Modelled		6	2	6	13	21	32	45	59	75	92
Potential Fatalities prevented											
2018 mandate		0	0	1	2	3	4	5	6	7	8
2019 mandate		0	0	0	1	2	3	4	5	7	8
2020 mandate		0	0	0	1	2	3	4	5	6	7
Modelled		0	0	0	1	1	2	3	4	5	6
Potential Serious injuries prevented											
2018 mandate		0	2	13	27	42	58	75	93	112	130
2019 mandate		0	2	6	18	33	49	66	84	102	122
2020 mandate		0	2	6	13	26	41	58	76	94	113
Modelled		0	2	6	13	21	32	45	59	75	92
Potential Minor injuries prevented											
2018 mandate		0	2	14	29	45	62	80	98	118	137
2019 mandate		0	2	7	20	36	53	70	89	108	128
2020 mandate		0	2	7	14	28	44	62	81	100	120
Modelled		0	2	7	14	23	34	48	63	79	97

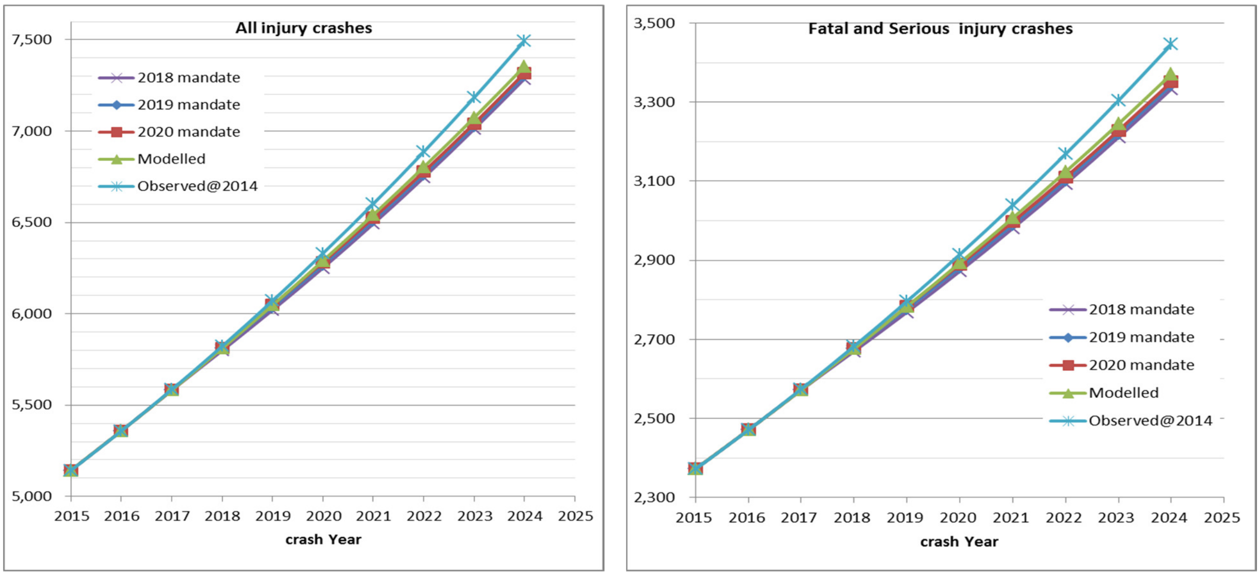

Figure 5: *Future trends of LC>125cc road motorcycle (excluding scooters) injury crashes in Australia under various ABS uptake scenarios (vehicles aged 0-22 only)*

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.

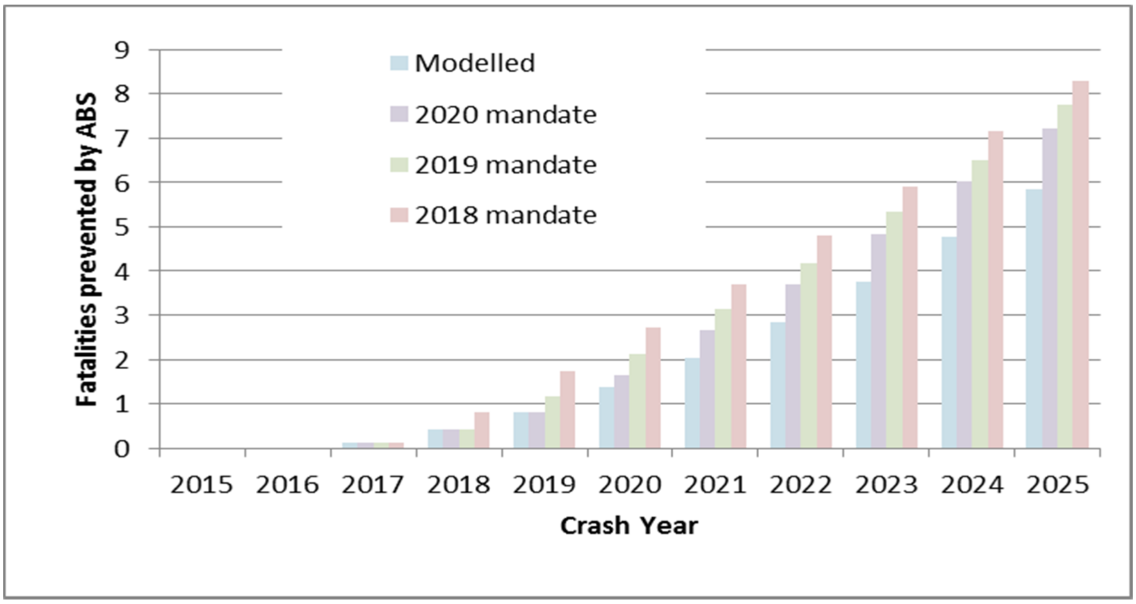

Figure 6: *Potential reductions in fatalities from LC>125CC road motorcycle (excluding scooters) injury crashes in Australia for increased ABS uptake scenarios above the 2014 ABS uptake*

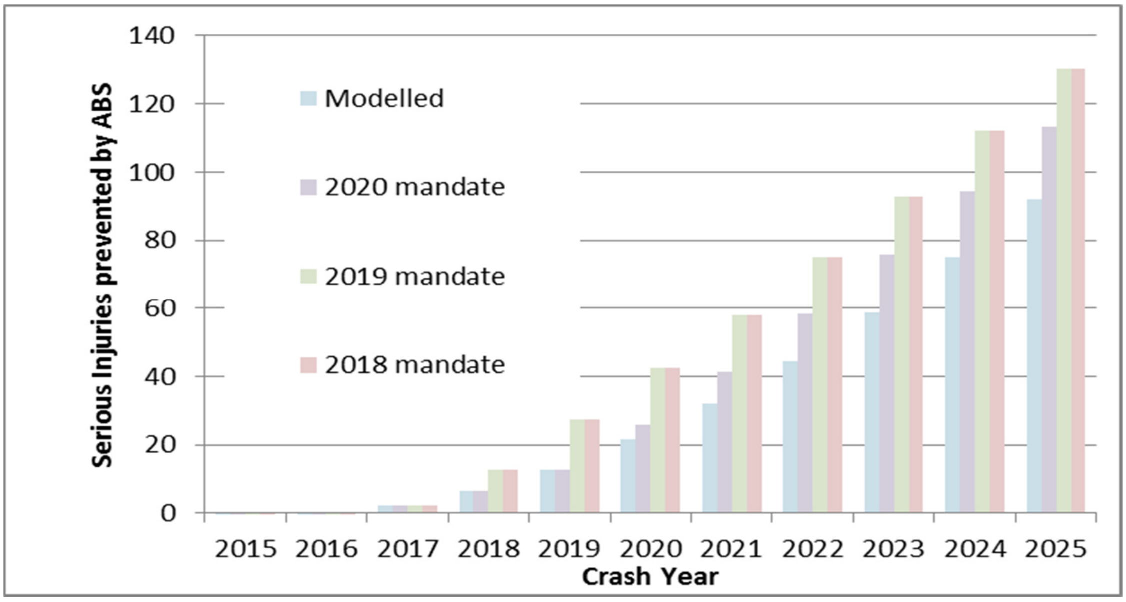

Figure 7: *Potential serious injury savings from LC>125CC road motorcycle (excluding scooters) injury crashes in Australia for increased ABS uptake scenarios above the 2014 ABS uptake*

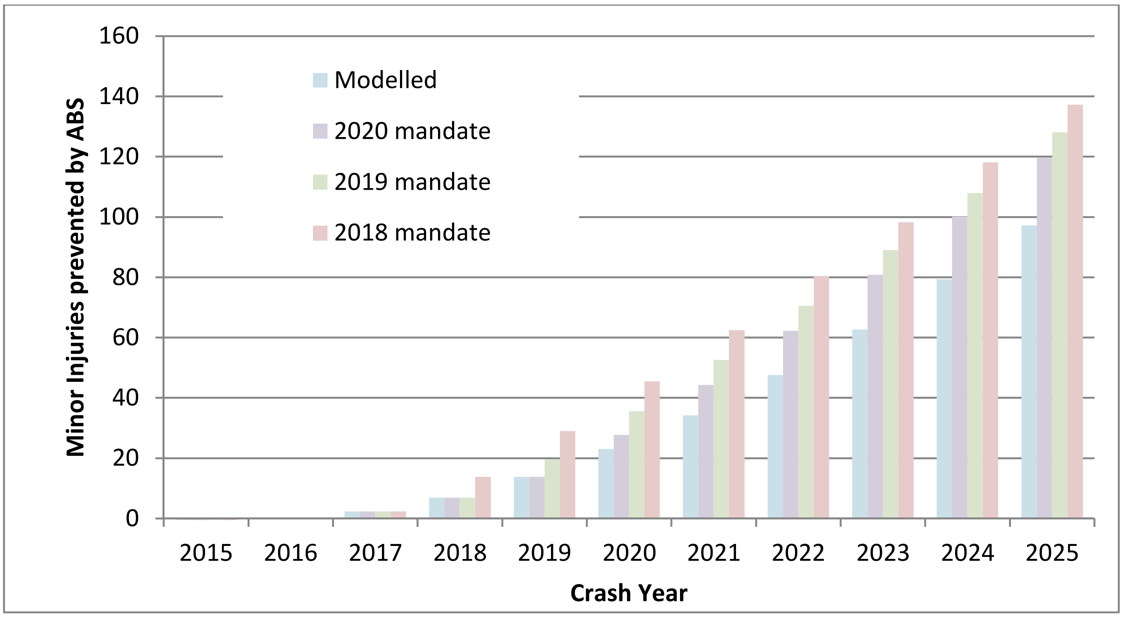

Figure 8: *Potential minor injury savings from LC>125CC road motorcycle (excluding scooters) injury crashes in Australia for increased ABS uptake scenarios above the 2014 ABS uptake*

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

Injuries Saved	Modelled savings*	Mandatory Introduction Dates		
		2018	2019	2020
Injury crashes	643	1029	898	802
Fatalities	22	35	31	27
Serious Injuries	345	553	482	430
Minor Injuries	367	587	512	458

* *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>
<tr><th colspan="2" rowspan="2"></th><th rowspan="2">Modelled savings</th><th colspan="3">Mandatory Introduction Dates</th></tr>
<tr><th>2018</th><th>2019</th><th>2020</th></tr>
<tr><td rowspan="2">Average Annual Savings</td><td>Injury Crashes</td><td>14.3</td><td>22.9</td><td>20.0</td><td>17.9</td></tr>
<tr><td>Fatal and Serious Injury crashes</td><td>16.4</td><td>26.2</td><td>22.9</td><td>20.4</td></tr>
<tr><td rowspan="2">2015 Present Value for ten year period</td><td>Injury Crashes</td><td>103.1</td><td>164.8</td><td>143.9</td><td>128.5</td></tr>
<tr><td>Fatal and Serious Injury crashes</td><td>117.7</td><td>188.5</td><td>164.3</td><td>146.6</td></tr>
</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.

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Appendix A – Extracts from HLDI (2013)

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

Make and series	Exposure	Percent ABS	Percent Non-ABS
Aprilia Mana 850	494	20%	80%
Aprilia Scarabeo 500	1,406	49%	51%
Honda Gold Wing	217,874	22%	78%
Honda Interceptor 800	14,806	25%	75%
Honda NT700V	1,300	21%	79%
Honda Reflex	15,070	13%	87%
Honda Silver Wing	18,258	17%	83%
Honda ST1300	22,596	36%	64%
Kawasaki Ninja 1000	88	39%	61%
Kawasaki Ninja 650R	16	29%	71%
Kawasaki Ninja ZX-10R	138	20%	80%
Suzuki Bandit 1250	4,382	23%	77%
Suzuki B-King	1,873	3%	97%
Suzuki Burgman 400	1,075	24%	76%
Suzuki Burgman 650	20,333	27%	73%
Suzuki SV650	11,113	6%	94%
Suzuki V-Strom 650	12,525	23%	77%
Triumph Rocket III	1,773	21%	79%
Triumph Speed Triple	290	33%	67%
Triumph Sprint ST	6,232	39%	61%
Triumph Thunderbird	1,953	50%	50%
Triumph Tiger	6,093	28%	72%
Triumph Tiger 800	910	84%	16%
Victory Cross Country	340	91%	9%
Yamaha FJR1300	18,723	50%	50%
Total	**379,660**	**24%**	**76%**
Make and series	Exposure	Percent ABS/CCBS	Percent Non-ABS/CCBS
Honda CBR1000RR	4,091	8%	92%
Honda CBR600RR	8,985	8%	92%
Honda Fury	7,660	2%	98%
Honda Interstate	441	1%	99%
Honda NC700X	122	18%	82%
Honda Shadow Aero 750	99	41%	59%
Honda Stateline	916	5%	95%
Kawasaki Concours 14	14,553	56%	44%
Kawasaki Vulcan 1700 Voyager	3,374	63%	37%
Victory Vision	7,638	15%	85%
Total	**47,878**	**26%**	**74%**

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.

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

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

	NSW		Queensland		WA	
	Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS	
	Yes	No	Yes	No	Yes	No
Pedestrian						
Ped nearside	208		62		49	
Ped emerging	37		5		5	
Ped far side	123		72		28	
Ped playing	31		20		21	
Pedest: Walking With Traffic	13		9		4	
Pedest: Walking Against Traffic	3		1		1	
Pedest: On Footway	32		4		7	
Pedest: In Driveway	2		2		0	
Pedest: Struck Boarding / Alighting	0		2		0	
Ped other	11		26		12	
Intersection-Adjacent						
Cross traffic	1645		823		658	
Right far	294		168		181	
Left far	67		29		32	
Right near	1096		1100		904	
2 right turning	30		69		91	
Right/left far	8		46		26	
Left near	187		189		186	
Left/right far	3		1		1	
2 left turning	1		8		4	
Other adjacent	8		92		69	
Opposite Direction						
Head on		1135		705		261
Right through	2738		1832		1297	
Left through	2		4		4	

Right/left	22		30		25	
Right/right	3		8		3	
Opposite Dirn: Left - Left	0				0	
Other opposing	23		28		19	
Same Direction						
Rear end	2520		1507		1585	
Left rear	216		257		649	
Right rear	550		424		503	
Lane sideswipe	502		356		426	
Lane change right	560		251		377	
Lane change left	829		328		333	
Right turn sideswipe	276		683		245	
Left turn sideswipe	443		283		198	
Other same direction	91		72		31	
Manouevring						
Opposite Dirn: U - Turn		819		170		52
Same Dirn: Same Lane U - Turn				34		134
U turn into object	12					
Leaving parking	20	313	10	95	39	34
Entering parking	2	43	26	21	19	5
Parking vehicles		8		5		296
Reversing	3	42	0	22	11	91
Reversing into obj		4		1		2
Emerging from drive	747		448		561	
From footpath	108		192		93	
Manoeuv: Loading Bay					0	
Other manoeuvring	115		379		127	
Overtaking						
Head on (overtake)		56		52		8
Overtaking: Out Of Control:	81		71		22	
Pulling out	12		20		10	
Overtaking: Into Right Turn	362		286		336	
Cutting in		17		4		4
Overtaking: Pull Out - Rear End	24		7		11	
Other overtaking	16		42		19	
On Path						
Parked	62		88		111	
Double parked	1				0	
Accident	67		12		16	
Vehicle door	114		13		26	
Perm obstruction	8		6		8	
Temp roadworks	21		4		11	
Object on road	348		537		123	
Struck animal	732		444		259	
Other on path	34		115		59	
Off path-Straight						
Off road to left	458		79		109	
Off rd left => obj	512		295		283	
Off road to right	151		27		31	
Off rd rght => obj	294		101		255	
On road-out of cont.	3526		1332		1514	
Off end of road	81					
Loss Of Control: Left Turn - Intx			164		373	

Loss Of Control: Right Turn - Intx		186	395
Other straight	27	390	93
Off Path-Curve			
Off Path On Curve: Off Cway Right Bend	883	206	150
Off Path On Curve: Off Right Bend In Obj	235	591	420
Off Path On Curve: Off Cway Left Bend	474	103	109
Off Path On Curve: Off Left Bend In Obj	716	347	328
Off Path On Curve: Lost Control On Cway	2955	967	316
Off Path On Curve: Other	18	282	0
Miscellaneous			
Fell in/from vehicle	6	297	34
Misc: Load Struck Veh	14	28	14
Struck train	1	3	2
Misc: Struck Rail Xing Furniture		2	2
Misc: Parked Car Ran Away	4	1	14
Misc: Hit Animal Off Cway		2	0
Other	6		9
Unknown	33	75	15

Table B2: Australian ABS Sensitive Motorcycle Crashes of 2000-2011 -All Injury Crashes by Crash type, NSW, Queensland, Victoria and Western Australia

	NSW		Victoria		Queensland		WA	
	Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS		Crash Sensitive to ABS	
	Yes	No	Yes	No	Yes	No	Yes	No
Pedestrian								
Ped nearside	208		96		62		41	
Ped emerging	36		40		5		4	
Ped far side	121		97		72		24	
Ped playing	31		23		20		18	
Pedest: Walking With Traffic	13		6		9		4	
Pedest: Walking Against Traffic	3		8		1		1	
Pedest: On Footway	32		15		4		4	
Pedest: In Driveway	2		4		2		0	
Pedest: Struck Boarding / Alighting	0		10		2		0	
Ped other	11		19		26		12	
Intersection-Adjacent								
Cross traffic	1461		773		808		466	
Right far	259		191		165		114	
Left far	54		29		29		18	
Right near	971		913		1080		696	
2 right turning	28		22		68		56	
Right/left far	8		22		44		14	

Left near	158		180		183		128	
Left/right far	2		1		1		1	
2 left turning	1		4		8		2	
Other adjacent	7		44		89		46	
Opposite Direction								
Head on		1029		843		694		205
Right through	2425		1787		1797		1012	
Left through	2		6		3		2	
Right/left	20		26		30		14	
Right/right	3		2		8		1	
Opposite Dirn: Left - Left	0						0	
Other opposing	21		27		28		10	
Same Direction								
Rear end	2077		1269		1449		838	
Left rear	190		162		252		276	
Right rear	485		301		414		278	
Lane sideswipe	458		320		347		164	
Lane change right	498		338		246		153	
Lane change left	748		409		320		195	
Right turn sideswipe	231		286		674		159	
Left turn sideswipe	395		262		278		103	
Other same direction	86		105		70		18	
Manouevring								
Opposite Dirn: U - Turn		740		775		165		37
Same Dirn: Same Lane U - Turn						33		85
U turn into object	10		10					
Leaving parking	16	281	5	95	10	93	25	13
Entering parking	2	35	8	99	26	21	7	2
Parking vehicles		3		1		5		3
Reversing	1	24	2	25	0	18	0	26
Reversing into obj		3		1		1		0
Emerging from drive	681		494		441		338	
From footpath	104		69		189		59	
Manoeuv: Loading Bay							0	
Other manoeuvring	105		69		375		71	
Overtaking								
Head on (overtake)		54		56		51		7
Overtaking: Out Of Control:	80		68		71		21	
Pulling out	11		290		20		6	
Overtaking: Into Right Turn	341				283		221	
Cutting in		16		15		4		0
Overtaking: Pull Out - Rear End	22		23		7		7	
Other overtaking	14		22		41		9	
On Path								
Parked	55		192		88		52	
Double parked	1						0	
Accident	57		22		12		11	
Vehicle door	103		98		13		8	
Perm obstruction	7		45		6		6	
Temp roadworks	21		25		4		10	

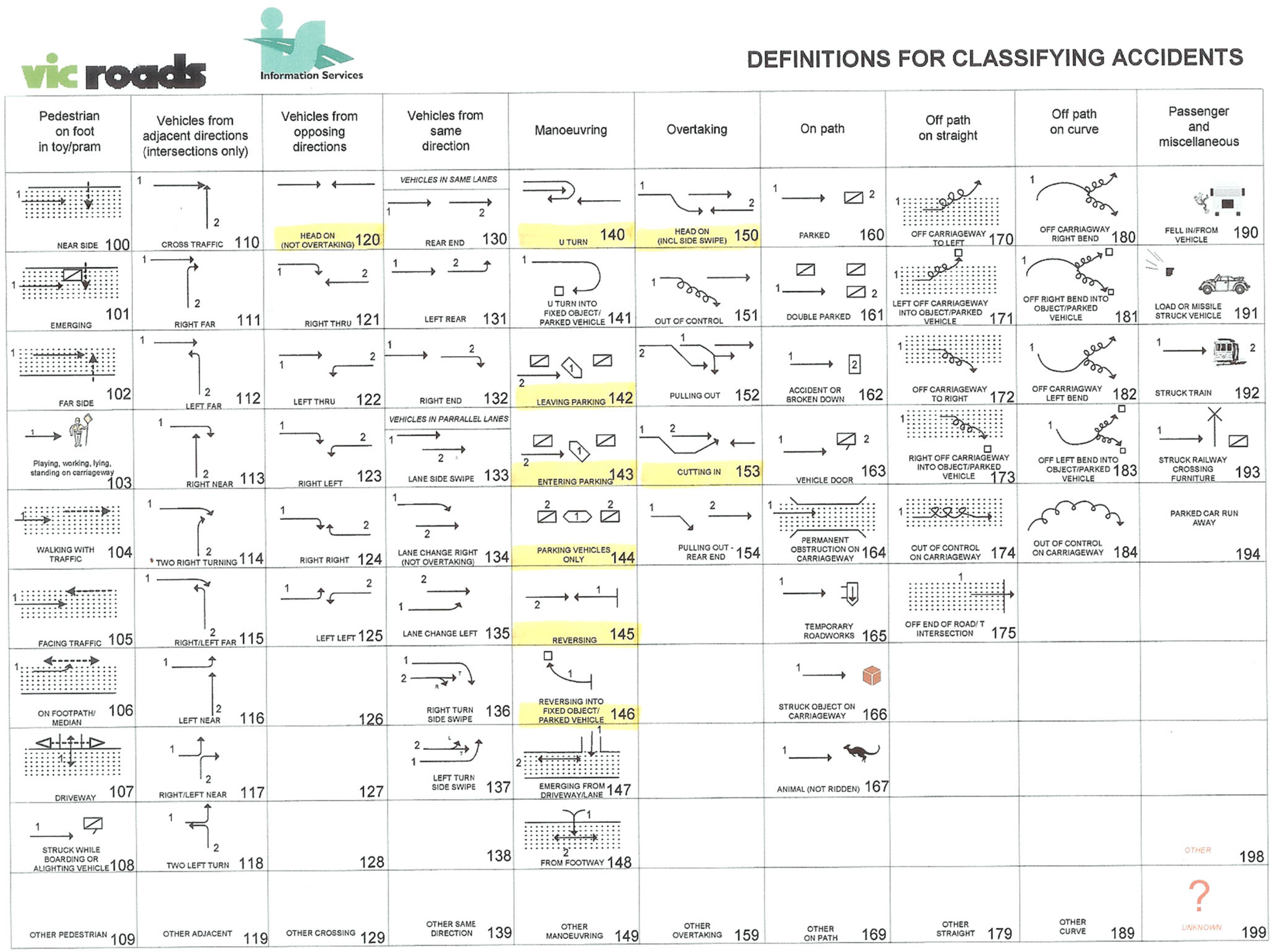
Object on road	328	716	529	87
Struck animal	691	547	441	199
Other on path	33	47	115	18
Off path-Straight				
Off road to left	430	754	78	88
Off rd left => obj	481	615	294	207
Off road to right	145	321	27	26
Off rd rght => obj	274	399	97	197
On road-out of cont.	3339	4757	1320	1185
Off end of road	73	101		
Loss Of Control: Left Turn - Intx			161	260
Loss Of Control: Right Turn - Intx			185	271
Other straight	26	387	386	68
Off Path-Curve				
Off Path On Curve: Off Cway Right Bend	835	788	205	122
Off Path On Curve: Off Right Bend In Obj	167	752	582	376
Off Path On Curve: Off Cway Left Bend	447	456	103	87
Off Path On Curve: Off Left Bend In Obj	679	537	343	267
Off Path On Curve: Lost Control On Cway	2799	1139	955	245
Off Path On Curve: Other	17	118	281	0
Miscellaneous				
Fell in/from vehicle	6	139	297	27
Misc: Load Struck Veh	14	39	28	7
Struck train	1	1	3	1
Misc: Struck Rail Xing Furniture		2	2	1
Misc: Parked Car Ran Away	4		1	1
Misc: Hit Animal Off Cway			2	0
Other	5	78		4
Unknown	31	29	75	4

Table B3: Australian ABS Sensitive Motorcycle Crashes of 2000-2011
All and injury Crashes by Crash Type, South Australia

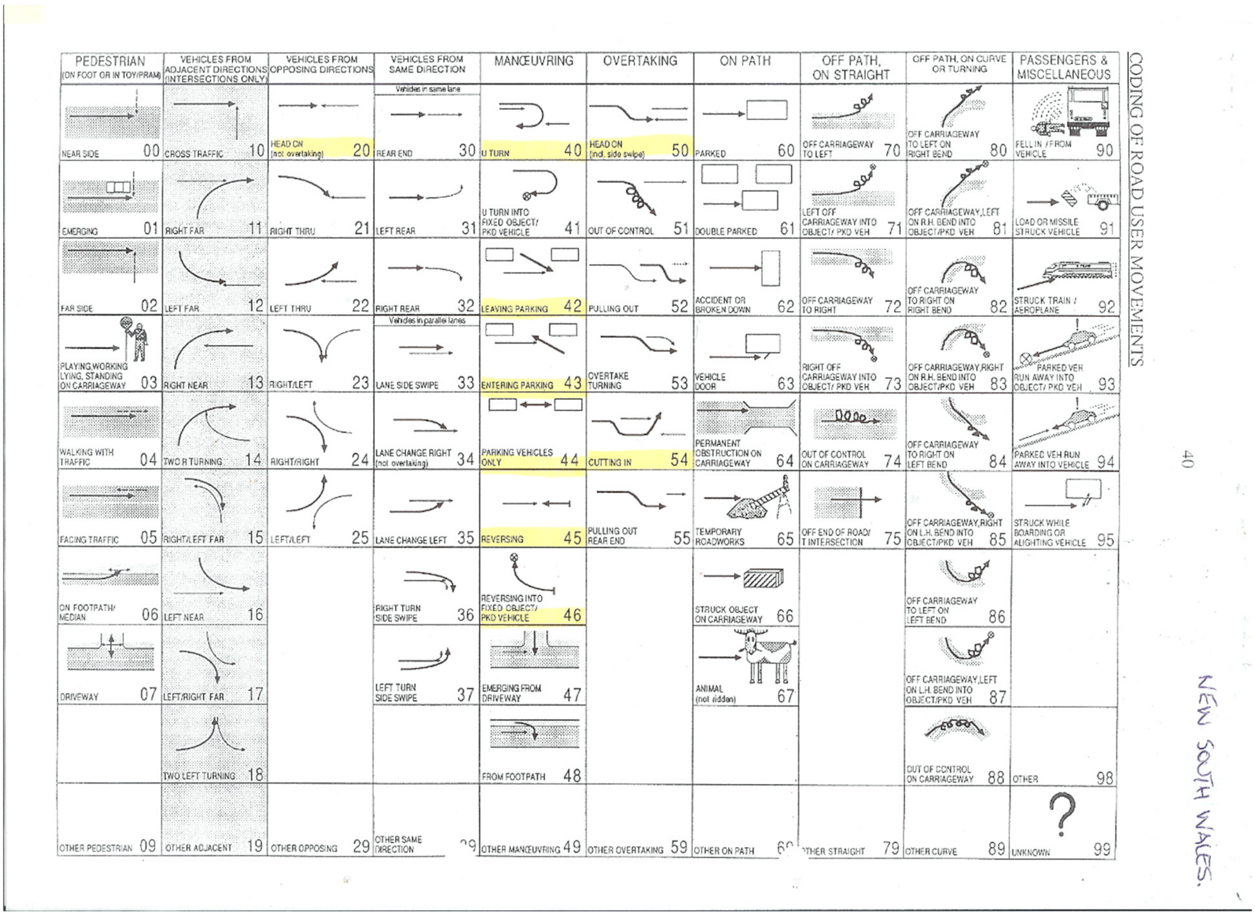
Type of crash	All crashes		Injury Crashes		Type of crash	All crashes		Injury Crashes	
	Yes	No	Yes	No		Yes	No	Yes	No
Rear End	1297		525	0	Right Turn	802		199	0
Hit Fixed Object	1153		172	0	Hit Parked Vehicle	142		56	0
Side Swipe	1018		337	0	Hit Animal	164		29	0
Right Angle	1616		433	0	Hit Object on Road	101		42	0
Head On		344	0	86	Left Road - Out of Control	209		52	0
Hit Pedestrian	91		3	0	Other	115		23	0
Roll Over	1793		382	0	Unknown	0	-	0	0

DCA Coding Charts for Relevant States

VICTORIA.



1. DEFINITION FOR CLASSIFYING ACCIDENTS (DCA) SHOULD BE DETERMINED BY FIRST SELECTING A COLUMN USING THE TEXT ABOVE EACH COLUMN AND THEN BY DIAGRAMATIC SUB-DIVIVISION
2. THE SUB-DIVISION CHOSEN SHOULD BE 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 INDENTIFY 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 (RUM) CODE.



CODING OF ROAD USER MOVEMENTS
PEDESTRIAN (ON FOOT OR IN TOY/PRAM)
NEAR SIDE 00
EMERGING 01
FAR SIDE 02
PLAYING,WORKING LYING, STANDING ON CARRIAGEWAY 03
WALKING WITH TRAFFIC 04
FACING TRAFFIC 05
ON FOOTPATH/ MEDIAN 06
DRIVEWAY 07
OTHER PEDESTRIAN 09
VEHICLES FROM ADJACENT DIRECTIONS (INTERSECTIONS ONLY)
CROSS TRAFFIC 10
RIGHT FAR 11
LEFT FAR 12
RIGHT NEAR 13
TWO R TURNING 14
RIGHT/LEFT FAR 15
LEFT NEAR 16
LEFT/RIGHT FAR 17
TWO LEFT TURNING 18
OTHER ADJACENT 19
VEHICLES FROM OPPOSING DIRECTIONS
HEAD ON (not overtaking) 20
RIGHT THRU 21
LEFT THRU 22
RIGHT/LEFT 23
RIGHT/RIGHT 24
LEFT/LEFT 25
OTHER OPPOSING 29
VEHICLES FROM SAME DIRECTION
Vehicles in same lane
REAR END 30
LEFT REAR 31
RIGHT REAR 32
Vehicles in parallel lanes
LANE SIDE SWIPE 33
LANE CHANGE RIGHT (not overtaking) 34
LANE CHANGE LEFT 35
RIGHT TURN SIDE SWIPE 36
LEFT TURN SIDE SWIPE 37
OTHER SAME DIRECTION 39
MANŒUVRING
U TURN 40
U TURN INTO FIXED OBJECT/ PKD VEHICLE 41
LEAVING PARKING 42
ENTERING PARKING 43
PARKING VEHICLES ONLY 44
REVERSING 45
REVERSING INTO FIXED OBJECT/ PKD VEHICLE 46
EMERGING FROM DRIVEWAY 47
FROM FOOTPATH 48
OTHER MANŒUVRING 49
OVERTAKING
HEAD ON (incl. side swipe) 50
OUT OF CONTROL 51
PULLING OUT 52
OVERTAKE TURNING 53
CUTTING IN 54
PULLING OUT REAR END 55
OTHER OVERTAKING 59
ON PATH
PARKED 60
DOUBLE PARKED 61
ACCIDENT OR BROKEN DOWN 62
VEHICLE DOOR 63
PERMANENT OBSTRUCTION ON CARRIAGEWAY 64
TEMPORARY ROADWORKS 65
STRUCK OBJECT ON CARRIAGEWAY 66
ANIMAL (not ridden) 67
OTHER ON PATH 69
OFF PATH, ON STRAIGHT
OFF CARRIAGEWAY TO LEFT 70
LEFT OFF CARRIAGEWAY INTO OBJECT/ PKD VEH 71
OFF CARRIAGEWAY TO RIGHT 72
RIGHT OFF CARRIAGEWAY INTO OBJECT/ PKD VEH 73
OUT OF CONTROL ON CARRIAGEWAY 74
OFF END OF ROAD/ T INTERSECTION 75
OTHER STRAIGHT 79
OFF PATH, ON CURVE OR TURNING
OFF CARRIAGEWAY TO LEFT ON RIGHT BEND 80
OFF CARRIAGEWAY,LEFT ON R.H. BEND INTO OBJECT/PKD VEH 81
OFF CARRIAGEWAY TO RIGHT ON RIGHT BEND 82
OFF CARRIAGEWAY,RIGHT ON R.H. BEND INTO OBJECT/PKD VEH 83
OFF CARRIAGEWAY TO RIGHT ON LEFT BEND 84
OFF CARRIAGEWAY,RIGHT ON L.H. BEND INTO OBJECT/PKD VEH 85
OFF CARRIAGEWAY TO LEFT ON LEFT BEND 86
OFF CARRIAGEWAY,LEFT ON L.H. BEND INTO OBJECT/PKD VEH 87
OUT OF CONTROL ON CARRIAGEWAY 88
OTHER CURVE 89
PASSENGERS & MISCELLANEOUS
FELL IN / FROM VEHICLE 90
LOAD OR MISSILE STRUCK VEHICLE 91
STRUCK TRAIN / AEROPLANE 92
PARKED VEH RUN AWAY INTO OBJECT/ PKD VEH 93
PARKED VEH RUN AWAY INTO VEHICLE 94
STRUCK WHILE BOARDING OR ALIGHTING VEHICLE 95
OTHER 98
UNKNOWN 99
40
NEW SOUTH WALES.

QUEENSLAND ·

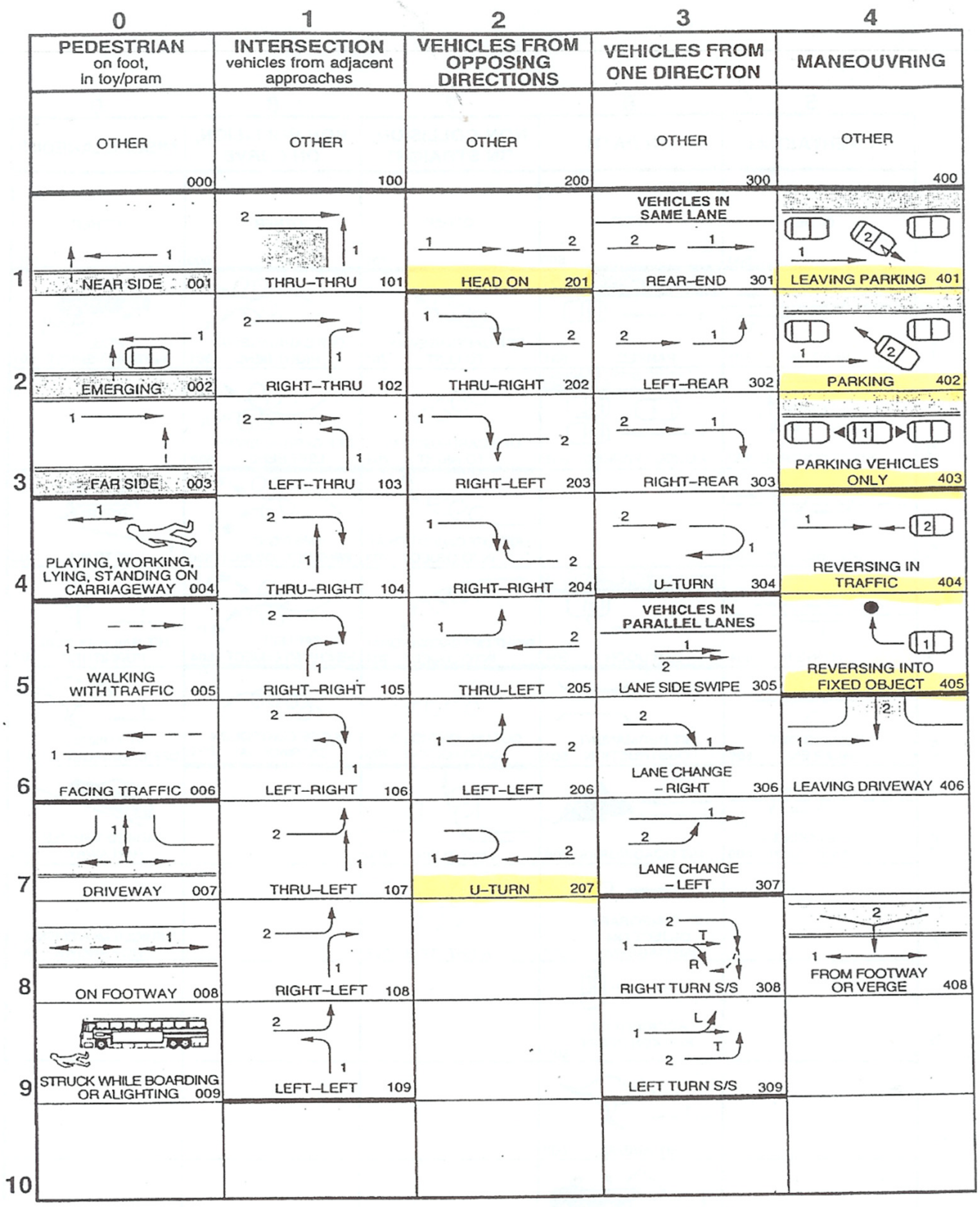


Fig. 46 - Definitions for coding crashes - left hand version (1994)

QUEENSLAND.

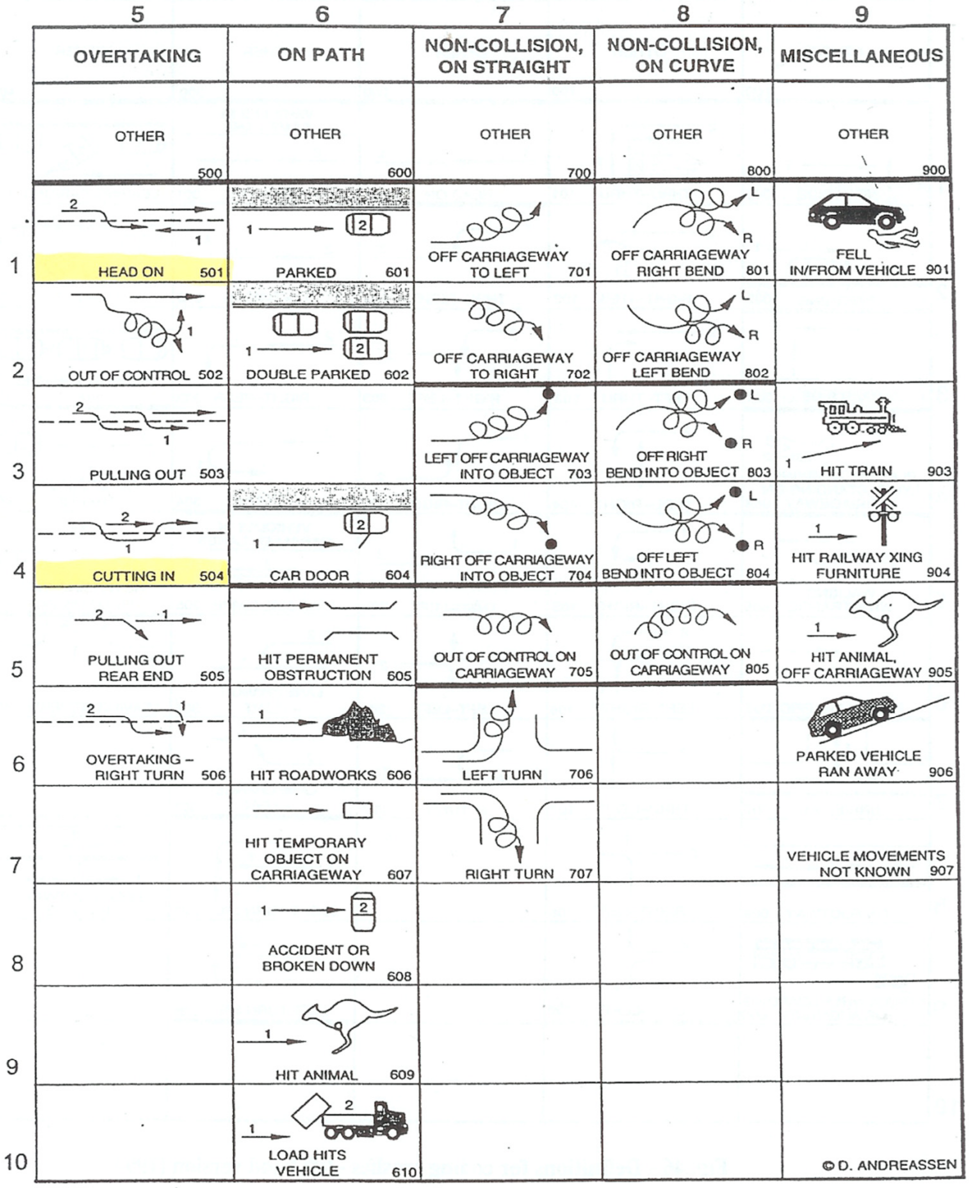


Fig. 47 - Definitions for coding crashes - left hand version(1994)

WESTERN AUSTRAIA

EVT_PED_MOVEMENT	23	13	Lying On Cway
EVT_PED_MOVEMENT	24	14	Stationary Off Cway
EVT_PED_MOVEMENT	25	15	Attending Acc
EVT_PED_MOVEMENT	30	16	Playing On Cway
EVT_PED_MOVEMENT	31	17	Playing Off Cway
PER_PROT_WORN	1	1	Worn
PER_PROT_WORN	2	2	Not Worn
PER_PROT_WORN	3	3	Failed
ACC_ROAD_ALIGN	1	1	Curve
ACC_ROAD_ALIGN	2	2	Straight
ACC_ROAD_COND	1	1	Wet
ACC_ROAD_COND	2	2	Dry
ACC_ROAD_FEAT	1	1	4-way Intx
ACC_ROAD_FEAT	2	2	3-way Intx (T-junction)
ACC_ROAD_FEAT	3	3	Intx > 4 Legs
ACC_ROAD_FEAT	4	4	Roundabout
ACC_ROAD_FEAT	5	5	Median Opening
ACC_ROAD_FEAT	6	6	Rail Xing
ACC_ROAD_FEAT	7	7	Bridge
ACC_ROAD_FEAT	8	8	Subway
ACC_ROAD_FEAT	9	9	Driveway
ACC_ROAD_FEAT	11	10	Mid Block Latm Device (Slow Pt Sp Hump Etc.)
ACC_ROAD_FEAT	12	11	Pedestrian Refuge Island
ACC_ROAD_GRADE	1	1	Level
ACC_ROAD_GRADE	2	2	Crest Of Hill
ACC_ROAD_GRADE	3	3	Slope
ACC_ROAD_SURF	1	1	Sealed
ACC_ROAD_SURF	2	2	Unsealed
PER_ROAD_USER	1	1	Driver
PER_ROAD_USER	2	2	Passenger
PER_ROAD_USER	3	3	Pedestrian
EVT_ROAD_USER_MOVE	98	1	Pedest: Other
EVT_ROAD_USER_MOVE	1	2	Pedest: Near Side
EVT_ROAD_USER_MOVE	2	3	Pedest: Emerging From Near Side
EVT_ROAD_USER_MOVE	3	4	Pedest: Far Side
EVT_ROAD_USER_MOVE	4	5	Pedest: Play / Work / Stand On Cway
EVT_ROAD_USER_MOVE	5	6	Pedest: Walking With Traffic
EVT_ROAD_USER_MOVE	6	7	Pedest: Walking Against Traffic
EVT_ROAD_USER_MOVE	7	8	Pedest: In Driveway
EVT_ROAD_USER_MOVE	8	9	Pedest: On Footway
EVT_ROAD_USER_MOVE	9	10	Pedest: Struck Boarding / Alighting
EVT_ROAD_USER_MOVE	10	11	Intx: Other
EVT_ROAD_USER_MOVE	11	12	Intx: Thru - Thru
EVT_ROAD_USER_MOVE	12	13	Intx: Right - Thru
EVT_ROAD_USER_MOVE	13	14	Intx: Left - Thru
EVT_ROAD_USER_MOVE	14	15	Intx: Thru - Right
EVT_ROAD_USER_MOVE	15	16	Intx: Right - Right
EVT_ROAD_USER_MOVE	16	17	Intx: Left - Right
EVT_ROAD_USER_MOVE	17	18	Intx: Thru - Left
EVT_ROAD_USER_MOVE	18	19	Intx: Right - Left
EVT_ROAD_USER_MOVE	19	20	Intx: Left - Left
EVT_ROAD_USER_MOVE	20	21	Opposite Dirn: Other

EVT_ROAD_USER_MOVE	21	22	Opposite Dirn: Head On
EVT_ROAD_USER_MOVE	22	23	Opposite Dirn: Thru - Right
EVT_ROAD_USER_MOVE	23	24	Opposite Dirn: Right - Left
EVT_ROAD_USER_MOVE	24	25	Opposite Dirn: Right - Right
EVT_ROAD_USER_MOVE	25	26	Opposite Dirn: Thru - Left
EVT_ROAD_USER_MOVE	26	27	Opposite Dirn: Left - Left
EVT_ROAD_USER_MOVE	27	28	Opposite Dirn: U - Turn
EVT_ROAD_USER_MOVE	30	29	Same Dirn: Other
EVT_ROAD_USER_MOVE	31	30	Same Dirn: Same Lane Rear End
EVT_ROAD_USER_MOVE	32	31	Same Dirn: Same Lane Left Rear
EVT_ROAD_USER_MOVE	33	32	Same Dirn: Same Lane Right Rear
EVT_ROAD_USER_MOVE	34	33	Same Dirn: Same Lane U - Turn
EVT_ROAD_USER_MOVE	35	34	Same Dirn: Parallel Lanes - S/swipe
EVT_ROAD_USER_MOVE	36	35	Same Dirn: Change Lanes - Right
EVT_ROAD_USER_MOVE	37	36	Same Dirn: Change Lanes - Left
EVT_ROAD_USER_MOVE	38	37	Same Dirn: Parallel Lanes - Turn Right S/swipe
EVT_ROAD_USER_MOVE	39	38	Same Dirn: Parallel Lanes - Turn Left S/swipe
EVT_ROAD_USER_MOVE	40	39	Manoeuv: Other
EVT_ROAD_USER_MOVE	42	40	Manoeuv: Leaving Parking
EVT_ROAD_USER_MOVE	43	41	Manoeuv: Parking
EVT_ROAD_USER_MOVE	44	42	Manoeuv: Parking Veh Only
EVT_ROAD_USER_MOVE	45	43	Manoeuv: Reversing In Traffic
EVT_ROAD_USER_MOVE	46	44	Manoeuv: Reverse Into Fixed Obj
EVT_ROAD_USER_MOVE	47	45	Manoeuv: Leaving Driveway
EVT_ROAD_USER_MOVE	48	46	Manoeuv: Loading Bay
EVT_ROAD_USER_MOVE	49	47	Manoeuv: From Footway
EVT_ROAD_USER_MOVE	50	48	Overtaking: Other
EVT_ROAD_USER_MOVE	51	49	Overtaking: Head On
EVT_ROAD_USER_MOVE	52	50	Overtaking: Out Of Control:
EVT_ROAD_USER_MOVE	53	51	Overtaking: Pulling Out
EVT_ROAD_USER_MOVE	54	52	Overtaking: Cutting In
EVT_ROAD_USER_MOVE	55	53	Overtaking: Pull Out - Rear End
EVT_ROAD_USER_MOVE	56	54	Overtaking: Into Right Turn
EVT_ROAD_USER_MOVE	60	55	On Path: Other
EVT_ROAD_USER_MOVE	61	56	On Path: Parked
EVT_ROAD_USER_MOVE	62	57	On Path: Double Parked
EVT_ROAD_USER_MOVE	63	58	On Path: Accident Or Breakdown
EVT_ROAD_USER_MOVE	64	59	On Path: Open Car Door
EVT_ROAD_USER_MOVE	65	60	On Path: Permanent Obstruction
EVT_ROAD_USER_MOVE	66	61	On Path: Temp Roadworks
EVT_ROAD_USER_MOVE	67	62	On Path: Temp Obj On Cway
EVT_ROAD_USER_MOVE	69	63	On Path: Hit Animal
EVT_ROAD_USER_MOVE	70	64	Off Path On Straight: Other
EVT_ROAD_USER_MOVE	71	65	Off Path On Straight: Off Left Cway
EVT_ROAD_USER_MOVE	72	66	Off Path On Straight: Off Left Cway Obj
EVT_ROAD_USER_MOVE	73	67	Off Path On Straight: Off Rigth Cway
EVT_ROAD_USER_MOVE	74	68	Off Path On Straight: Off Right Cway Obj
EVT_ROAD_USER_MOVE	75	69	Off Path On Straight: Lost Control On Cway
EVT_ROAD_USER_MOVE	76	70	Loss Of Control: Left Turn - Intx
EVT_ROAD_USER_MOVE	77	71	Loss Of Control: Right Turn - Intx
EVT_ROAD_USER_MOVE	80	72	Off Path On Curve: Other
EVT_ROAD_USER_MOVE	81	73	Off Path On Curve: Off Cway Right Bend

EVT_ROAD_USER_MOVE	82	74	Off Path On Curve: Off Right Bend In Obj
EVT_ROAD_USER_MOVE	83	75	Off Path On Curve: Off Cway Left Bend
EVT_ROAD_USER_MOVE	84	76	Off Path On Curve: Off Left Bend In Obj
EVT_ROAD_USER_MOVE	85	77	Off Path On Curve: Lost Control On Cway
EVT_ROAD_USER_MOVE	90	78	Misc: Passenger Other
EVT_ROAD_USER_MOVE	91	79	Misc: Passenger Fell In / From Veh
EVT_ROAD_USER_MOVE	92	80	Misc: Load Struck Veh
EVT_ROAD_USER_MOVE	93	81	Misc: Struck Train
EVT_ROAD_USER_MOVE	94	82	Misc: Struck Rail Xing Furniture
EVT_ROAD_USER_MOVE	95	83	Misc: Hit Animal Off Cway
EVT_ROAD_USER_MOVE	96	84	Misc: Parked Car Ran Away
EVT_ROAD_USER_MOVE	97	85	Misc: Veh Movement Unknown
ACC_SCOPE	1	1	Normal
ACC_SCOPE	2	2	Out Of Scope - Off Road
ACC_SCOPE	3	3	Out Of Scope - Traffic
STATE	ACT	1	Australian Capital Territory
STATE	INT	2	International
STATE	NSW	3	New South Wales
STATE	NT	4	Northern Territory
STATE	NZ	5	New Zealand
STATE	QLD	6	Queensland
STATE	SA	7	South Australia
STATE	TAS	8	Tasmania
STATE	VIC	9	Victoria
STATE	WA	10	Western Australia
PER_SEX	M	1	Male
PER_SEX	F	2	Female
ACC_TRAFF_CTRL	1	1	Intersection Traffic Lights
ACC_TRAFF_CTRL	2	2	Stop Sign
ACC_TRAFF_CTRL	3	3	Give Way Sign
ACC_TRAFF_CTRL	4	4	Zebra Crossing
ACC_TRAFF_CTRL	5	5	Rail Xing - Boomgates
ACC_TRAFF_CTRL	6	6	Rail Xing - Flashing Lights Only
ACC_TRAFF_CTRL	7	7	Rail Xing - Stop Signs
ACC_TRAFF_CTRL	8	8	Rail Xing - Unguarded
ACC_TRAFF_CTRL	9	9	School Crossing
ACC_TRAFF_CTRL	10	10	No Sign Or Control
ACC_TRAFF_CTRL	11	11	Pointsman
ACC_TRAFF_CTRL	12	12	Traffic Lights & Stop Sign
ACC_TRAFF_CTRL	13	13	Traffic Lights & Give Way Sign
ACC_TRAFF_CTRL	14	14	Traffic Lights & Stop Sign & Give Way Sign
ACC_TRAFF_CTRL	15	15	Stop & Give Way Sign
ACC_TRAFF_CTRL	16	16	Mid Block Traffic Lights
EVT_DIRECTION	N	1	North
EVT_DIRECTION	S	2	South
EVT_DIRECTION	E	3	East
EVT_DIRECTION	W	4	West
EVT_VEH_MOVEMENT	1	1	Stopped: By Traffic Control
EVT_VEH_MOVEMENT	2	2	Stopped: By Congestion
EVT_VEH_MOVEMENT	3	3	Stopped: By Prior Acc
EVT_VEH_MOVEMENT	4	4	Stopped: By Mechanical Failure
EVT_VEH_MOVEMENT	5	5	Stopped: To Avoid Veh

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.

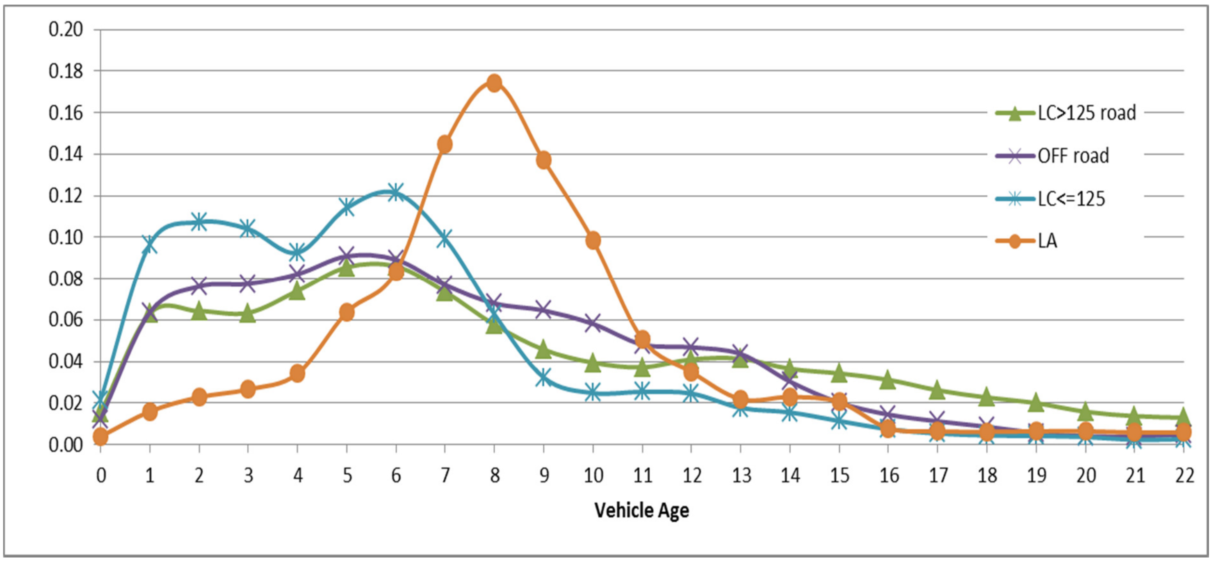


Figure 7: *Average 2013-2014 Age Distribution of Victorian Motorcycles by vehicle type (from 0 to 22 years)*

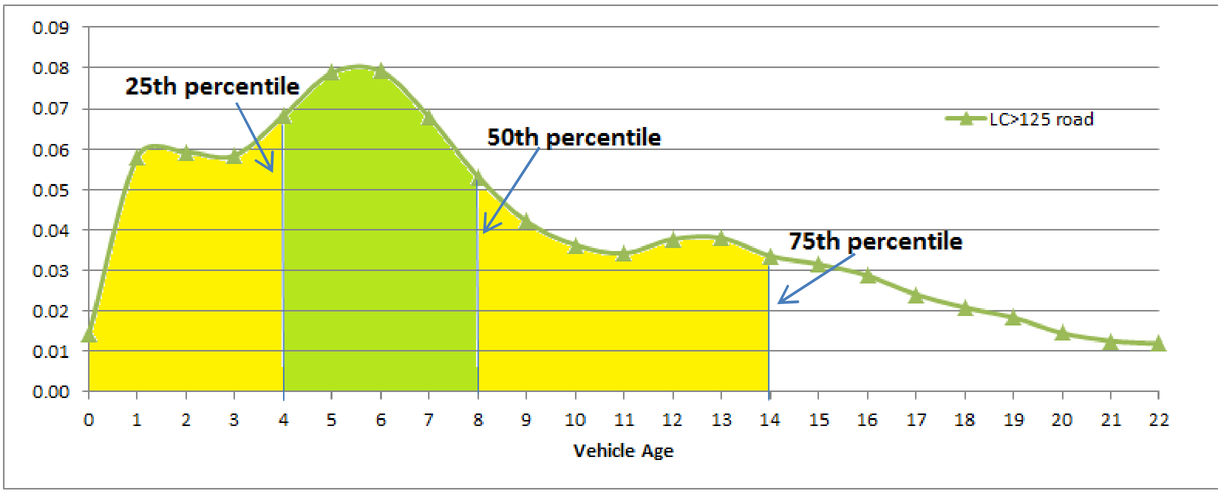


Figure 8: *Average 2013-2014 Age Distribution of Victorian LC>125CC road (excl. scooters) Motorcycles (all years)*

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.

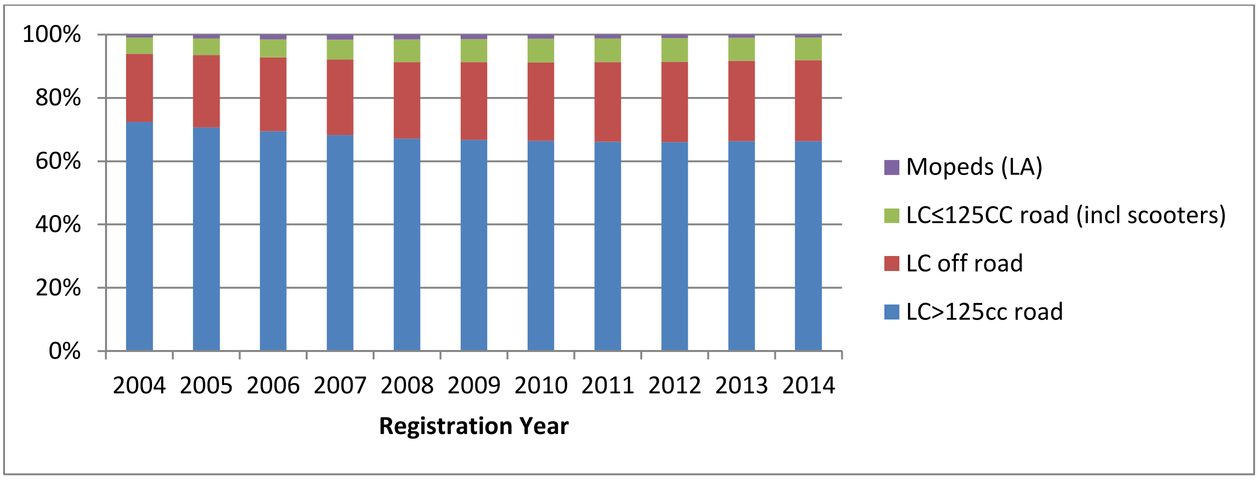


Figure 9: *Proportion vehicle type of registered Victorian motorcycle fleet (aged 0 to 22 years only)*

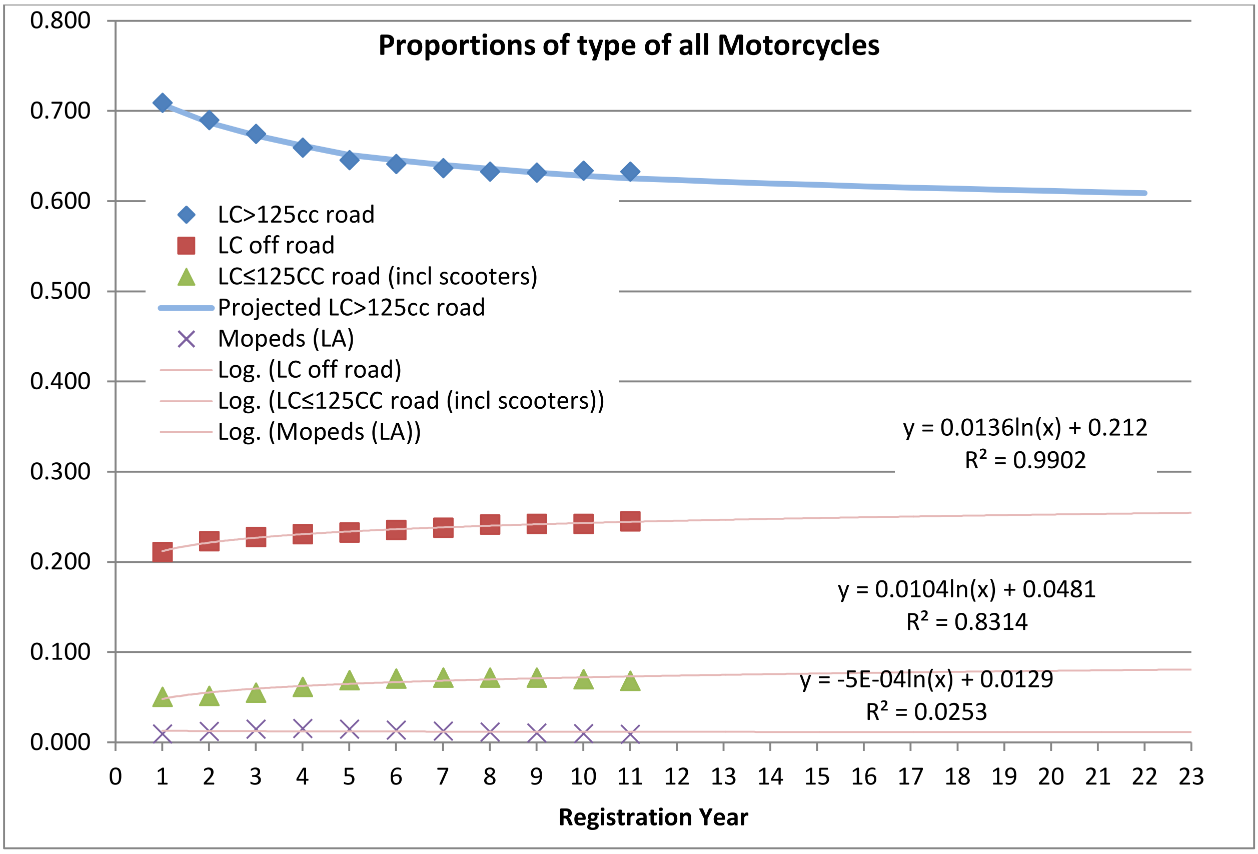


Figure 10: *Projected proportion vehicle type of registered Victorian motorcycle fleet (vehicles aged 0 to 22 years only)*

0=2004, 23=2025

Figure 11 depicts the future modelling of the entire Victorian motorcycle fleet.

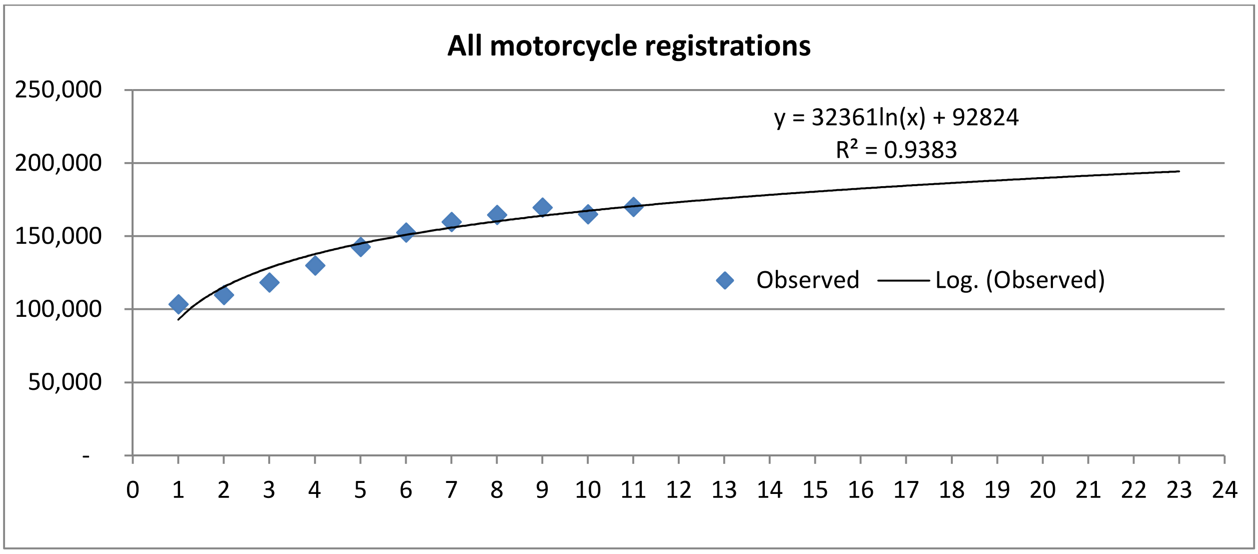


Figure 11: *Projected registered Victorian motorcycle fleet (vehicles aged 0-22 years only*)

0=2004, 23=2025

Appendix D – Projected crashes unaffected by LC>125CC ABS modelling

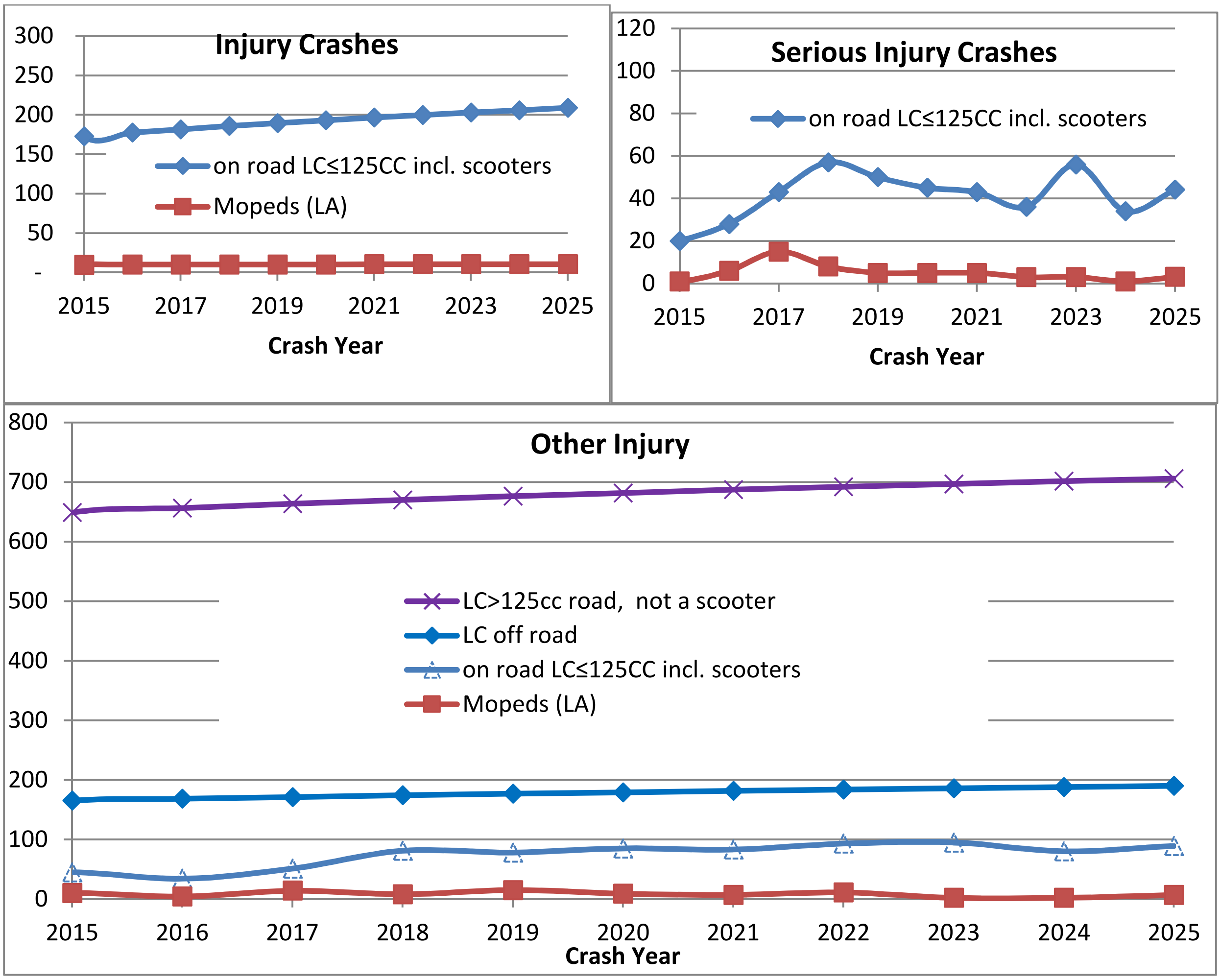


Figure 12: *Projected crashes of Victorian motorcycle fleet unaffected by ABS (vehicles aged 0-22 only)*

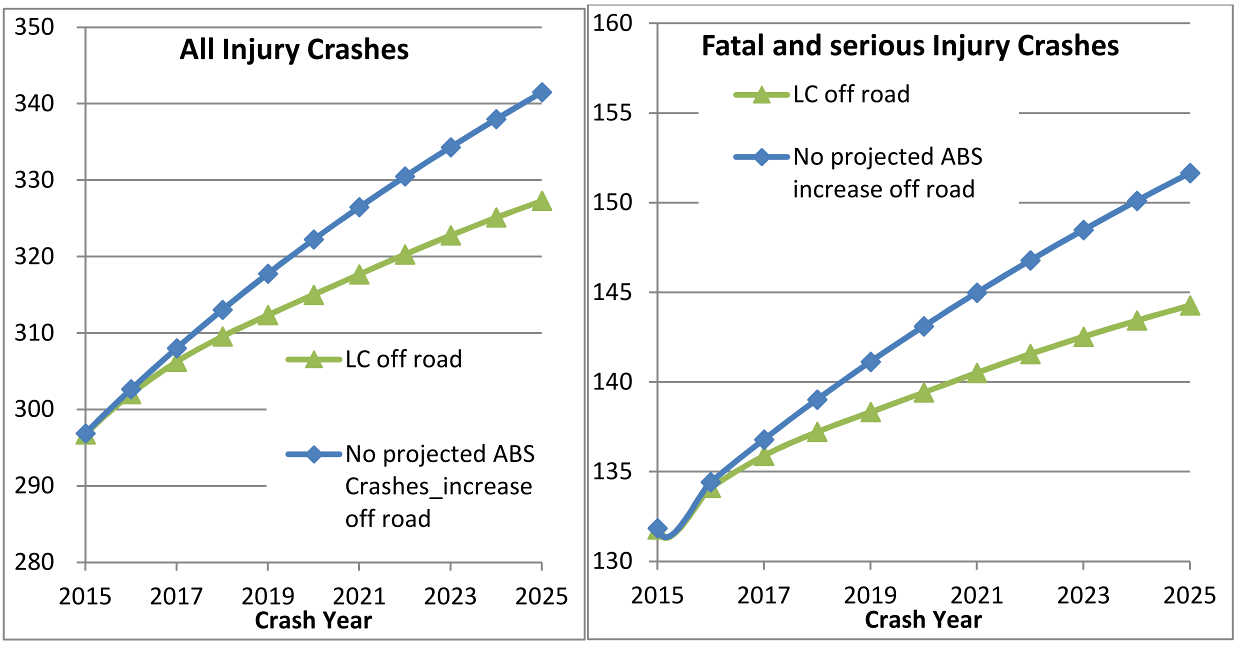


Figure 13: *Projected crashes of Victorian off road fleet (vehicles aged 0-22 only)*