AUSTRALIAN COMPETITION & CONSUMER COMMISSION

Quad bike safety

Final Recommendation to the Minister

February 2019

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Australian Competition and Consumer Commission
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Glossary

Term	Definition
50th PAM H3 ATD	50th Percentile Adult Male (PAM) Hybrid III (H3) Anthropomorphic Test Dummy (ATD)
ACCC	Australian Competition and Consumer Commission
ACL	Australian Consumer Law, Schedule 2 of the *Competition and Consumer Act 2010*.
ADRs	Australian Design Rules
ANCAP	Australasian New Car Assessment Program
ANSI	American National Standards Institute
ANSI/SVIA 1–2010	American National Standard for Four-Wheel All-Terrain Vehicles Equipment Configuration, and Performance Requirements (2010 version)
ANSI/SVIA 1–2017	American National Standard for Four-Wheel All-Terrain Vehicles Equipment Configuration, and Performance Requirements (2017 version)
AORVA	Australasian Off Road Vehicle Association
ATD	Anthropomorphic Test Dummy
ATVs	All-terrain vehicles (where possible referred to as quad bikes in this Consultation Regulation Impact Statement)
Ay	Lateral acceleration
CARRS-Q	Centre for Accident Research and Road Safety—Queensland
CCA	*Competition and Consumer Act 2010* (Cth)
CG or CoG	Centre of gravity
Consultation RIS	Consultation Regulation Impact Statement released by the Australian Competition and Consumer Commission on 22 March 2018
CPD	Crush protection device—a device mounted to quad bike to mitigate the risk of the rider being crushed by the vehicle if it rolls over.
Cth	Commonwealth
DALY	Disability-Adjusted Life Year
DPIPWE	Department of Primary Industries, Parks, Water and the Environment
DRE	Design Research Engineering Inc
DRI	Dynamic Research Inc.
ED	Emergency Department
EEA	European Economic Area
EN Standard	European Standard EN 15997:2011 All Terrain Vehicles (atvs—Quads)—safety Requirements and Test Methods
EU	European Union
EU Regulation	EU Regulation 168/2013—European type approval framework for motorcycles, tricycles and quadricycles (lightweight low power vehicles with four wheels), which also includes some power assisted pedal cycles
Experience goods	Experience goods require consumers to use the product to understand the attributes and limitations of the product. This is in contrast to 'search goods', where all the relevant information about the product is known prior to purchase
FCAI	Federal Chamber of Automotive Industries

Final recommendation	In the form of a Decision Regulation Impact Statement (this document)
Hcg	Height of centre of gravity above the ground
HWSA	Heads of Workplace Safety Authorities
IDC	Inter-Departmental Committee for Quad Bike Safety
Issues Paper	Issues Paper on Quad Bike Safety released by the Australian Competition and Consumer Commission on 13 November 2017
JTI	Jamieson Trauma Institute
K	Stability coefficient
Kpf	Forward pitch stability coefficient
Kpr	Rearward pitch stability coefficient
Kst	Lateral stability coefficient
L	Wheelbase
L1	Distance of the combined CG from forward or rear axle for forward and reward pitch respectively
Lateral rollover	Where a vehicle rolls over sideways to the left or right
Lcg	Location of centre of gravity forward of the rear axle
MTAA	Motor Trades Association of Australia
NSW farm survey	New South Wales Quad Bike safety improvement program: Survey results prepared for SafeWork NSW by Instinct and Reason
NFF	National Farmers Federation
NHTSA	National Highway Traffic Safety Administration
NPV	Net Present Value
NZ	New Zealand
OBPR	Office of Best Practice Regulation
OPDs	Operator protection devices, includes both CPDs and ROPSs
Oversteer	Occurs when a vehicle turns by more than the amount commanded by the operator
QISU	Queensland Injury Surveillance Unit
QUT	Queensland University of Technology
RACS	Royal Australasian College of Surgeons
Responsible Minister	Assistant Treasurer the Hon. Stuart Robert MP
RIS	Regulation Impact Statement
Rollover	Includes lateral, forward and rearward rolls
ROPS	Rollover protective structure—a protective structure that encloses the rider
ROVs	Recreational Off-Highway Vehicle
SEA	SEA Limited
SSF	Static stability factor
SSVs	Side-by-side vehicles (also known as ‘utility task vehicles’ (UTVs))
Supplier	Quad bike manufacturers and distributors
SVIA	Speciality Vehicle Institute of America
t_1 and t_2	Front and rear track width
Tan Ø	Tilt platform angle at second wheel lift
TTR	Table Tilt Ratio

TRG	Technical Reference Group established by the Inter-Departmental Committee
UK	United Kingdom
Understeer	Occurs when a vehicle turns less than the amount commanded by the operator
UNSW TARS	University of New South Wales Transport and Road Safety Research Unit
UNSW TARS Project	University of New South Wales Transport and Road Safety Quad Bike Performance Project
US	United States
US CPSC	United States Consumer Product Safety Commission
US Standard	ANSI/SVIA 1–2017 for Four-Wheel All-Terrain Vehicles Equipment Configuration, and Performance Requirements
VISU	Victorian Injury Surveillance Unit

1. Vehicle types

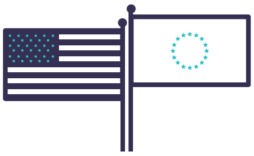
Different types of quad bikes and other vehicles are referred to throughout this Final Recommendation.

Descriptions of each of the vehicle types are provided below for reference.

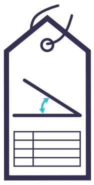
Quad bike definition	A motorised off-highway vehicle designed to travel on four low pressure or non-pneumatic tyres, having a seat designed to be straddled by the operator and handlebars for steering control.	
General-use model (marketed as Utility quad bikes in Australia)	**Type I**—A quad bike intended for recreational and/or utility use by an operator age 16 or older.	
	Type II—A quad bike intended for recreational and/or utility use by an operator age 16 or older with or without a passenger.	
Sport model	A quad bike intended for recreational use by an experienced operator, age 16 or older.	
Youth and transition models (sometimes marketed as 'Fun ATVs' in Australia)	**Y-6+**—A youth model quad bike that is intended for use by children age six, seven, eight and nine under adult supervision. **Y-10+**—A youth model quad bike that is intended for use by children age 10, 11, 12, 13 under adult supervision. **Y-12+**—A youth model quad bike that is intended for use by children age 12, 13, 14, 15 under adult supervision. **Transition model**—A quad bike of appropriate size that is intended for recreational use by an operator age 14, 15 or older under adult supervision.	
Side-by-side vehicle	Motorised off-road vehicle for an operator who remains seated and controls the vehicle by using a steering wheel. Has the ability to carry one or more passengers and is fitted with a rollover protection system.	
Polaris Ace®	Motorised off-road vehicle for a single operator that remains seated and controls the vehicle by using a steering wheel. Is fitted with a rollover protection system and operator restraint system.	

2. Quad bike safety standard recommendation

Within 12 months



All quad bikes must meet the specified requirements of the US quad bike Standard, ANSI/SVIA 1-2017 or the EN 15997:2011 Standard.

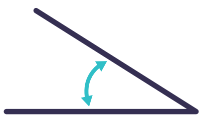


All quad bikes must be tested for lateral static stability using a tilt table test and display the angle at which it tips on to two wheels on a hang tag at the point of sale.

All quad bikes must have a durable label affixed, visible and legible when the quad bike is in operation, alerting the operator to the risk of rollover and must include rollover safety information in the owner's manual.

Within 24 months

All general-use model quad bikes must be fitted with, or have integrated into the design, an operator protection device.



All general-use model quad bikes must meet the minimum stability requirements of:

1. lateral stability - a minimum TTR of 0.55
2. front and rear longitudinal pitch stability - a minimum TTR of 0.8.

Exemption: The safety standard will provide an exemption for second hand quad bikes, except for those that are imported.

3. Executive summary

On 31 August 2017, the Australian Ministers for Consumer Affairs agreed to 'support all steps necessary to expedite the regulatory impact assessment process and any other safety measures necessary to introduce a consumer safety quad bike rating system and a safety standard'. This Final Recommendation is the Australian Competition and Consumer Commission's (ACCC) finding from its investigation into a safety standard for quad bikes.

What is the problem?

As the regulator of consumer products, the ACCC monitors fatalities and serious injuries attributable to consumer products on the Australian market. Of all consumer products that are not subject to an Australian design, safety or performance minimum standard, quad bikes are the leading cause of fatalities in Australia and are estimated to be responsible for an average of 16 fatalities per year and six emergency department presentations per day of which two people are being hospitalised for serious injuries.

The ACCC estimates these fatalities and injuries cost the Australian economy at least $200 million per year. This does not include intangible costs associated with fatalities and injuries, including but not limited to, the pain and suffering of family, friends and Australian communities.

Quad bikes are used extensively in Australia as work vehicles in the agriculture and forestry industries. They are also used for recreation, hunting, sport, tourism, and commercial hire. The major use in Australia, farming, is distinct from the major international quad bike market (the United States), where recreational use is dominant.

While there has been significant investment in quad bike education campaigns and rebates from the Commonwealth, state and territory governments and industry, fatalities and injuries continue to occur at rates that do not meet community expectations of safety.

In Australia, quad bike fatalities are divided equally between workplace and non-workplace activities and frequently involve adults between the ages of 45 and 75 operating a general-use model quad bike on an incline on a farm or rural property and experiencing a rollover. Children below the age of 16 years account for approximately 14 per cent of all recorded fatalities and the majority of these fatalities involved a child operating an adult sized general-use model quad bike and experiencing a rollover incident.

The ACCC estimates there are around 186 000 quad bikes in use across Australia and more than 44 new quad bikes are sold every day. However, these vehicles are unusual in that, unlike cars, trucks, tractors and motorbikes, they are not subject to any regulation, and do not have to meet any minimum safety or design standard prior to supply.

Many of the ways consumers are using general-use model quad bikes are reasonably foreseeable uses, and feature as part of the marketed utility of these vehicles, for example, operating the vehicles:

- over bumps in off-road terrain
- on relatively steep slopes
- at relatively high speeds
- while carrying/towing differing loads
- with the operator's attention shared between the vehicle operation and another task, for example mustering livestock.

From the information provided to the ACCC, operating general-use model quad bikes in these reasonably foreseeable ways can result in safety risks causing fatalities and injuries. This assessment has led the ACCC to conclude general-use model quad bikes cannot be safely operated across all the terrains or conditions consumers are believing they can be. Additionally, only a minority of consumers are purchasing aftermarket products to correct inherent design limitations.

Quad bikes are ‘experience goods’, meaning consumers cannot fully assess the key characteristics and limitations of the product until after they have purchased and used it. However, there are no requirements in Australia to provide consumers with quad bike safety or performance information. Without objective safety information at the point of sale, it is difficult for consumers to understand and compare the relative safety of different quad bike models and consumers may not properly understand the vehicle’s limitations until exceeding them. This information asymmetry exacerbates the design limitations by preventing consumers from making informed purchasing decisions.

Addressing the problem

Government action may be justified where the market fails to provide the most efficient and effective solution to a problem. The design of quad bikes is deficient—their performance characteristics in certain reasonably foreseeable uses and misuses is inadequate.

Without government action, individual manufacturers are unlikely to redesign quad bikes to improve safety or to provide enhanced information about their safety performance. It is also likely that in the absence of government action, fatalities and injuries associated with quad bikes will continue at the same frequency, costing the Australian economy over $200 million per year.

The Australian Consumer Law (ACL) is the legal framework which empowers the responsible Commonwealth Minister to reduce the cost and trauma associated with quad bike incidents. Introducing mandatory licensing, age limits, training requirements and requiring all operators to wear protective clothing (including helmets) are not within the powers of the responsible Minister, and can only be achieved through the state and territory laws.

The ACCC has prepared this report with a focus on addressing quad bike design deficiencies (through performance requirements), and information asymmetries, which are within the portfolio and powers of the responsible Minister, the Hon. Stuart Robert MP.

While the responsible Minister has powers under the ACL to ban consumer goods if satisfied they will or may cause injury, this could impose significant cost and disruption on the agriculture sector and other operations involving quad bikes. A ban on quad bikes is an option that could be explored further if other regulatory measures have been pursued, and fatalities and injuries continue to occur at rates that do not meet community expectations of safety.

Product safety is best addressed when a product is at the design stage.[1] The design of quad bikes should include consideration of safety under conditions of reasonably foreseeable use and misuse to ensure the vehicles can be operated safely for the purpose for which they are advertised, sold and used. At the design stage it is often more economical to address product flaws, and design changes that impact engineering controls are less susceptible to consumers’ personal attitude or behaviour towards safety.

In conducting this safety investigation, the ACCC has released two public documents and undertaken two formal consultations with stakeholders, seeking feedback on ways to improve quad bike safety. One hundred and nineteen submissions were received in response, and the ACCC conducted additional targeted consultation with key stakeholders throughout all stages of the investigation. An independent consultant was also commissioned to examine the evidence and critically review the regulatory options that were subject to public consultation.

The information provided to the ACCC indicates the need for improving quad bike safety is addressing the risk of rollovers, which are attributable to at least 60 per cent of quad bike fatalities in Australia. This should include design changes to reduce the likelihood of a rollover incident occurring and mitigating the harm if a rollover incident does occur. Additionally, crucial safety information should be provided to consumers accompanying quad bikes. This approach is consistent with product safety best practice and uses both administrative and engineering controls.

1 The Australian Standard Consumer Product Safety—Guidelines for Suppliers. AS ISO 10377:2017.

Feedback from submissions and the independent consultant has led to a refinement of the options presented in the Consultation Regulation Impact Statement (Consultation RIS) to ensure the recommendation addresses the priority areas for quad bike safety through streamlined and efficient regulation.

The revised options considered in this report are:

- Option 1 is a baseline option and does not include any regulatory changes.
- Options 2 requires **all quad bikes** supplied in Australia to meet the US or EN Standard, affix a rollover warning label to the vehicle, include rollover safety information in the owner's manual, and provide consumers with vehicle stability information at the point of sale. It also requires **general-use model quad bikes** to have operator protection devices integrated into the design, or fitted to the vehicles.
- Option 3 requires Option 2 and additionally stipulates minimum stability requirements **general-use model quad bikes** must meet before being supplied in Australia.

The ACCC recommends the safety standard exempt second hand vehicles, except those that are imported.

The ACCC received compelling information from medical associations and child advocacy groups demonstrating children have insufficient physical and cognitive abilities to operate quad bikes safely. However, for the reasons outlined at section 10.12 of this document, the ACCC is not proposing to recommend design changes or a ban on youth quad bikes at this time.

Assessing the regulatory options

Suppliers have been vocally resistant to regulation that may require quad bike redesign and, with few exceptions, have not assisted the ACCC in reconciling the costs that may be realised from regulation. This has resulted in uncertainty about the monetary costs and the extent of benefits that may be realised from adopting the above options. There is also uncertainty around the innovative or technological responses that may arise from performance-based regulation to improve quad bike safety. The uncertainty associated with the costs and benefits limited the extent to which a reliable quantitative assessment of the above options could be developed.

Instead, the ACCC has conducted a qualitative assessment of the options, with consideration given to five categories of impact:

- consumer safety
- consumer choice
- affordability
- costs to government
- flexibility and openness to innovation.

The ACCC's assessment concludes that Option 3 is the preferred option and will most likely improve the safety characteristics of quad bikes through:

- improving safety information available to consumers and introducing an incentive for manufacturers to compete on lateral stability results
- introducing minimum design requirements to all quad bikes through the adoption of international quad bike standards
- providing increased protection to operators of general-use model quad bikes in the event of a rollover
- reducing the frequency of rollovers of general-use model quad bikes by introducing minimum stability performance requirements.

The ACCC considers these requirements to be reasonably necessary to reduce the risk of injury posed by quad bikes.

While the stability requirements are intended to address the inherent instability of quad bikes, they will not stop all rollovers from occurring. Therefore, operator protection devices (OPDs) are required to mitigate the risk of serious crush injuries and asphyxiation. Information available to the ACCC indicates the addition of an OPD on a quad bike, without any other regulatory intervention, may help to prevent around a third of all quad bike deaths in Australia.

Overall, Option 3 is most likely to result in significant improvements to safety outcomes for consumers and enable them to play a role in creating a safer quad bike fleet through informed purchasing decisions. Option 3 has been developed to minimise disruption to the quad bike market to ensure these vehicles remain available for consumers, many of whom rely on these vehicles for daily work tasks.

Complementary safety measures and future work to improve quad bike safety

As part of a holistic approach to mitigate the safety risks of quad bikes, the ACCC recommends appropriate complementary regulatory measures be considered by other jurisdictions and agencies. These may include:

- measures that increase the use of helmets and other personal protection equipment
- education campaigns which encourage seatbelt use on SSVs
- prohibiting children from riding adult quad bikes
- prohibiting passengers on single seat quad bikes
- a continuation of current quad bike safety rebates and education initiatives
- improvements to quad bike incident data collection.

The ACCC recommends the responsible Minister write to state and territory ministers with a responsibility for workplace health and safety, asking them to consider these measures.

The ACCC also recommends consumers take advantage of these education and rebate schemes to ensure their practices are as safe as possible.

The ACCC considers a number of other measures are important for the continual improvement of quad bike safety, however further exploration is required before they may be considered for inclusion in a safety standard. These include:

- tests to improve quad bike dynamic handling
- a five star safety rating system
- options to protect children from the risks posed by youth and adult quad bikes.

4. Introduction

In March 2017, following a succession of quad bike fatalities, the then Minister for Employment, the Hon. Michaelia Cash MP, brought together a range of agencies with an interest in quad bike safety, including the ACCC, in an interdepartmental committee (IDC).

On 31 August 2017, the Australian Ministers for Consumer Affairs agreed to 'support all steps necessary to expedite the regulatory impact assessment process and any other safety measures necessary to introduce a consumer safety quad bike rating system and a safety standard'.

On 24 October 2017, the then Minister for Small Business, the Hon. Michael McCormack and Minister for Employment, the Hon. Michaelia Cash MP jointly announced the ACCC led Taskforce would conduct an investigation to address quad bike safety as an urgent priority and the Taskforce would work with the IDC to examine solutions to improve quad bike safety, including whether to introduce a quad bike product safety standard.

This Final Recommendation delivers on those commitments made by the Australian Government.

The Final Recommendation sets out the ACCC's recommendation to the Minister to make a safety standard under s. 104 of the ACL to reduce the fatalities and injuries associated with quad bikes in Australia.

Under s. 104 of the ACL, a safety standard can include requirements that are reasonably necessary to prevent or reduce risk of injury to any person. A safety standard can:

- mandate certain performance and design requirements
- require testing during or after the completion of manufacture
- require the provision of information in the form of markings, warnings or instructions.

Among other things, a safety standard under the ACL cannot:

- control use through age or passenger restrictions
- mandate that purchasers must undergo training
- prescribe speed limits
- mandate the use of personal protective equipment.

The ACCC has undertaken extensive consultation in relation to the recommended mandatory safety standard. It released an Issues Paper on Quad Bike Safety (Issues Paper) on 13 November 2017, which invited responses and comments from interested parties. The Issues Paper posed a range of questions relating to the current use of quad bikes within Australia, perceived safety risks, the existing regulatory environment, international regulatory standards, consumer information and vehicle design.

The ACCC received 56 submissions in response to the Issues Paper from a broad range of stakeholders, including industry representative bodies, quad bike manufacturers and retailers, individual farmers and other consumers, academics, hospitals and health professionals, quad bike tourism operators and government agencies.

Following the consideration of the submissions in response to the Issues Paper, the ACCC released a Consultation Regulation Impact Statement (Consultation RIS) on 22 March 2018 for a six week consultation period. The Consultation RIS included five policy options considered to improve the safety of quad bikes and SSVs, the ACCC's preliminary recommendation and a series of questions for stakeholder consideration. SSVs were included into the scope of the investigation for the purposes of considering whether they should be required to be tested in accordance with a star rating system.

The ACCC received 63 submissions from a variety of interested parties and undertook targeted consultation with 23 stakeholders (further information outlined in section 9).

The ACCC commissioned Troutbeck and Associates to critically review the options presented in the Consultation RIS. The Principal of Troutbeck and Associates, Emeritus Professor Rod Troutbeck authored the report. Emeritus Professor Troutbeck was a Professor of Civil Engineering at Queensland University of Technology and specialised in traffic management, Intelligent Transport systems, vision and driving and road safety. He is also currently working as an Adjunct Professor with the Centre for Accident Research and Road Safety (CARRS-Q) and has been a member on a number of safety committees, including Chair of the Standards Association Committee CE/33—Road Safety Barriers and devices. Given Emeritus Professor Troutbeck's background in vehicle safety, the ACCC considered him an appropriate expert to review the options proposed in the Consultation RIS.

The report provided by Troutbeck and Associates was also peer-reviewed by Dr Gary Heydinger of SEA Ltd. SEA Ltd is a US forensic engineering and consultancy company and Dr Heydinger is SEA's Director of Vehicle Dynamics. Dr Heydinger has worked extensively with the United States Consumer Product Safety Commission (US CPSC), undertaking research and testing on quad bikes and SSVs for the past 10 years. His expertise includes modelling, simulating, testing, and analysing vehicle handling dynamics and stability; vehicle rollovers; and suspension and tyre dynamics.

After extensive consultation and detailed advice from safety experts, the ACCC considers the introduction of a safety standard for quad bikes consisting of each of the requirements outlined in Option 3, is reasonably necessary to prevent or reduce the risk of injury to any person, as provided for in section 104 of the ACL. Option 3 requires:

- **all quad bikes** to:
  - meet certain requirements of the US Standard or EN Standard
  - have a durable label affixed, visible when the quad bike is in operation, alerting the operator to the risk of rollover
  - be tested for lateral static stability using a tilt table test and display the angle at which it tips on to two wheels on a hang tag at the point of sale
- **general-use model quad bikes** to:
  - be fitted with, or have integrated into the design, an operator protection device
  - meet the minimum stability performance requirements of:
    - lateral stability—a minimum TTR of 0.55
    - front and rear longitudinal pitch stability—a minimum TTR of 0.8.

The ACCC considers these requirements to be reasonably necessary to reduce the risk of injury posed by quad bikes.

5. Overview of quad bikes

Quad bikes

In Australia, quad bikes are primarily purchased for use in the agriculture and forestry industries as work vehicles. Quad bikes are also used for recreation, hunting, sport, tourism and commercial hire. Broadly, quad bikes can be categorised into three vehicle-types:

- utility (general-use model) quad bikes
- sports quad bikes
- youth quad bikes ('fun' quad bikes).

Quad bikes are marketed for off-road use in Australia. They are used in different terrains and conditions for many purposes, including mustering, spraying weeds, towing, hauling, recreational trail riding, hunting and organised recreational activities.

Most quad bikes are not designed to carry passengers.[2] The few that are manufactured to carry a passenger, are only designed to accommodate a single passenger, and are equipped with a designated passenger seat behind the operator.[3]

General-use model quad bikes (marketed as 'utility', 'farm', or 'work' quad bikes in Australia) are widely purchased for work-related use in the farming and forestry industry, but are also used for recreational use on farms, and less frequently solely for recreation, sport and use in the tourism industry. The features and characteristics of general-use model quad bikes vary and some of these features are summarised in table 1.

Table 1: Some features of general-use model quad bikes sold in Australia

Feature	Range or different types
Engine size	250 cc–1000 cc
Unladen kerb weight	<200 kg to >350 kg
Drive	2WD and 4WD (with 2WD option)
Rear suspension	Swingarm or independent rear suspension

A number of general-use model quad bikes with four-wheel-drive have a limited slip differential, or lockable limited slip differential on the front axle and a small number of models also have a lockable rear differential. A small number of models are sold with Active Descent Control (engine braking), which controls speed when going down inclines. General-use model quad bikes are typically the heaviest of the three quad bike types and have towing capabilities.

Sports quad bikes are lighter, have a lower centre of gravity, accelerate more quickly and are used predominantly for recreational and competitive sporting purposes.

Youth quad bikes are specifically designed for children and young riders between the ages of six and 15 years and are smaller, lighter weight, have smaller engine capacities and are normally used for recreation under adult supervision (recommended by major manufacturers). Where they have been manufactured to the US or European standards, they also include a speed limiting device.

2 These quad bikes are classified as Type I ATVs in the US, see ANSI/SVIA 1-2017, approved by the American National Standard Institute 8 June 2017.

3 These quad bikes are classified as Type II ATVs in the US, see ANSI/SVIA 1-2017, approved by the American National Standard Institute 8 June 2017.

Side-by-side vehicles (SSVs)

Similarly to quad bikes, in Australia SSVs are used primarily for utility purposes in farming and forestry and to a lesser extent for recreational purposes, for example on rural properties, and for sporting and tourism.

SSVs are designed to allow the operator to remain seated and control the vehicle by using a steering wheel. SSVs are capable of carrying one or more passengers, depending on the vehicle type.[4] Generally SSVs are larger than quad bikes, have a longer wheelbase and a wider track width, include an occupant restraint system (seat belts) and most models have a rollover protective structure (ROPS).

Since being introduced in the Australian market in 2007, sales of SSVs have increased steadily. Rebate schemes in Victoria and New South Wales reduce the out of pocket price of SSVs for farmers and farm businesses, providing an additional incentive for farmers to purchase a SSV. Such initiatives may be contributing to SSVs progressively being used in agricultural businesses as a substitute for quad bikes for a range of applications. However, a quad bike is still preferred for some activities, particularly for mustering, moving animals, moving around the farm and inspecting property.[5]

If the sales of SSVs continue to increase in Australia, it is anticipated that the number of injuries and fatalities associated with SSV use will also increase. While the number of fatalities associated with SSVs is clear, there is little data available on SSV injury rates (often incident reports do not differentiate between quad bikes and SSVs), however, it is generally understood that injuries occur at a lower rate than quad bikes. This is likely to be due to the additional design features that provide SSVs with greater stability and increased occupant protection compared to quad bikes.

Other vehicle types

The Polaris Ace is a hybrid of a quad bike and a SSV. It has a similar footprint to a quad bike and is designed for a single operator. However, similar to a SSV, the operator is in the seated position, controls the vehicle using a steering wheel and the vehicle is fitted with a ROPS and operator restraint system (a seat belt). Polaris consider this vehicle to fall within the same class of vehicles as SSVs and have reported it complies with the US Standard for SSVs, the ANSI-ROHVA 1–2016.

5.1 The quad bike market

Retail market

The global quad bike market was valued at almost $7.8 billion in 2015.[6] The Australian market makes up around three percent of the global market, and in 2015 was valued at $231.4 million.[7] Based on feedback from consumers, suppliers and farming industry bodies, sales are predominantly driven by workplace demand in the agricultural and forestry sectors.

This differentiates the Australian market from the US, where quad bikes are mostly used as recreational vehicles and demand fluctuations depend on product prices, per capita disposable income, population trends, age distribution and overall preference for particular recreational and sporting activities.[8]

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4 There is also the Polaris Ace which is similar in many regards to an SSV but designed for use by a single rider only.

5 Instinct and Reason, *New South Wales quad bike safety improvement program: Survey results for mid-point evaluation*, August 2017, prepared for SafeWork NSW, p. 9, available at: https://www.safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

6 Using an exchange rate of 1 US Dollar equals 1.28 Australian Dollar. Global Market Insights, *ATV Market Report* (2017), p. 20.

7 Ibid, p. 87.

8 IBISWorld, 'IBISWorld Industry Report OD5714: ATV Manufacturing in the US' K O'Hollaren, provided 30 August 2017, pp. 13–14.

According to annual sales data (figure 1), more than 16 000 quad bikes were sold in Australia in 2017.[9] Of these approximately:

- 76 per cent were general-use models
- seven per cent were sports models
- 17 per cent were youth models.[10]

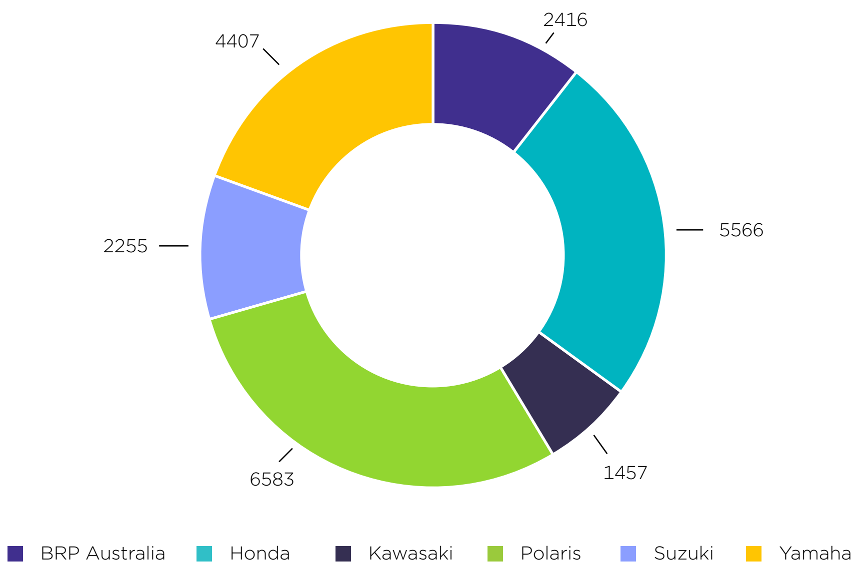
Seventy-five per cent of farmers surveyed in a New South Wales survey on quad bike safety (the NSW farm survey) said they would be looking to buy another quad bike or SSV in the next five years.[11]

Supply chain

The supply chain for new quad bikes includes manufacturers, importers, distributors, retailers (dealers) and consumers. New quad bike sales also generate demand for aftermarket services (vehicle servicing, replacement parts and repairs), accessories (such as operator protective devices, trailers, gun boots and spray tanks) and provide vehicles for sale in the second-hand vehicle market.

FCAI-member manufacturers and Polaris report annual vehicle sales to the FCAI. The sales figures for 2017 indicate that Polaris, Honda and Yamaha had the largest market share by number of quad bikes and SSVs sold (figure 1).

Figure 1: FCAI members and Polaris 2017 quad bike and SSV sales



Source: Federal Chamber of Automotive Industries.

Consumers typically purchase new quad bikes from dealers, although manufacturers may supply some customers directly for special purpose applications such as defence. A feature of the industry is the vertical integration of 'manufacturer authorised' supply chains, including dealerships owned by manufacturers and authorised dealer agreements.

9 Federal Chamber of Automotive Industries, 'Motorcycles', *YTD Market Summary*, accessed 5 September, https://www.fcai.com.au/motorcycles.

10 Based on information provided at the Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, http://www.courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

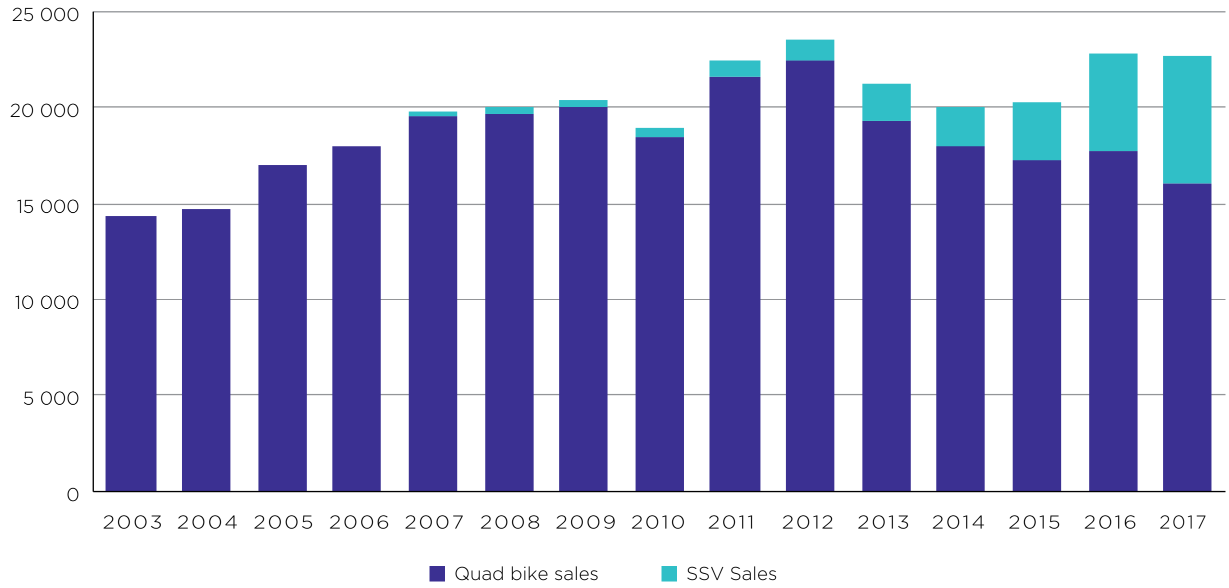
11 Instinct and Reason, *New South Wales quad bike safety improvement program: Survey results for mid-point evaluation*, August 2017, prepared for SafeWork NSW, p. 28.

New and second-hand quad bikes are also sold online. Some online sales are conducted directly between suppliers and consumers, while others occur through online marketplaces such as eBay, Bikesales or Gumtree. A 2013 survey of recreational quad bike users indicated that most of the vehicles sold online are new vehicles (73 per cent).[12]

Quad bike and SSV fleet size

Submissions in response to the Issues Paper indicated the lifespan of a vehicle could range from two to 30 years, with a likely average age of 10 years (dependent on use).

Figure 2: Australian quad bike and SSV sales



Source: Polaris Industries and the Federal Chamber of Automobile Industries.

Assuming an average 10-year lifespan, there are an estimated 186 000 quad bikes currently in operation in Australia.

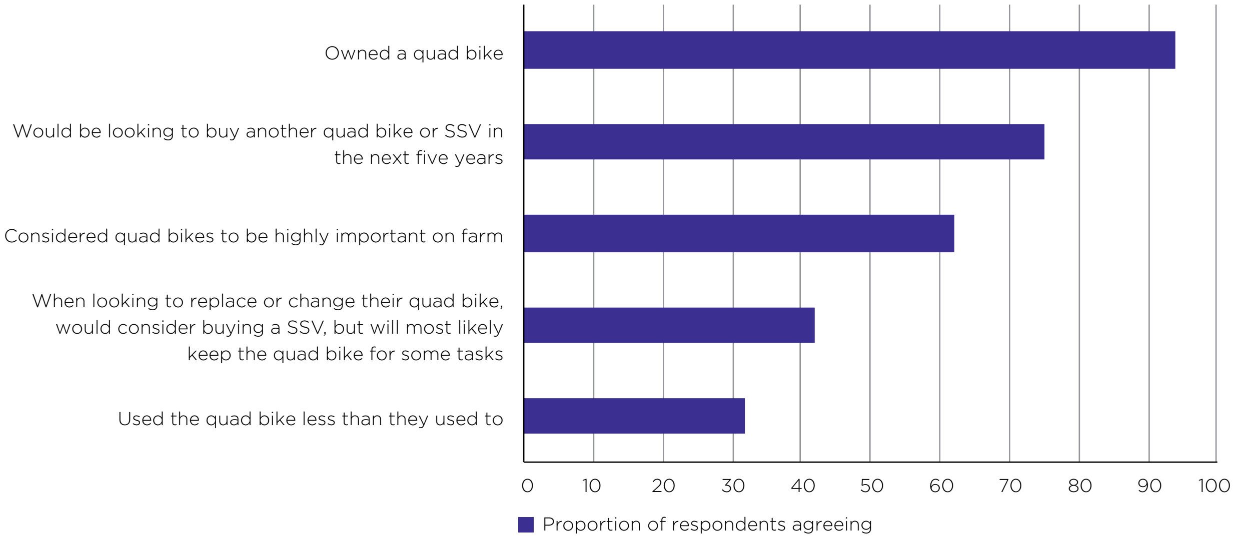
Vehicle ownership

The NSW farm survey reported 94 per cent of farmers owned a quad bike, indicating that on farms, quad bikes are as common as utility vehicles (often referred to as 'utes') and tractors.[13]

12 Colmar Brunton, *Recreational Quad Bike Usage*, submitted to ACCC 26 March 2013, p. 7, available at: productsafety.gov.au/system/files/Quad%20bikes%20-%20Consumer%20research%20report%20- %20March%202013.pdf.

13 Instinct and Reason, New South Wales quad bike safety improvement program: Survey results for mid-point evaluation, August 2017, prepared for SafeWork NSW, p. 9, available at: safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

Figure 3: NSW farm survey responses, NSW, 2017



Source: New South Wales quad bike safety improvement program.

Vehicle sales show decreasing quad bike sales in recent years and an increasing trend in SSVs sales (figure 2). Manufacturers and distributors submitted SSV sales were partly driven by government rebates that reduce the price of SSVs for farmers and farm businesses in New South Wales and Victoria.

The NSW farm survey found almost a third of farmers agreed they were using quad bikes less than they previously did,[14] but almost two thirds said quad bikes were still considered to be 'highly important on the farm'.[15]

Many suppliers stated that despite the increased sales in SSVs, there would always be demand for quad bikes in Australia because they can:

- be operated in small and tight spaces, such as between crop lines
- offer the operator an unobstructed, 360 degree view
- accelerate quickly, making them highly valued for mustering livestock.

The NSW farm survey found that when next needing to replace their quad bike, 42 per cent of farmer respondents would consider buying an SSV but will most likely keep the quad bike for some tasks.

The NSW farm survey report concluded 'it will be unlikely that quad bikes will disappear from the farming environment but the arrival of the SSV heralds an alternative and complementary vehicle'.[16] The ACCC agrees with this view, but also acknowledges that it is unlikely SSVs will replace quad bikes on a permanent basis for the majority of current users.

14 Instinct and Reason, New South Wales quad bike safety improvement program: Survey results for mid-point evaluation, August 2017, prepared for SafeWork NSW, p. 14, available at: https://www.safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

15 Ibid, p. 18.

16 Ibid, p. 24.

Future of quad bike sales

The global quad bike market for recreational and sporting application is reported to be growing.[17] The recreation sector is reported to be a leading growth segment, with predictions of increased demand for quad bikes to be used for off-roading, eco-tourism and safari operations.[18]

As outlined above, the ACCC considers SSVs may become more common as an alternative and complementary vehicle for on farm use, although some quad bike users may convert entirely to SSVs. Quad bike sales may also be impacted by the uptake of new technologies, including drones, virtual fencing and automation systems. However, it is likely for the foreseeable future that quad bikes will continue to be common on Australian farms and also as recreational vehicles.

17 Global Market Insights, ATV Market Report (2017) p. 25.

18 Ibid, p. 30.

6. Product safety best practice

Key points

- Operating general-use model quad bikes in reasonably foreseeable ways can result in safety risks causing fatalities and injuries.
- The design of general-use model quad bikes should include consideration of safety under conditions of reasonably foreseeable use and misuse to ensuare the vehicles can be operated safely for the purpose for which they are advertised, sold, and used.

To reduce risk, product safety is best addressed when a product is at the design stage.[19] At the design stage, manufacturers should consider the reasonably foreseeable decisions and actions of consumers when purchasing, assembling, using, storing and maintaining the product.[20] This approach enables continual improvement in product safety design[21] and is more economically viable than aftermarket design modifications.

Quad bikes are not an exception to product safety best practice and the design of quad bikes should include consideration of safety under conditions of reasonably foreseeable use and misuse. What can be considered to be reasonably foreseeable use or misuse is open to interpretation.

The Productivity Commission (PC) considered the case for moving towards a 'reasonably foreseeable use' approach for administering bans and recalls in 2006. The Productivity Commission's findings contributed to the adoption of 'reasonably foreseeable use (including a misuse)' in the ACL.

The PC considered that any foreseeable use concept that is the basis for government action must reflect two elements, the foreseeability or predictability of the use, and the reasonableness of the use.

The PC noted:[22]

- often a product will be used in a manner which the user considers reasonable, but the manufacturer considers abuse
- merely warning consumers against unsafe uses of a product will not necessarily be sufficient to make a product 'safe'. Instead, manufacturers are required to consider reasonably foreseeable uses in light of normal use, regardless of whether such use has been warned against in warnings or instructions
- some monitoring of the post-marketing history of manufacturers' products may be required to determine what uses the products are actually put to.

While the ACCC is not aware of any relevant Australian case law that considers 'reasonably foreseeable use' under the ACL in detail, a recent case in the Queensland District Court found that without rollover protection and additional safety measures, a quad bike was not suitable for the purpose of mustering cattle on the relevant property.[23]

Reasonably foreseeable uses of general-use model quad bikes is likely to involve operators sometimes operating the vehicles:

- over bumps in off-road terrain
- on relatively steep slopes
- at relatively high speeds
- while towing differing loads or attachments

19 The Australian Standard Consumer Product Safety—Guidelines for Suppliers. AS ISO 10377:2017.
20 Ibid.
21 AS ISO 10377:2017.
22 Productivity Commission, 'Review of the Australian Consumer Product Safety System' *Productivity Commission Research Report,* 16 January 2006.
23 *McHugh v BKE Pty Ltd as trustee for the B W King Family Trust* [2018] QDC 254.

- with their attention shared between the vehicle operation and another task, including to muster livestock.

Many of these applications feature as part of the marketed utility of general-use model quad bikes, however in some circumstances are also behaviours warned against in manufacturers' owner's manuals. From the information provided to the ACCC, operating general-use model quad bikes in these reasonably foreseeable ways can result in safety risks causing fatalities and injuries. This assessment has led the ACCC to conclude general-use model quad bikes cannot be safely operated across all the terrains or conditions consumers are believing they can be. The foreseeable uses or misuses of these vehicles is leading to serious injuries and fatalities. It is also reasonably foreseeable that quad bikes would also be operated by a range of operators, with differing:

- levels of training
- levels of experience
- abilities to actively ride
- anthropometry (height, weight, etc.).

These differing characteristics of operators should also be considered at the design stage.

The ACCC has considered reasonably foreseeable use in determining the recommendations likely to prevent or reduce the risk of injury in this Final Recommendation. The purpose of the recommendations are to reduce the frequency of general-use model quad bike incidents and to protect the operator when an incident does occur.

Manufacturers should also provide information to consumers on the safety features of the consumer product. This may include labelling or advertising that provides information about the product use, including safety hazards.[24] The ACCC has also considered safety information that should be provided to consumers in its recommendation.

The approach of a product safety focus at the design stage is consistent with application of the Hierarchy of Control Measures under the Work Health and Safety laws and regulations (figure 4). [25] Under the hierarchy, where possible, the highest level of control approaches should be used, and in practice, a combination of approaches may work best. The ACCC's recommendation involves a combination of engineering and administrative controls.

Considering safety by design, the Australian Work Health and Safety Strategy 2012–22, includes Healthy and safe by design as one of the Action Areas.[26] Additionally, the Safe Systems Approach to Road Safety[27] implies that the design of vehicles should be such that the consequence of minor errors and lapses of attention is not a fatality or serious injury, and this is equally applicable to quad bikes.

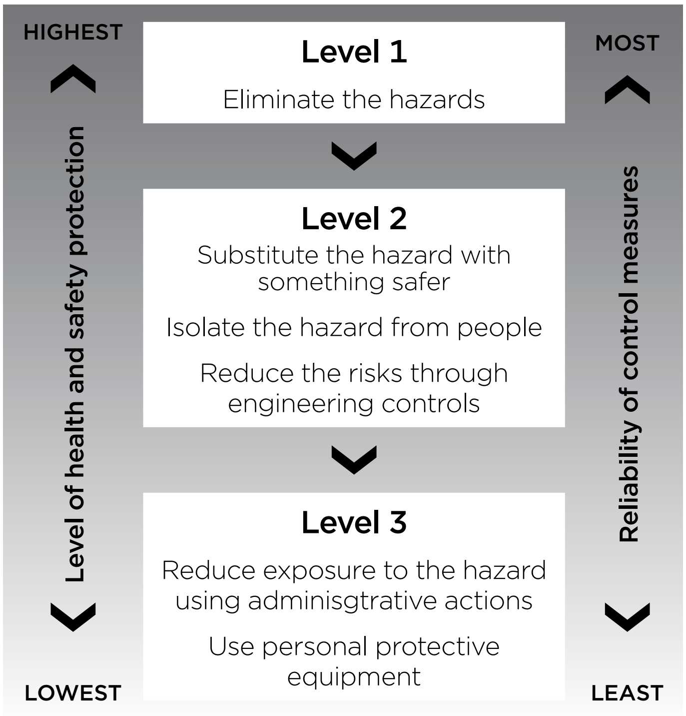
24 Safe Work Australia, *Model Code of Practice: How to manage work health and safety risks,* Safe Work Australia, December 2011, viewed 24 January 2018, https://www.safeworkaustralia.gov.au/doc/model-code-practice-how-manage-work-health-and-safety-risks.

25 Ibid.

26 Australian Work Health and Safety Strategy 2012–22. Viewed 20 August 2018, https://www.safeworkaustralia.gov.au/doc/australian-work-health-and-safety-strategy-2012-22.

27 National Road Safety Strategy, 1 November 2017, viewed 29 January 2018, http://roadsafety.gov.au/nrss/safe-system.aspx.

Figure 4: The Hierarchy of Control Measures



7. Why is government action needed?

Key points

- On average, in Australia quad bikes are associated with 16 fatalities per year and 6 emergency department presentations per day, of which 2 people are being hospitalised for serious injuries.
- Quad bikes are not regulated and are not required to meet minimum design standards prior to supply in Australia.
- General-use model quad bikes are not safe for reasonably foreseeably uses or misuses.
- Without government action, deaths and injuries attributable to quad bikes are likely to continue to cost the Australian economy over $200 million per year..

7.1 What is the problem the government is trying to solve?

Overview

Quad bikes and SSVs are popular vehicles in the Australian forestry and agricultural industries, used frequently for mustering, weed spraying and checking livestock and fences. These vehicles are also used for recreational and sporting activities and by small business, for example, in guided tour operations.

Both vehicles can flip or roll over if the operator loses control. However, quad bikes present a greater risk to the operator where the vehicle flips or rolls over, as they do not have the same level of occupant protection found on SSVs, such as ROPS and seat belts.

The ACCC has compiled data from multiple sources across different date ranges to build a comprehensive analysis of fatal and injurious quad bike incidents.

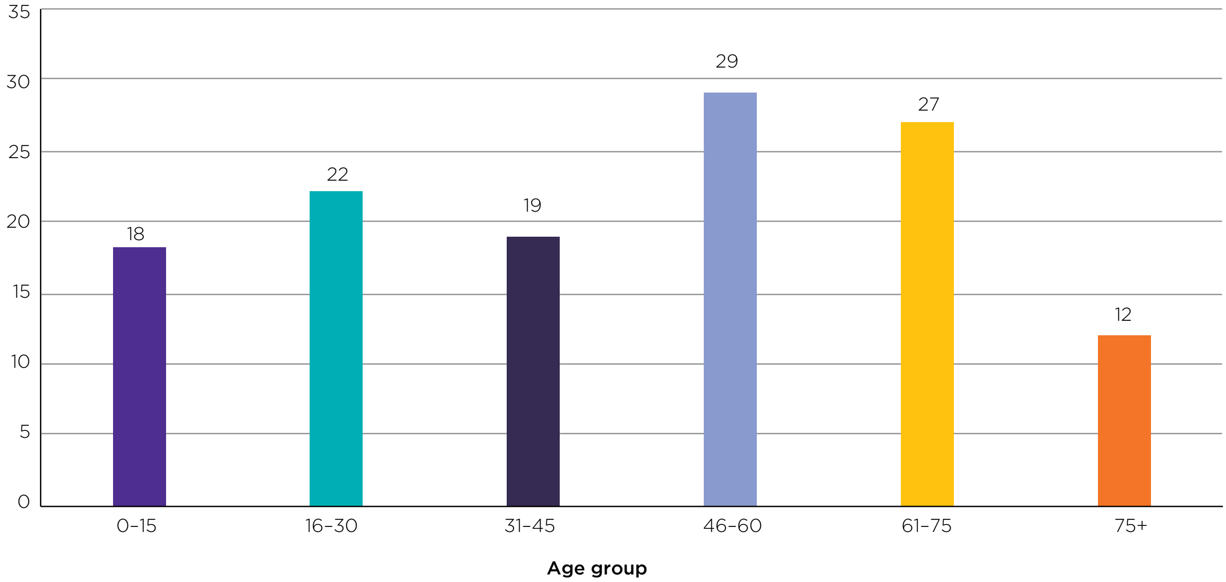
Data from multiple sources indicates quad bikes and tractors are associated with the highest number of on-farm fatalities, and are second only to motorbikes for causing the most on-farm injuries. Motorbikes are subject to Australian Design Rules under the *Motor Vehicle Standards Act 1989* and under the Occupational Health and Safety Regulations 2017, an employer must ensure that a tractor is not used unless it is fitted with roll-over protection. However, quad bikes are not regulated and are not required to meet minimum safety or design standards prior to supply in Australia.

Over the period 2011–18, there were 126 recorded fatalities associated with quad bike incidents in Australia.[28] This is an average of 16 fatalities per year.

Figure 5 shows the age group of each fatality over the 2011–18 period. The age group most represented is 46–60 years (29 fatalities) and 18 of the fatalities were of children below the age of 16 years, with the majority of these involving children on adult-sized quad bikes.

28 Safe Work Australia 2018, *Quad bike fatality data,* Australian Government, viewed January 2019, safeworkaustralia.gov.au/quad-bike-fatality-data#2001.

Figure 5: Australian fatalities by age group, 2011–18



Source: Safe Work Australia Quad bike fatality data.

Over the same period (2011–18), 13 fatalities in Australia were associated with SSVs, with five of these fatalities involving children below the age of 16 years. Records indicate that the deceased were not wearing seat belts in the majority of fatal incidents involving SSVs.

An estimated six Australians present to a hospital emergency department (ED) every day with injuries arising from quad bike incidents, and approximately one third (two people per day) are admitted to hospital for more serious injuries attributable to these vehicles.[29]

The 2011–18 data on quad bike fatalities and the analysis conducted by the University of New South Wales Transport and Road Safety Quad Bike Performance Project (UNSW TARS project) indicates that the highest risk to quad bike operators in the workplace is general-use model quad bikes laterally rolling (rolling to the left or right) and pinning the operator beneath the vehicle, causing crush injuries and/or asphyxiation. The highest risk for recreational users is collision incidents that cause head injuries. Rollovers that lead to crush injuries and asphyxiation do occur in incidents involving recreational users, although at a lower rate than is the case for workplace users.

The analysis below is derived from the best data available to the ACCC. More comprehensive data collection of quad bike fatalities and injuries would considerably inform quad bike incident analysis and understanding. The ACCC understands the Queensland University of Technology is conducting a prospective data collection analysis through phone interviews with patients who presented to hospitals across Queensland and Northern Territory with quad bike injuries.

Quad bike fatality trends

In the past three years (2016–18), there has been a reduction in fatalities attributed to quad bikes. Information provided to the ACCC indicates this reduction is not due to an increased level of safety offered by quad bike models. A New Zealand rural insurer, FMG, reports that over the past five years:

> *Quads that are two years old or newer at the time of the incident account for half of all rollover claims, despite accounting for only a quarter of the quads insured.*[30]

29 Based on estimates set out at Section 11 of this Decision Regulation Impact Statement.

30 FMG, *Quad bike advice worth listening to, Quad Bike Safety Advice Guide,* accessed 30 January 2019, available: fmg.co.nz/globalassets/advice/quad-bikes-risk-advice-guide.pdf.

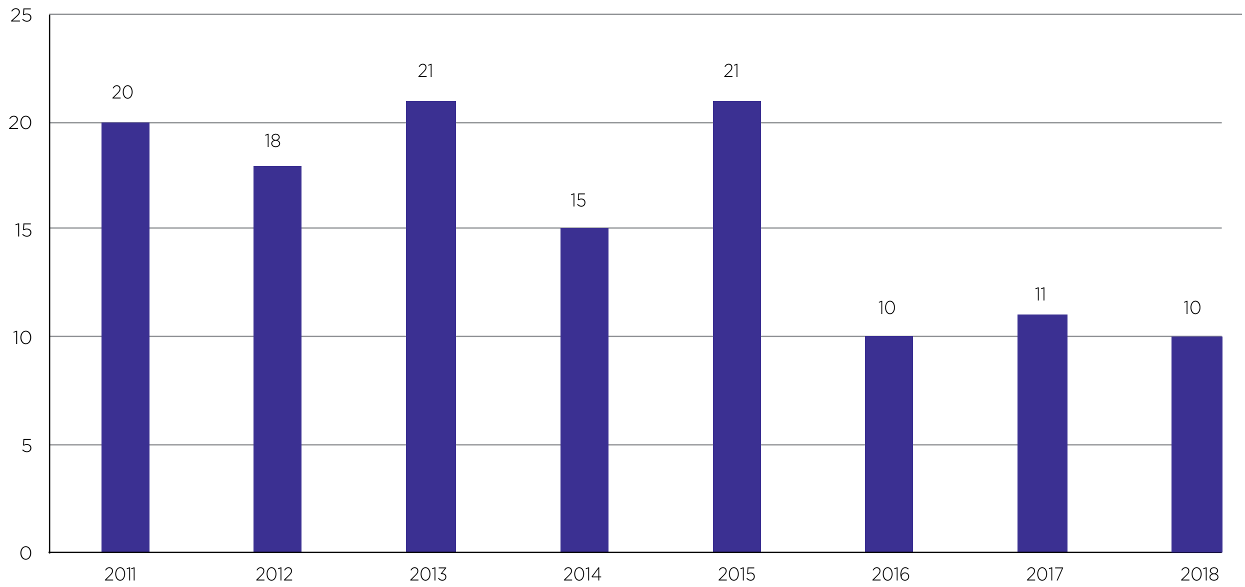
The New Zealand and Australian markets offer substantially similar quad bike models. Instead, the reduction in Australian fatalities over the last three years is likely to be due to a combination of factors, including:

- increased training and awareness of quad bike safety amongst consumers
- an increase in the uptake of OPDs
- substitution by some quad bike operators to SSVs
- an increase in uptake of personal protective equipment, including helmets.

Many of the above factors are likely to be as a result of the increased safety campaigns and rebates offered by governments and industry players.

Quad bike fatalities and injuries may begin to increase without ongoing promotion of quad bike safety by these groups. Any mandatory quad bike safety standard addressing design and engineering controls should be supported by quad bike safety training and awareness campaigns to continue reducing quad bike fatalities and injuries.

Figure 6: Australian fatalities by year, 2011–18



Source: Safe Work Australia Quad bike fatality data.

Fatalities and injuries on Australia farms

Among recreational and workplace quad bike operators, the most common location for a quad bike incident is on a farm or rural property.

Over the six years from 2010–15, there were 208 fatalities on farms involving vehicles, an average of 35 people each year. The majority of these fatalities were associated with quad bike and tractor use (table 2).

Over the periods 2010–11 and 2014–15, data arising from hospitalisations associated with incidents involving farm vehicles indicates motorcycles are associated with a significantly higher portion of hospitalisations than any other farm vehicle (table 3).

Tractors, motorcycles, utility vehicles and trucks are all regulated vehicles and are subject to Australian Standards and Australian Design Rules. However, quad bikes and SSVs are not subject to any minimum performance or design requirements in Australia.

Table 2: Fatalities on-farm due to vehicle accidents, 2010–15

	Number of fatalities	Age of deceased	
		Under 15 years	15 and above
Quad bike	73	13	60
Tractor	71	3	68
Motorcycle	23	5	18
Utility	22	1	21
Truck	10	0	10
Side-by-side	9	3	6
Total	**208**	**25**	**183**

Source: AgHealth Australia.

Table 3: Hospitalisations due to injuries associated with the use of vehicles on farms 2010–11 to 2014–15

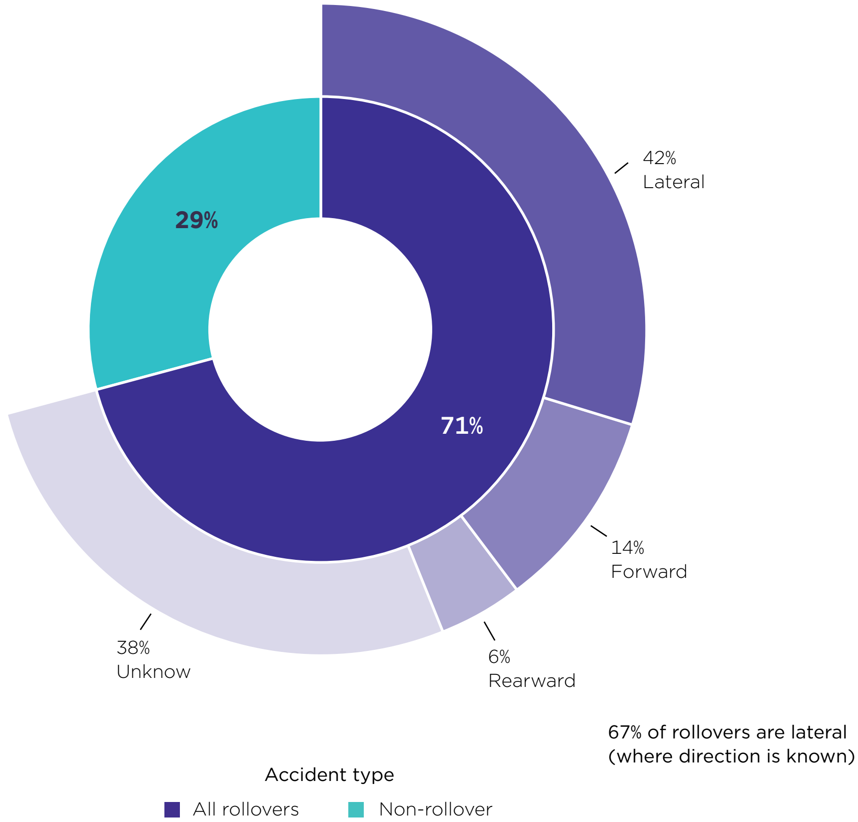
Type of vehicle	Number of injuries
Motorcycle	3894
Quad bike or SSV	1144
Utilities and trucks	75
Total	**5113**

Source: Australian Institute of Health and Welfare.

Quad bike fatalities

The highest cause of fatalities from quad bike incidents from 2011–18 was from rollovers (table 4). Rollovers predominantly involved the quad bike rolling laterally and pinning the operator beneath the vehicle resulting in asphyxiation and/or crush injuries (table 5). Excluding instances where the direction is unknown, lateral rollovers are responsible for 67 per cent of rollover fatalities (figure 7).

Figure 7: Breakdown of rollover incidents by rollover direction, 2010–12



Source: Safe Work Australia quad bike fatality data.

Table 4: Cause of death 2011–18

Total fatalities (126)	Cause of death		
	Rollover	Collision	Unknown
Number	76	37	13
Percentage	60%	29.5%	10.5%

Source: Safe Work Australia quad bike fatality data.

Table 5: Breakdown of rollover incidents 2000–12

Total fatalities (109)	All fatalities		Quad bike roll direction			
	Non-rollover fatalities	All rollovers	Lateral	Forward	Rearward	Unknown direction
Number	32	77	32	11	5	29
Percentage	29%	71%	41%	14%	6%	38%

Source: UNSW TARS Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries.

Statistics from 2000–12 indicate that most fatalities occur on farms while using general-use model quad bikes (table 6).

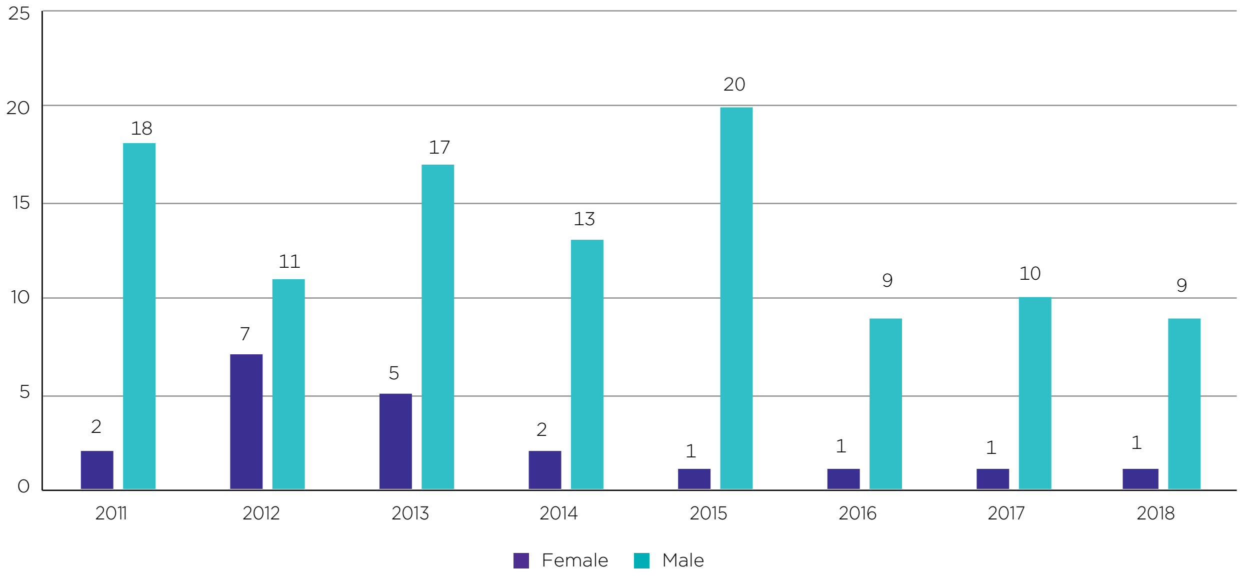
Table 6: Breakdown of location and quad bike vehicle types 2000–12

Total fatalities (109 location, 72 vehicles type recorded)	Location		Quad bike type		
	Farm	Other	General-use model	Sports	Youth
Number	82	27	57	11	4
Percentage	75%	25%	79%	15%	6%

Source: UNSW TARS Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries, Attachment C.

A high proportion of the persons killed in quad bike accidents were males (figure 8). While 95 per cent of those killed were quad bike operators, a number of these fatalities involved the presence of passengers on the vehicle who survived the incident (table 7).

Figure 8: Australian fatalities by year and sex, 2011–18



Source: Safe Work Australia quad bike fatality data.

Table 7: Breakdown of quad bike fatalities by sex and position on quad bike 2011–18

Total fatalities (126)	Sex		Operator/Passenger		
	Male	Female	Operator	Passenger	Unknown
Number	106	20	119	8	1
Percentage	84%	16%	94%	6%	0%

Source: Safe Work Australia Quad bike fatality data.

Fatalities frequently involved adults aged 46 years and above (table 8) operating quad bikes predominantly off-road (table 9). Children are overrepresented in the fatality statistics given the likely lower proportion of children in the quad bike riding population.

According to the Australian Bureau of Statistics, 23 per cent of all farmers were aged 65 years or over in 2011.[31] This age group is slightly over-represented in quad bike fatality statistics (28 per cent).

31 Australian Bureau of Statistics, *Australian farming and farmers*, Australian Bureau of Statistics, accessed 29 August 2018, available: abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features10Dec+2012#AN%20AGEING.

Table 8: Breakdown of incidents by age group 2011–18

Total fatalities (126)	Age of deceased					
	0–15	16–30	31–45	46–60	61–75	76+
Number	18	22	19	29	27	12
Percentage	14%	17%	15%	23%	21%	10%

Source: Safe Work Australia Quad bike fatality data.

Table 9: Breakdown of terrain, where recorded, in quad bike fatalities 2011–18

Total fatalities (126)	Terrain						
	Dirt	Gravel/ Rocky	Uneven/ Ditch	Paved/ Road	Sand/ Muddy	Grass	Unknown
Number	30	20	14	12	7	5	38
Percentage	37%	22%	17%	10%	7%	6%	

Source: Safe Work Australia Quad bike fatality data.

Detailed information about quad bike incidents is often unavailable because many incidents occur in remote areas and without witnesses. However, the information available indicates that in 39 percent of fatalities, the quad bike was being used to navigate an incline.

Child fatalities

Approximately 14 per cent of all recorded quad bike fatalities between 2011–18 were children below the age of 16 years. These fatalities most frequently involved a child using an adult sized quad bike and experiencing a rollover incident. Approximately one third of the child fatalities were passengers.

Table 10: Breakdown of children (under the age of 16) fatalities 2011–18

Child fatalities (18)	Operator/Passenger		Quad bike type			Cause of death		
	Operator	Passenger	Adult	Youth[32]	Unspecified	Rollover	Collision	Unknown
Number	12	6	12	1	5	16	1	1
Percentage	66.5%	33.5%	66.5%	5.5%	28%	89%	5.5%	5.5%

Source: Safe Work Australia Quad bike fatality data.

SSV fatalities

During 2011–18, 13 fatalities were attributed to SSVs. These fatalities most frequently involved a rollover incident, where the occupant (driver or passenger) was not wearing a seatbelt. Five of the fatalities were children aged eleven or under, and when compared with quad bike fatalities, a smaller proportion of people (18 per cent) were aged over 46 years old.

32 The Safe Work Australia website reports two deaths attributable to youth quad bikes. Under the definitions in the US Standard, one of the recorded vehicles is defined as an adult quad bike.

Table 11: Breakdown of SSV fatalities 2011–18

Total fatalities (13)	Child/Adult		Sex		Location	
	Child (under 16)	Adult	Male	Female	Farm or other rural property	Not farm or other rural property
Number	5	8	9	4	11	2
Percentage	38%	62%	69%	31%	85%	15%

Source: AgHealth Australia.

Table 12: Further breakdown of SSV fatalities 2011–18

Total fatalities (13)	Cause of death (where known)		Seatbelt worn (where known)		Driver or passenger (where known)	
	Rollover	Not rollover	Worn	Not worn	Driver	Passenger
Number	9	2	1	8	9	3
Percentage	82%	18%	11%	89%	75%	25%

Source: AgHealth Australia.

Injuries

There is no single national source of injuries involving quad bikes and reports on injuries often do not differentiate between quad bikes and SSVs.

The Centre for Automotive Safety Research at the University of Adelaide examined Australian hospitalisation data for incidents involving quad bikes and SSVs over the period 1 July 2002 to 30 June 2013.[33] Discounting incidents that are unlikely to have involved the use of a quad bike or SSV, a total of 7194 hospitalisations occurred over the 11 year period (average of 654 per year or nearly two people per day).

The number of ED presentations associated with quad bike and SSV injuries has been extrapolated from New South Wales[34] and Queensland[35] data, resulting in an estimated 2100–2500 ED presentations per year in Australia (average of six people per day).

In Queensland, the most common cause of injury resulting in ED presentations were falling from the vehicle (over 40 per cent), with approximately half of hospitalisations due to fractures. Rollovers accounted for close to 18 per cent of ED presentations and almost 35 per cent of ambulance attendances.[36]

Some of these injuries result in a permanent disability. The majority of quad bike permanent disabilities involve traumatic brain injuries, followed by a smaller number of spinal cord injuries.[37, 38]

33 Wundersitz LN, Doecke SD, Raftery SJ, Harrison J, *Quad bikes in South Australia. An investigation of their use, crash characteristics and associated injury risks,* Centre for Automotive Safety Research, University of Adelaide, 2016, for SafeWork SA, viewed January 2018, casr.adelaide.edu.au/publications/list/?id=1605.

34 Grzebieta R, Rechnitzer G, McIntosh A, Mitchell R, Patton D, Simmons K, University of New South Wales Transport and Road Safety Research Unit, *Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries,* provided to WorkCover Authority of New South Wales January 2015, Attachment 2.

35 Vallmurr K, Watson A, Catchpoole J, Centre for Accident Research and Road Safety—Queensland, *Quad bike-related injuries in Queensland: Final Report,* August 2017, viewed 19 February 2018, worksafe.qld.gov.au/__data/assets/pdf_file/0020/152219/carssq-quad-bike-research-final-report.PDF.

36 Ibid.

37 This includes injuries reported as being to 'neck', 'head and neck, other', 'spinal cord', 'vertebral column' and 'thorax'.

38 Vallmurr K, Watson A, Catchpoole J, Centre for Accident Research and Road Safety—Queensland, *Quad bike-related injuries in Queensland: Final Report,* August 2017, viewed 19 February 2018, worksafe.qld.gov.au/__data/assets/pdf_file/0020/152219/carssq-quad-bike-research-final-report.PDF.

It is difficult to measure the physical, emotional and social harm caused by fatalities and injuries. However, the cost is likely to be substantial, impacting the injured party and families, friends, workplaces and the wider Australian community.

7.2 Are quad bike fatalities just an Australian problem?

Quad bike fatalities are a problem in many countries, not just in Australia. For Australia, the US and New Zealand, the average number of fatalities per year for the period 2011–17 from incidents involving a quad bike is shown in table 13.

Table 13: Comparison of average number of quad bike fatalities per year in Australia, United States and New Zealand for the period 2011–17

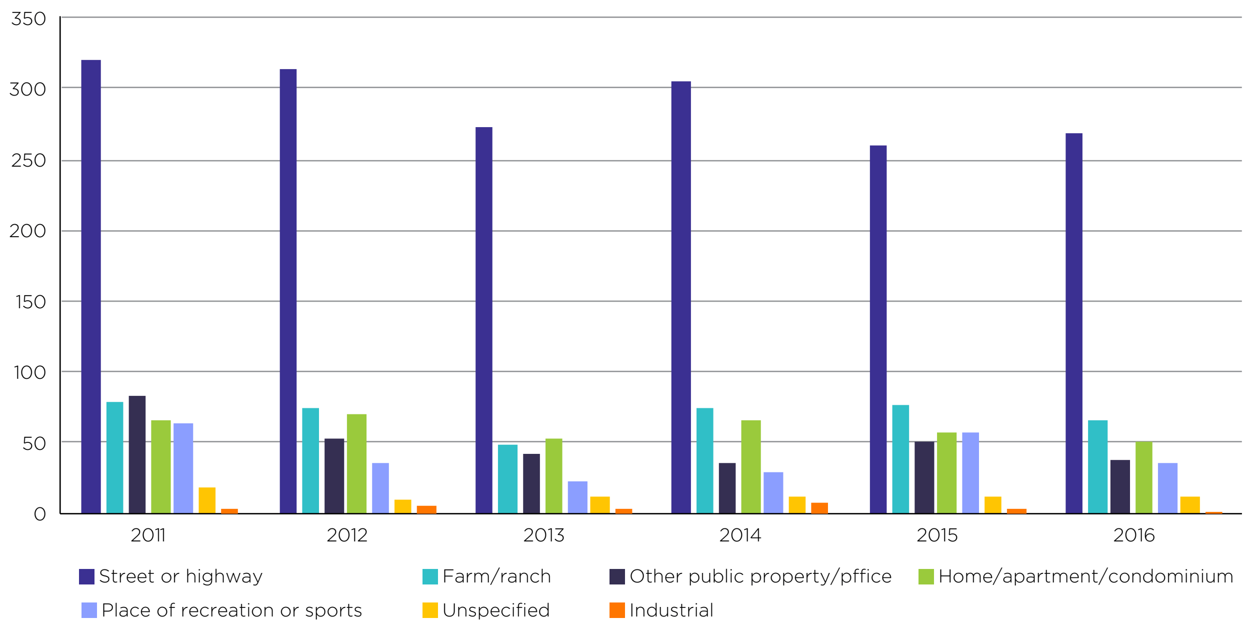
	Country and detail				
	Australia (total)	Australia (working)	New Zealand (workplace fatalities)	United States (total)	United States (farm/ranch)
Average number of fatalities per year	16	8	5	569	63

Source: Safe Work Australia fatality data, United States Consumer Product Safety Commission and WorkSafe New Zealand.

Comparison of fatalities in Australia and US for the period 2011–17

In the US, quad bikes are mostly used as recreational vehicles and a majority of quad bike-related fatalities (55 per cent) over the period from 2011–16 occurred on a street or highway.[39] The second most frequent location of US quad bike fatalities over the same period was on a farm or ranch. In contrast, in Australia the majority of fatalities occur on farms (above 80 per cent).[40]

Figure 9: Location of quad bike incidents, US, 2011–16



Source: United States Consumer Product Safety Commission.

39 Between 2011–16.
40 Based on data from fatalities between 2000–12.

There are a number of similarities between the statistics associated with quad bike fatalities on farms in Australia and on farms/ranches in the US. These include similarities in the percentage of fatalities involving:

- males (83 per cent in Australia and 86 per cent in the US)
- rollover incidents (59 per cent in Australia and 65 per cent in the US)
- victims not wearing helmets (84 per cent in Australia and 84 per cent in the US)
- the presence of a passenger (12 per cent in Australia and 10 per cent in the US).

In addition, the mean age of those killed in quad bike accidents on farms in Australia and the US (47 years and 48 years respectively) is essentially the same.

A higher percentage of fatalities in Australia occurred in incidents which occurred while driving on an incline, or towing an attachment than was the case for the US. However, the US data may not always identify whether the incident occurred on an incline or while towing an attachment.

Table 14: Comparison of statistics arising from quad bike fatalities in Australia and United States[41]

	Average		Percentage of fatalities involving:					
	Number of fatalities per year	Age	Males	Deceased not wearing a helmet*	A rollover	Carriage of a passenger	Driving on an incline	Towing
Australia (total)	16	47	83%	84%	59%	12%	41%	15%
United States (farm/ranch)	70	48	86%	84%	67%	10%	20%	3%
United States (total)	529	49	85%	77%	57%	18%	12%	4%

* Where records specify helmet worn or not worn.

Source: Safe Work Australia fatality data and United States Consumer Product Safety Commission.

The data indicates that the characteristics of Australian quad bike fatalities are not dissimilar to the characteristics of some other international markets.

7.3 Consumer purchasing decisions

Safety information provided

As quad bikes are 'experience goods', consumers cannot fully evaluate the safety of vehicles until after they have purchased and used them. There are currently no requirements for any information to be provided at the point of sale. Suppliers are also not voluntarily supplying comprehensive safety information, which exacerbates the design limitations by preventing consumers from making comparisons between models and making informed purchasing decisions.

The FCAI provides dealers and consumers with safety resources, including the FCAI Vehicle Selection Matrix, an online safety course, and an industry safety video. Safety advice is also provided in quad bike owner's manuals. However, none of this information helps to compare the relative safety of different quad bike models.

41 US data covers the period 2011–16, Australian data covers the period 2011–17.

Consideration of safety in purchasing decisions

Ninety three per cent of respondents to the NSW farm survey on quad bikes and 43 per cent of recreational riders surveyed agreed that quad bikes can be dangerous.[42, 43]

While these survey results indicate the majority of consumers consider quad bikes to be dangerous, during consultations many quad bike retailers and distributors reported that safety features do not sell vehicles. When asked why there was an increase in SSV sales, retailers and distributors commonly attributed the increase in SSV sales to their larger towing capacity, sun and wind protection and ease of operation.

Retailers also submitted that when approached by consumers concerned about safety, they recommend a SSV. A number of suppliers also submitted to the ACCC that SSVs were designed as an alternative to quad bikes for consumers with safety concerns or physical limitations.

7.4 How consumers use quad bikes

Farmers use quad bikes for a wide range of different activities. These include:

- checking and mustering livestock
- checking fences, crops and pastures, especially in less accessible areas
- spraying and fertilising orchards, crops and pastures, and spot-spraying weeds and burrs
- checking and adjusting irrigation equipment, pumps, windmills and water troughs
- moving personnel, equipment and dogs quickly and efficiently around farms.

Recreational users ride quad bikes predominantly in off-road locations to access areas such as national parks or state forests, and for transport associated with hunting and fishing activities. Other recreational uses include guided tours of beaches and natural attractions, and trail riding. Some quad bikes are also used in competitive events, which involve racing or navigating obstacle courses.

Consumers' attitude to safety

Consumers (including quad bike operators), make subjective judgments about the likelihood of a negative occurrence, such as an injury or fatality. These subjective judgments are called 'risk perception', which is important in health and risk communication as it determines which hazards people care about, and how they deal with them.[44] One area of research on risk perception distinguishes between the personal and societal levels of risk perception.[45] This distinction helps to explain the impact the risk has on the individual and their subsequent behaviour.[46] To use quad bikes as an example, if a quad bike operator thinks a quad bike injury is more likely to affect other people (societal), they may not take any proactive action to reduce the risk. Conversely, if the operator considers an injury likely to happen to them personally (personal), they make take direct action to reduce the risk of injury, for example, wear a helmet or install an OPD.

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42 Instinct and Reason, New South Wales quad bike safety improvement program: Survey results for mid-point evaluation, August 2017, prepared for SafeWork NSW, p. 21, available at: safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

43 Colmar Brunton, *Recreational Quad Bike Usage*, submitted to ACCC 26 March 2013, p. 29, available at: productsafety.gov.au/system/files/Quad%20bikes%20-%20Consumer%20research%20report%20- %20March%202013.pdf.

44 Paek, H and Hove, T, 'Risk Perceptions and Risk Characteristics' *Oxford Research Encyclopedia of Communication,* March 2017, p. 1, available: oxfordre.com/communication/view/10.1093/acrefore/9780190228613.001.0001/acrefore-9780190228613-e-283?print=pdf.

45 Ibid, p. 13.

46 Ibid.

As part of the NSW farm survey, the consultants analysed the values and behaviours of different respondents and categorised them into four segments based on their quad bike behaviour and attitudes towards work, health and safety. They found a relatively even split across the four segments:

- 23 per cent of the respondents were categorised as 'libertines', who are not consciously concerned about the safety of their quad bikes, have a strong perception of their riding ability and an underestimation of the inherent risks of operating quad bikes
- 22 per cent of respondents were categorised as 'responsible' and consider accidents to be the result of their own personal carelessness or abilities, and think quad bikes are safe within limits
- 28 per cent of respondents were categorised as 'safety driven' and were safety conscious, recognise that they can make mistakes, and apply safe practices for both business and personal reasons
- 28 per cent of the respondents were categorised as 'fatalists', believing accidents were simply a part of the nature of farm work, and that if they had not been injured in the past they were unlikely to get injured at all.

This information demonstrates the variety of risk perceptions consumers hold and strengthens the argument for engineering controls, which increase the safety of quad bikes, regardless of the personal views, attitudes or mental and physical capacity of the operator.

Multitasking

The University of New South Wales Transport and Accident Studies Workplace Safety Survey (workplace survey) found only 9.8 per cent of all incidents occurred while the operator was concentrating exclusively on operating the quad bike.[47] Over 57 per cent of quad bike incidents (including those that did not result in injury) occurred while mustering.[48]

The workplace survey also found over 40 per cent of all incidents involved the operator splitting their attention between the work task and operating the vehicle, and in almost half of incidents the operator was concentrating exclusively on the work task (not on vehicle operation). See Section 10.4 for more analysis on this survey.

According to staff at the US CPSC:

> *'…(quad bikes) unique and complex handling characteristics require a relatively high degree of skill as well as constant attentiveness to operate.'* [49]

The above information indicates quad bike operators often share their attention between the operation of the vehicle and another task (for example, checking crops or mustering) and are unlikely to be able to operate quad bikes with constant attentiveness at all times. However, without constant attentiveness, there is a higher risk of an incident occurring. Product safety best practice and the Hierarchy of Controls Measures dictate that given quad bikes are frequently used with the operator's attention shared between the operation of the vehicle and another task, the design of the vehicle should be such that it mitigates the risks associated with the use of the vehicle in this foreseeable way.

Operators' varied skills and experience

Some operators have years of experience riding quad bikes and others may have very rarely ridden a quad bike. Contrary to what might be anticipated, the workplace survey indicated that many accidents (where injuries were or were not sustained) involved operators who report having 20 or more years of experience operating quad bikes (46.7 per cent).[50] Less than 2 per cent of incidents (where injuries were or were not sustained) involved an operator with less than three years' experience riding quad bikes.

47 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017, p. 145.

48 Ibid.

49 United States Consumer Product Safety Commission *CPSC Staff Response Regarding Follow-Up Questions from Commissioner Nancy Nord after the June 15, 2006 ATV Safety Review Briefing,* Memorandum of the United State Consumer Product Safety Commission, 30 June 2006, p. 2, available: cpsc.gov/PageFiles/88056/atvnord.pdf.

50 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017, p. 144.

Reinforcing this, the Queensland coronial inquest, found that a common thread in all of the nine fatalities examined was that the riders (including the young children) were all considered experienced quad bike operators by those closest to them.[51]

These statistics are perhaps not surprising given increased exposure to risks increases the statistical likelihood of an incident occurring. The statistics also align with anecdotal comments from experienced riders who comment that quad bike accidents often arise from a simple, isolated operator error (for example failing to see a rock or bump), that has major consequences due to the inherent instability of quad bikes.

Reliance on active riding for safe operation

Active riding involves the rider actively shifting their body position on the quad bike to increase stability and rollover resistance as well as mobility, visibility and other performance attributes.[52]

Throughout consultation, manufacturers have emphasised that active riding changes the dynamics, stability and handling of quad bikes. However, a third of workplace riders in the NSW farm survey were found to not understand what is meant by active riding techniques[53] and more than three quarters of recreational riders responded 'no' when asked if they had heard of active riding.[54]

In work commissioned by the US CPSC, SEA Ltd examined the effects of active riding on quad bike vehicle characteristics, finding the effect reduced as quad bike weight increased.[55] As quad bikes are relatively heavy vehicles compared to the weight of the riders (general-use model quad bikes often weigh in excess of 300 kg), there are clear limitations for even those quad bike riders who may have the ability to actively ride. This was reflected in the workplace survey, which reported that 41.8 per cent of all Australian incidents occurred while the operator was actively riding.[56]

Authors of the UNSW TARS Project do not accept active riding as an effective and reliable risk control measure.[57] A Queensland coronial inquest into nine quad bike related fatalities also expressed concerns about promoting active riding as a safety strategy. According to the inquest, active riding should not be held out as the answer to stability issues and children and those disproportionately represented in fatalities (riders with strength and/or mobility issues) would be unlikely to be able to employ active riding skills.[58]

From the information available, the ACCC considers active riding is unable to compensate for general-use model quad bike design limitations. This is because:

- it relies on the operator being able to understand when to actively ride; if a bump or terrain change surprises the operator they may not be able to quickly compensate by active riding
- the effect of active riding is determined in part by the quad bike/consumer's weight, so active riding may not be an effective safety strategy for some lighter consumers (lighter operators will be

51 Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, p. 14, available at: courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

52 Grzebieta R, et al., University of New South Wales Transport and Road Safety Research Unit, *'Final Summary Project Report: Test Results, Conclusions, and Recommendations'*, Quad Bike Performance Project TARS Research Report No. 4, submitted to the WorkCover Authority of New South Wales, University of New South Wales, 2015, p. 35.

53 Instinct and Reason, New South Wales quad bike safety improvement program: Survey results for mid-point evaluation, August 2017, prepared for SafeWork NSW, p. 27, available at: safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

54 Colmar Brunton, Recreational Quad Bike Usage, submitted to ACCC 26 March 2013, p. 34, available at: productsafety.gov.au/system/files/Quad%20bikes%20-%20Consumer%20research%20report%20- %20March%202013.pdf.

55 United States Consumer Product Safety Commission, *Effects on ATV Vehicle Characteristics of Rider Active Weight Shift: Results from Tests on Twelve 2014–15 Model Year Vehicles,* SEA Ltd, provided to the United States Consumer Product Safety Commission, December 2017.

56 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017, p. 146.

57 Grzebieta R, et al., University of New South Wales Transport and Road Safety Research Unit, *'Final Summary Project Report: Test Results, Conclusions, and Recommendations'*, Quad Bike Performance Project TARS Research Report No. 4, submitted to the WorkCover Authority of New South Wales, University of New South Wales, 2015, p. 12.

58 Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, pp. 77–79, available at: courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

less able to move the centre of gravity of the quad bike), and for all consumers operating heavier quad bikes

- it assumes operators are willing and able to actively ride at all times
- it is impacted by the operator's physical abilities and level of fatigue
- it may not be possible to actively ride at the same time as safely completing tasks that are within the foreseeable use of the product, such as mustering livestock[59].

Product safety best practice and the Hierarchy of Control Measures outline that pursuing engineering controls to increase the stability of the vehicle is preferable to administrative controls which, in the case of active riding, amount to relying on consumers to undertake difficult manoeuvres continuously.

Vehicle attachments

Work-related fatalities frequently involve incidents where objects were attached to the quad bike, as shown in table 15. A survey of recreational riders found 64 per cent rarely or never attached equipment (for example, trailers) to the quad bike when riding.[60]

Table 15: Presence of vehicle attachments, passengers and trailers on quad bikes involved in work-related fatalities 2000–12

Total fatalities (54)	Present on the quad bike						
	Front attachment	Rear attachment	Front & rear attachments	Rear attachment & trailer	Rear passenger	No attachment	Unknown
Number	3	13	7	1	1	15	14
Percentage	6%	24%	13%	2%	2%	28%	26%

Source: UNSW TARS, Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries, table 1–17.

Where known, a majority of work-related fatalities occurred when the vehicle was loaded. It is not known whether loads were less than the maximum recommendation in the vehicle specification, or whether they were appropriately attached. Objects loaded onto a quad bike or towed frequently feature in quad bike advertisements and are part of the marketed utility of quad bikes.

General-use model quad bikes are frequently used with loads, and the ability to carry loads is part of the marketed utility of these vehicles. Therefore, at the design stage, product safety best practice involves manufacturers considering and mitigating against reasonably foreseeable decisions and actions of consumers that may cause harm when using a loaded general-use model quad bike.

Terrain

Australia has diverse landscapes. The workplace survey found Australian quad bike incidents (including where injuries were or were not sustained) occurred on varied slopes, with 44.4 per cent occurring on relatively flat slope, 26 per cent occurring on a rolling or gentle slope, 25.7 per cent occurring on hilly or steep slope and 3.8 per cent unknown (figure 9).[61]

According to the workplace survey the majority of Australian incidents (38.6 per cent) (where injuries were or were not sustained) occurred on uneven or rough terrain, while around a quarter (25.3 per cent)

59 Over 57 per cent of quad bike incidents in the UNSW TARS workplace survey occurred while mustering (including incidents that did not result in injury).

60 Colmar Brunton, *Recreational Quad Bike Usage*, submitted to ACCC 26 March 2013, p. 19, available at: productsafety.gov.au/system/files/Quad%20bikes%20-%20Consumer%20research%20report%20- %20March%202013.pdf.

61 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017, p. 149 'slope'.

occurred on relatively smooth surfaces (figure 9).[62] Further, most Australian incidents (where injuries were or were not sustained) occurred on grass (73.5 per cent).[63]

This information is consistent with feedback the ACCC received throughout consultation that consumers are using quad bikes on varied terrain. The reference to quad bikes as 'all terrain vehicles' or 'ATVs' encapsulates the vehicle's marketing strategy as appropriate for varied terrains. At the design stage, product safety best practice involves manufacturers considering and mitigating against reasonably foreseeable decisions and actions of consumers that may cause harm when using a general-use model quad bike across varied terrains.

Table 16: Terrain associated with quad bike incidents (with or without an injury reported)

	Slope				Surface smoothness				
	Relatively flat	Rolling or gentle	Hilly or steep	Unknown	Relatively smooth	Isolated bumps	Uneven/ rough	Corrugated/ rough	Unknown
Number	290	170	168	25	165	199	252	36	1
Percentage	44%	26%	26%	4%	25%	31%	39%	6%	>1%

Source: UNSW TARS workplace survey.

7.5 Consumer demand for increased safety features

Consumers have demonstrated demand and a willingness to pay for increased quad bike safety characteristics through the introduction of after-market products such as wheel-spacers and OPDs. The development of the Polaris Ace, may also be seen as a response to consumer demand for quad bike features with increased safety. In its submission to the Issues Paper, Polaris Industries provides an overview of the Polaris Ace, including but not limited to:

> *'...the unique Polaris 'Ace' range: single-seat vehicles with the footprint of an ATV (quad bike) but the control mechanisms and protective structures of a Side-by-Side (SSV, UTV, ROV) vehicle.*
>
> *...The single seat Polaris 'Ace' variants of these ROPS-equipped vehicles are around the same price (or in some cases even less expensive) than many similarly powered non-ROPS-equipped ATVs (quad bikes).*
>
> *...Polaris has provided consumers the opportunity to reduce the extent of training required to safely use a vehicle that can meet their needs...'* [64]

The NSW farm survey referred to earlier included questions on attitudes towards safety features on quad bikes. Figure 10 shows the proportion of respondents who agreed with specific statements concerning quad bike safety. The majority of respondents wanted:

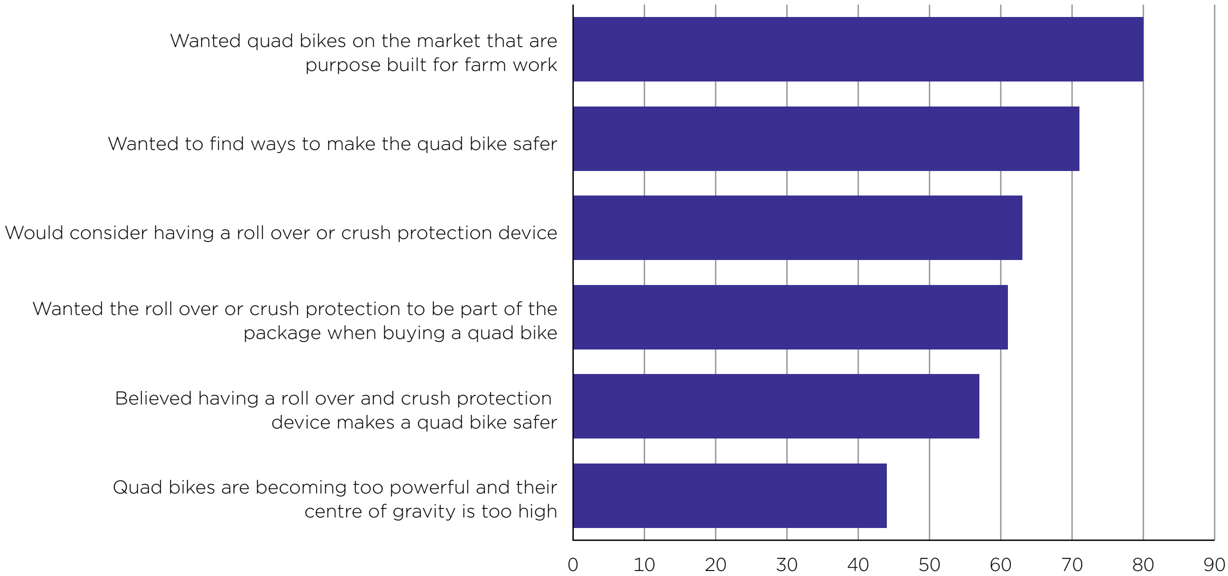
- quad bikes on the market that are purpose built for farm work
- to find ways to make the quad bike safer
- rollover or crush protection to be part of the package when buying a quad bike.

62 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017, p. 149 'slope', 'surface smoothness'.

63 Ibid, 'surface'.

64 Polaris Industries, submission to the Issues Paper.

Figure 10: NSW farmer attitudes towards increased quad bike safety features



Source: New South Wales quad bike safety improvement program.

Additionally, 44 per cent of respondents agreed quad bikes are becoming too powerful and the centre of gravity is too high.[65]

Consumers have demonstrated a willingness to pay for increased safety through purchasing aftermarket safety products, and regulation that increases the safety and price of quad bikes is unlikely to significantly reduce demand.

7.6 Does the government have the capacity to intervene successfully?

Quad bikes are not designed or manufactured in Australia. These vehicles are subject to the consumer guarantees legislated under the ACL, but otherwise, the supply of quad bikes in Australia is un-regulated. Specifically:

- there are no design standards that are required to be met prior to sale or importation
- the Australian Design Rules (ADRs) are national standards for vehicle safety, anti-theft and emissions. The ADRs are generally performance based and cover issues such as occupant protection, structures, lighting, noise, engine exhaust emissions, braking and a range of miscellaneous items. The ADRs are administered under the *Motor Vehicle Standards Act 1989* (the Act)*.* The Act requires all road vehicles, whether they are newly manufactured in Australia or are imported as new or second hand vehicles, to comply with the relevant ADRs at the time of manufacture and supply to the Australian market.[66] The *Motor Vehicle Standards (Road Vehicles) Determination 2017* determines that quad bikes are not 'road vehicles' for the purposes of the Act. This exemption means quad bikes cannot be subjected to vehicle standards under the Act and are not required to comply with the ADRs
- there are no uniform requirements for the registration of quad bikes in Australia under existing state and territory road transport rules
- there are no requirements for safety information to be displayed on the vehicles or supplied to consumers at the point of purchase.

65 Instinct and Reason, New South Wales quad bike safety improvement program: Survey results for mid-point evaluation, August 2017, prepared for SafeWork NSW, pp. 31–32, available at: safework.nsw.gov.au/__data/assets/pdf_file/0014/330017/2568_Quad_bike_mid_point_report.pdf.

66 Department of Infrastructure, Regional Development and Cities, *Australian Design Rules*, Department of Infrastructure, Regional Development and Cities, viewed 30 January 2019, infrastructure.gov.au/vehicles/design/.

At the request of the government, the ACCC conducted its investigation into quad bike safety to determine whether a mandatory safety standard for these vehicles should be made under the ACL.[67]

Under s. 104 of the ACL, a safety standard may impose certain requirements in relation to consumer goods of a particular kind that are reasonably necessary to prevent or reduce risk of injury to any person arising from the use of those consumer goods. A safety standard under the ACL can include requirements for:

- the performance, composition, contents, method of manufacture or processing, design, construction, finish or packaging of consumer goods
- the testing of consumer goods during or after the completion of manufacture or processing
- the form and content of markings, warnings or instructions to accompany consumer goods.

The responsible Minister also has powers under the ACL to ban products if satisfied they will, or may, cause injury.

These powers enable the responsible Minister to take actions across multiple levels of the Hierarchy of Control Measures; eliminate the hazard (ban), reduce the risk through engineering controls (introduce design or performance requirements) and reduce exposure to the hazard through administrative controls (markings, warnings or instructions). These powers are essential to increasing the safety of quad bike operators as they address inherent design limitations, rather than relying on consumer behaviour. This point is underscored by the Queensland Deputy State Coroner:

> *'The difficulty is that people will continue to ignore warnings about behaviour, even if mandated. Hence the need to continue to explore any possible engineering solutions to protect riders, even when they make bad choices and decisions.'*[68]

A safety standard made under the ACL for quad bikes cannot, among other things:

- impose user age restrictions
- mandate passenger restrictions
- mandate speed limits
- impose an obligation to wear personal protective equipment
- impose an obligation on users to receive training or a licence for the operation of these vehicles.

Other jurisdictions and agencies can pursue these requirements as complementary risk controls.

If a safety standard for quad bikes is made under the ACL, a person must not, in trade or commerce, supply, offer for supply, manufacture for supply, possess for supply, have control for supply or export quad bikes, that do not comply with the safety standard. Such conduct constitutes an offence and attracts civil penalties (see s. 194 and s. 224).

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67 The ACL is set out in Schedule 2 to the *Competition and Consumer Act 2010* (CCA) and is applied as a law of the Commonwealth (CCA Part XI) and as a law of the states and territories (through the enactment of legislation in each state or territory that applies the ACL as a law of its jurisdiction).'Consumer goods' are broadly defined in s. 2 of the ACL and includes quad bikes.

68 Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner at 160, available: courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

7.7 Government measures so far to address the problem

The Commonwealth and state and territory governments have implemented numerous initiatives to help improve quad bike safety, for example through educational campaigns to increase quad bike safety awareness, commissioning research, providing training for quad bike users and providing rebate schemes for users who purchase helmets, aftermarket OPDs or SSVs. Some measures to increase quad bike safety include:

- In 2012, the Australian Government (via Safe Work Australia) launched 'QuadWatch', a website dedicated to providing work health and safety information, relevant data and guidance about managing risk associated with quad bikes. It also sets out the existing initiatives in the jurisdictions and contact details for state and territory regulatory bodies. Safe Work Australia has also published guidance material for quad bike use, see for example the guidance on managing the risks of machinery in rural workplaces.
- In 2012, the Heads of Workplace Safety Authorities (HWSA) commissioned UNSW TARS to examine design solutions to improve the safety of quad bikes. Funding was provided by the WorkCover Authority of New South Wales and the work was also supported by HWSA and the ACCC. The final research results were released in August 2015.
- Since 2013, the ACCC has been promoting quad bike safety through a number of initiatives including a summer awareness campaign and the release of a YouTube video 'Quad bike safety—would you risk it?' This video highlights the risks to riders of not wearing adequate personal protective equipment, the dangers associated with children operating adult-sized quad bikes and the risks posed to riders attempting to navigate unsafe terrain.
- In 2013, the ACCC commissioned CARRS-Q to examine recreational quad bike related injury patterns and trends in Australia. In the same year, the ACCC also commissioned Colmar Brunton to undertake a survey on the behaviours and attitudes of Australian recreational quad bike users.
- In July 2016, SafeWork NSW introduced a quad bike safety improvement program that offers NSW farmers and small businesses rebates and training packages. Rebates are offered for the purchase of approved alternate vehicles (agricultural SSVs) or for fitting of an OPD (Quadbar or ATV Lifeguard) to existing quad bikes. Farmers and farm workers are also offered a rebate towards the purchase of compliant helmets and are provided free an eligible training course. In May 2018, NSW launched a communication campaign across regional NSW involving television, print, radio and social media to raise awareness of safety issues and the rebate scheme.
- WorkSafe Victoria introduced a quad bike safety rebate scheme in October 2016. Under the scheme, eligible farmers can apply for a rebate for the purchase of an alternate vehicle, e.g. SSV or small utility vehicle, which must be designed for use in agriculture and at point of sale have rollover protection and a fitted seatbelt or for fitment of an eligible OPD (currently, Quadbar or ATV Lifeguard) to existing quad bikes. Victoria has also launched a communication campaign across regional Victoria involving television, print, radio and social media to raise rebate awareness. WorkSafe Victoria also attends regional field days and engages directly with farming communities.
- SafeWork SA sponsored a study by the University of Adelaide's Centre for Automotive Safety Research in 2016: 'Quad bikes in South Australia: an investigation of their use, crash characteristics and associated injury risks'. The study examined the number and circumstances of fatal and non-fatal quad bike incidents in South Australia. Hospital admission data from the report has been used in this Final Recommendation to estimate the number of quad bike injuries.
- Workplace Health and Safety Queensland has a 'State-wide Plan for Improving Quad Bike Safety in Queensland 2016–19'. A major part of this plan is the 'Ride Ready' awareness campaign, which aims to raise awareness of the risks associated with the operation of quad bike and improve operator safety skills.
- In late 2016, a Tasmanian Inter-Departmental Taskforce was established to investigate methods for improving safety outcomes for quad bike users. In early 2017, the Taskforce released an Issues Paper for consultation: 'Quad Bike Safety in Tasmania'. The Issues Paper received 22 public submissions.

- WorkSafe Tasmania and the Department of Primary Industries, Parks, Water and the Environment (DPIPWE) run a joint initiative, the Safe Farming Tasmania Program, to provide training and educational resources to farmers including resources on the safe use of quad bikes. On 12 October 2017, a suite of worker induction materials, including videos and handbooks were released as part of the Safe Farming initiative.

7.8 Support for Commonwealth government action

In March 2017, following a succession of quad bike fatalities, the then Minister for Employment, the Hon. Michaelia Cash MP, brought together a range of agencies with an interest in quad bike safety, including the ACCC, in an IDC.

On 31 August 2017, the Australian Ministers for Consumer Affairs agreed to 'support all steps necessary to expedite the regulatory impact assessment process and any other safety measures necessary to introduce a consumer safety quad bike rating system and a safety standard'.[69]

On 24 October 2017, the then Minister for Small Business, the Hon. Michael McCormack and Minister for Employment, the Hon. Michaelia Cash MP jointly announced the ACCC led Taskforce would conduct an investigation to address quad bike safety as an urgent priority and the Taskforce would work with the IDC to examine solutions to improve quad bike safety, including whether to introduce a quad bike product safety standard.[70]

This recommendation delivers on those commitments made by the Australian Government.

Submissions to the Consultation RIS and Issues Paper also indicate there is wide public support for improving quad bike safety. Most submissions were strongly in favour of government action of some kind to reduce fatalities and injuries attributed to quad bikes. Of the submissions to the Consultation RIS that indicated a preference for one option over another, 88 per cent indicated a preference for a safety standard of some kind.[71]

7.9 Alternatives to Commonwealth government action

There are currently an average of 16 fatalities per year in Australia attributed to quad bikes. Since 2015, there have been three major coronial inquests into fatalities arising from the use of quad bikes and SSVs in Australia. In each of these, the coroners made a number of recommendations to increase quad bike safety and to date few of the recommendations have been implemented.

For example, recommendations made by the Queensland Coroner included the introduction of legislation prohibiting children under the age of eight from being carried as passengers on quad bikes and for all quad bike operators on private property to be required to wear safety helmets. While legislation was subsequently enacted banning children under the age of eight (not seven) being passengers and the mandatory use of safety helmets, this only applies on roads and road related areas, which is not where the majority of fatalities occur. See attachment B for a summary of the coronial recommendations.

Industry safety initiatives to date have focused on user controls, such as advocating the use of personal protective equipment, providing advice on fit-for-purpose use, promoting user training, and raising awareness of dangers of children riding adult quad bikes. Safety improvements developed by industry, such as active descent control, have been innovative, but have not kept pace with other vehicles' safety improvements or community expectations.

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69 Australian Consumer Law, Meeting of Ministers for Consumer Affairs 31 August 2017, viewed 8 March 2018, http://consumerlaw.gov.au/communiques/meeting-9-2/.

70 Senator the Hon. Michaela Cash, the Hon. Michael McCormack MP (2017). Joint Media Release. 24 October 2017. Viewed 8 March 2018, ministers.jobs.gov.au/cash/quad-bike-safety-taskforce.

71 This includes submissions that opposed all proposed changes except the implementation of the US Standard.

Information provided by manufacturers, distributors and retailers to quad bike consumers on the relative safety of the vehicles is limited and in some cases inconsistent, causing confusion. The ACCC is of the view there is an information asymmetry, preventing consumers from understanding the design limitations of quad bikes and comparing the relative safety of different models prior to purchase.

As reported in section 7.7 above, state and territory governments have safety programs in place. For example, the New South Wales and Victorian rebate schemes to reduce the price of SSVs, helmets and OPDs. Despite these initiatives, fatalities and injuries continue to occur at an unacceptably high rates.

No stakeholders have presented the ACCC with any alternative strategies that are able to be developed into an appropriate long-term solution that is capable of reducing the fatal and non-fatal injuries attributed to the operation of these vehicles. Consequently, the ACCC has concluded government action is appropriate.

7.10 The objective of Commonwealth government action

Government action may be justified where the market fails to provide the most efficient and effective solution to a problem. Across reasonably foreseeable uses and misuses, quad bikes are not safe and are reflective of a market failure.

A quad bike's design and production cost do not represent the design and cost corresponding to those of a safe vehicle. The design of quad bikes is deficient—their performance characteristics in certain reasonably foreseeable uses and misuses is inadequate. Were they to have been designed safely, their manufacture would have entailed higher costs, including research, design and production costs.

By manufacturing the bikes without adequate safety features, their production costs and market price have been lower. However, consumers value a safely designed vehicle, as demonstrated by a willingness to pay for a range of aftermarket products now available[72], which increase the total cost of the vehicle and subsequently improve its safety.

Compounding the problem is the information asymmetry in the market which prevents consumers from understanding the design limitations of quad bikes and comparing the relative safety of different models prior to purchase.

In addition to current quad bike safety initiatives, alternative strategies are needed to provide an appropriate long-term solution that is capable of reducing the fatalities and injuries attributed to the operation of quad bikes in Australia. The ACCC has concluded the Commonwealth government should intervene and introduce performance and information requirements to improve quad bike safety.

The objective of a safety standard made under the ACL is to prevent or reduce the risk of fatalities and injuries caused by a consumer good in Australia. The proposed quad bike safety standard requires manufacturers to improve the design of quad bikes and to reduce information asymmetries that hinder the choice of the most appropriate, fit-for-purpose quad bike.

7.11 Cost of no Commonwealth government action

It is likely the current rate of fatalities and injuries will remain if the Commonwealth government does not take action to address quad bike safety.

The estimated minimum economic cost of fatalities and injuries associated with the use of quad bikes is approximately $204 million per year.[73] This figure excludes intangible costs associated with fatalities and injuries, including but not limited to, the pain and suffering of family and friends, and the impact on emergency workers and affected communities.

72 For example, products that provide protection for operators or increase the stability of the vehicle.
73 See section 10 of this Final Recommendation.

8. International standards, approaches and initiatives

8.1 International standards and regulations

There are a number of international standards and regulations covering the design features of quad bikes, including those in:

- the United States (US)
- the European Union (EU)
- Israel.

United States

In 1987, the US Government commenced a series of legal actions against major quad bike manufacturers, contending that quad bikes constituted an 'imminent hazard' to consumers within the meaning of the US *Consumer Product Safety Act 1972.* In 1988, these actions were settled by negotiation in the form of consent decrees entered into between the United States Department of Justice and the representatives of the quad bike industry.

Pursuant to the consent decrees the quad bike industry agreed to:

- cease production and sale of new 3-wheeled quad bikes (but not to recall existing models already in the market)
- implement a free national rider-safety training program available to all quad bike purchasers and their families
- implement a major public awareness campaign on the operation of quad bikes
- implement age recommendations for operating quad bikes to prevent children from riding wrong sized quad bikes
- implement quad bike labelling and the provision of owner's manuals to consumers and other point of purchase materials to effectively inform consumers about the hazards of quad bike operation and the available safety options, and
- develop a voluntary standard to make quad bikes safer to operate.

The consent decrees expired in 1998, at which time the majority of quad bike manufacturers agreed to an All-Terrain Vehicle Action Plan, which included not marketing or selling 3-wheeled quad bikes, or adult-size quad bikes for use by children below the age of 16 years. Manufacturers also agreed to promote training and conduct safety education campaigns.

The Special Vehicle Institute of America (SVIA) through the American National Standards Institute, developed a voluntary quad bike standard, which was adopted as a mandatory quad bike standard into section 42 [15 U.S.C. §2089] of the *Consumer Product Safety Act 1972 in 2007*. It includes mandatory requirements for the design and construction, security, provision of information at point of sale and labelling of quad bikes in the United States. ANSI/SVIA issued a revised edition of its standard in June 2017 (the ANSI/SVIA 1–2017). The US CPSC has issued a final rule to amend the CPSC's mandatory quad bike standard to reference ANSI/SVIA 1–2017 and this rule became effective on 1 January 2019.[74]

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74 The United States Federal Register: The Daily Journal of the United States Government, *All-Terrain Vehicles: A Rule by the Consumer Product Safety Commission on 02/27/2018*, The United States National Archives and Records Administration, viewed 6 March 2018, https://www.federalregister.gov/documents/2018/02/27/2018-904/all-terrain-vehicles.

The US dominates the global quad bike market and most quad bikes are designed and manufactured to satisfy the US standard.

US transport laws vary between each state. In 2010, 'Sean's Law'[75] banned children under 14 from riding quad bikes in Massachusetts (unless supervised and involved in a racing event that had been approved by a municipal permitting authority). In addition, Massachusetts has mandated training for children 14–17 years old, required registration and helmets and restricted children to vehicles with engine displacements <30 cm^3. It also increased penalties for adults who allow children to ride quad bikes. After the passage of Sean's Law, it is reported emergency department discharges for off-road vehicle related injuries declined by 33 per cent in 0–9 year olds, declined by 50 per cent in 10–13 year olds and declined by 39 per cent in 14–17 year olds.[76]

The European Union (EU)

The European quad bike safety standard (CEN EN 15997:2011 *All-terrain vehicles (ATVs—Quads)—Safety requirements and test methods)* is based on the ANSI/SVIA 1-2010.

EU Regulation 168/2013 (EU Regulation) details requirements for the approval and market surveillance of two- or three-wheel vehicles and quadricycles.[77] The EU regulation applies to vehicles that are intended to travel on public roads. It does not apply to vehicles that are primarily intended for off-road use and designed to travel on unpaved surfaces. Annex VIII of the EU Regulation lists enhanced functional safety requirements. This includes (amongst other things) that L-category vehicles, which are defined to include quad bikes, have wheels that can rotate at different speeds at all times for safe cornering on hard-surfaced roads. It requires that if the vehicle is equipped with a lockable differential, it must be designed to be normally unlocked.

Israel

Israel has regulations that require quad bikes to be registered and riders to be licensed before the vehicle may be operated.[78] One of the conditions of registration is that an OPD must be installed on each vehicle.[79] The OPD is subject to a specific design standard that, among other things, mandates attachment mechanisms and materials, minimum dimensions and requirements for the frame to withstand loads without residual deformation.[80] Welding of the OPD may only be carried out by manufacturers licensed by the Ministry of Transport.[81]

75 General Laws, Part I (Administration of the Government) Title XIV (Public Ways and Works), Chapter 90B (Motorboats, Other Vessels and Recreational Vehicles), Section 26 (Prohibited or limited operation by underage persons; restrictions) (Commonwealth of Massachusetts, US).

76 Michael R. Flaherty, Toby Raybould, Cassandra M. Kelleher, Raghu Seethala, Jarone Lee, Haytham M.A. Kaafarani, Peter T. Masiakos 'Age Legislation and Off-Road Vehicle Injuries in Children' *Pediatrics,* Oct 2017, 140 (4) e20171164; DOI: 10.1542/peds.2017-64. Available at pediatrics.aappublications.org/content/pediatrics/140/4/e20171164.full.pdf.

77 Regulation (EU) No. 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles.

78 *Transport Regulations Amendments 2014* (Israel).

79 Ibid.

80 Manufacturing and Installation of Safety Frames for Quad Bikes Code—72, Specifications Document No.3876 (2005).

81 Ibid.

8.2 International approaches to quad bike safety

There are international approaches to managing quad bike safety in a number of jurisdictions (Canada, NZ, UK, US and others). Approaches vary and include:

- the ability to be lawfully used on public roads
- the ability to be regulated through transport laws
- registration requirements
- licensing requirements
- requirements depending on the intended use of the vehicle
- age restrictions for riders
- requirements for personal protective equipment.

International safety research and initiatives

There are a number of current international research activities and initiatives to improve quad bike safety, including:

- a joint strategy on quad bike safety in effect for the years 2014–20 in Sweden seeks to harmonise safety strategies undertaken across the country through improved cooperation between stakeholder groups
- a research team from the Public University of Navarra in Spain is currently developing an OPD known as 'Air-ROPS' for quad bikes, and
- a suite of research projects by SEA Ltd, commissioned by US CPSC examining quad bike characteristics and crashworthiness. Published reports include:
  - ATV Attribute Modification Study
  - Vehicle Characteristics Measurements of ATVs on Groomed Dirt
  - Effects on ATV Vehicle Characteristics of Rider Active Weight Shift
  - Effects on Vehicle Characteristics of Two Persons Riding ATVs
  - Autonomous rollovers of ATVs with instrumented vehicle and hybrid dummy and taken video footage from various angles for motion analysis
  - Developing an indoor roll simulator test device that will be used to evaluate occupant protection performance of ATVs in a rollover event. The US CPSC has indicated that they will likely test the Quadbar and ATV Lifeguard in 2019.

9. Who we consulted and what they said

Key points

- The ACCC received 119 written submissions from two formal consultations.
- Most submissions to the Consultation RIS that indicated a preference for an option preferred Option 5 (more than 54 per cent).
- A quarter of submissions preferred Option 2, however a large number of these submissions supported a safety star rating system *in principle*, but not the safety star rating system developed by UNSW TARS.

9.1 Consultation

Formal consultation

This safety investigation included a range of stakeholder engagement activities, including two formal rounds of public consultation. In addition, the ACCC conducted targeted consultation with key stakeholders throughout all stages of the investigation. Stakeholder feedback informed the development of this Final Recommendation.

On 13 November 2017, the ACCC published a paper requesting feedback on the key issues of relevance to the investigation. In response, the ACCC received 56 submissions from a wide range of interested parties, including farmers, medical and research organisations, technical experts, government agencies and industry representative groups.

On 22 March 2018, in line with best practice guidelines, the ACCC released a Consultation RIS for public comment for a six week consultation period. The Consultation RIS included five detailed policy options:

- **Option 1**: take no action at all (status quo)
- **Option 2**: make a mandatory safety standard in relation to quad bikes and SSVs that:
  - adopts the ANSI/SVIA 1–2017 US Standard for quad bikes
  - requires post manufacture testing for quad bikes and SSVs in accordance with the requirements of a safety star rating system and the disclosure of the star rating at the point of sale
  - requires an additional warning on quad bikes alerting the operator to the risk of rollover
- **Option 3**: make a mandatory safety standard that satisfies all of the requirements of option 2, and in addition requires general-use model quad bikes to be fitted with an operator protection device
- **Option 4**: make a mandatory safety standard that satisfies all the requirements of option 2, and in addition requires general-use model quad bikes to meet minimum performance tests for mechanical suspension, stability and dynamic handling. It also requires that all wheels be able to rotate at different speeds
- **Option 5**: make a mandatory safety standard that satisfies all of the requirements of Options 2, 3 and 4.

The Consultation RIS also contained a series of questions for consideration by stakeholders. A total of 63 submissions were received from a range of stakeholders.

All public submissions to the Issues Paper and Consultation RIS are available on the ACCC's Consultation Hub.

Stakeholder meetings and engagement

The ACCC conducted a number of meetings with key stakeholders throughout the safety investigation, including:

- National Farmers Federation (NFF)
- QB Industries
- Motor Trades Association of Australia
- Yamaha Motor Australia
- Bombardier Recreational Products/Can-AM/BRP
- Honda Australia
- Ag-Tech Industries
- Australian Council of Trade Unions
- Heavy Fix (NQ) Pty Ltd (quad bike accessories)
- Mojo Motorcycles
- Down Under Dirt Bikes
- Kawasaki
- Crossfire Motorcycles
- Polaris Industries
- John Deere
- Eco Charger Australasia
- Federal Chamber of Automotive Industries
- Australian New Car Assessment Program (ANCAP).

ACCC staff also attended:

- quad bike safety round table conducted by the IDC
- quad bike safety workshop conducted by the NSW Department of Primary Industries
- quad bike familiarisation day hosted by FCAI
- quad bike demonstration day hosted by Polaris Industries
- Safe Work Australia Members Meeting
- NSW Quad Bike Safety Industry Action Group meetings.

Engagement with government and experts

The ACCC engaged with a number of international and domestic government agencies and experts throughout the investigation, including:

- United States Consumer Product Safety Commission (US CPSC)
- Dr George Rechnitzer (UNSW TARS)
- Professor Raphael Grzebieta (UNSW TARS)
- Keith Simmons (KND Consulting)
- Frank Ford (Nexis Safety Solutions)
- Dr Andrew McIntosh (MacIntosh Consulting and Research)
- Dynamic Research Inc.
- SEA Ltd, Forensic Engineers and Consultants

- Adjunct and Emeritus Professor Rod Troutbeck
- Interdepartmental Committee on Quad Bike Safety (IDC)
- Technical Reference Group (TRG to the IDC).

9.2 Summary of stakeholder feedback

Overview

Most submissions to the Consultation RIS that indicated a preference for an option preferred Option 5 (54 per cent). A quarter of submissions preferred Option 2, however a large number of these submissions supported a safety star rating system in principle, but not the safety star rating system developed by UNSW TARS. All submissions were considered and the feedback provided was utilised to inform the development of the Final Recommendation.

Take no action to improve quad bike safety

The significant majority of submissions to the Consultation RIS indicated a preference for regulatory action to be taken to improve quad bike safety. Twelve per cent of submissions supported taking no action to improve quad bike safety under the ACL, and these submissions generally felt behavioural change and user control measures were required. Many who supported taking no action were also concerned with the potential impact the proposed options could have on their business and on quad bike costs.

Adoption of the ANSI/SVIA 1–2017 Standard for quad bikes

There was wide ranging support from stakeholders to adopt the current US standard for quad bikes, ANSI/SVIA 1–2017. However, the majority of stakeholders were of the view that the US standard is not sufficient as a stand-alone measure to improve quad bike safety.

Many stakeholders submitted that given the majority of quad bikes sold in Australia already comply with the US standard, its adoption as a mandatory requirement in Australia would be unlikely to reduce injuries and fatalities involving quad bikes.

All industry stakeholders that provided a submission to the Consultation RIS supported the adoption of the US standard. Many major manufacturers, including Honda, BRP and Polaris also provided support for adopting the US voluntary standard for side by side vehicles, ANSI/ROHVA 1–2016. A number of these submissions noted the adoption of the US standard would help to eliminate substandard vehicles from the Australian market.

Polaris and BRP also suggested an Australian mandatory standard should encompass both the US standard and its European variant, EN 15997.

Additional concerns raised by the WA Division of Mines, Industry Regulation and Safety Division in relation to the adoption of the standard included:

- adoption of the US standard may present a barrier to trade and may impact the market
- adoption of the US standard would not align with Australia's harmonised workplace health and safety laws, which have intentionally moved away from prescribing standards.

Safety star rating system

The concept of a safety star rating system for quad bikes was supported by the majority of stakeholders. The main benefit of the system highlighted through submissions was that a safety star rating system could better inform consumers about the relative safety of different vehicles at the point of sale.

The research, medical and legal sectors including: Consultative Council of Obstetric and Paediatric Mortality, Australian Injury Prevention Network, Royal Australian College of Surgeons (RACS), Queensland Trauma Committee, Queensland University of Technology (QUT), Jamieson Trauma Institute (JTI), Sydney Children's Hospital Network, Aghealth and Maurice Blackburn Lawyers were all strong supporters of a safety star rating system and suggested it should be implemented as soon as possible and managed by a stand-alone, independent body. They also suggested the UNSW TARS testing criteria was a good starting point and stated it could be reviewed and adjusted over time, similar to the ANCAP.

Many submissions also suggested additional details that could be included in a star rating system, such as seat designs that limited the carriage of passengers and child resistant start mechanisms.

The Technical Reference Group (TRG) submitted that a safety star rating system would be useful to inform consumers about relative safety of vehicles and drive continuous improvement and innovation within the industry. It was suggested that the system should be administered independently (not by manufacturers) and the structure should be flexible to allow testing criteria to evolve over time. Roy Deppa (the former Chief Engineer of All Terrain Vehicles for the US CPSC) stated that he was a strong advocate for sliding rating systems to inform consumers about safety, however expressed some concerns with the system proposed. Opinions were divided in relation to the inclusion of both SSVs and quad bikes within the same system.

> *'It is essential that the testing and the star rating system apply to quad bikes and SSVs and all similar type vehicles proposed for use on farms and the workplace. Only in this way can consumers be properly informed of the relative safety across a range of vehicles, and be supported to make appropriate 'fit for purpose' decisions at point of sale.'* (TRG)
>
> *'I have several concerns with the Safety Star rating system that is proposed. The most obvious concern is with the attempt to include both Quad Bikes and SSVs in direct comparison. These vehicles are quite different, and attempting to favor consumer choice for buying an SSV over a Quad Bike, by forcing a lower rating for the Quad Bikes, hurts the credibility of the whole exercise.'* (Roy Deppa)

All major manufacturers and the FCAI provided in principle support for a safety star rating system, but did not support the proposed UNSW TARS system.

The FCAI and manufacturers submitted that one of the major issues of the UNSW TARS system is the tests are not approved testing methods and the engineering changes the system seeks to promote are not supported by 'real world' evidence, and are opposed by other expert engineers. They suggest the incident data currently available lacks sufficient detail to determine which vehicle characteristics should be discouraged or promoted in a safety star rating system. The FCAI also asserts that due to the lack of evidential support for each of the tests proposed, the stars awarded under the UNSW TARS system do not reflect a quantifiable safety benefit and there is no way to know that a vehicle with a 5 star rating would be safer than a vehicle with a 1 star rating.

Manufacturers and the FCAI also opposed the inclusion of SSVs in the same safety star rating system as quad bikes for comparative purposes.

A number of stakeholders including Honda, Down Under Dirt Bikes and Quad Bike King submitted the UNSW TARS system would be cost prohibitive and the testing would be complex, requiring significant resources that were not feasible for small businesses.

MTAA provided support for the safety star rating system but also noted that the costs should not be prohibitively expensive as this would reduce consumer demand or force manufacturers to exit the Australian market.

A key point identified by many stakeholder groups, including technical experts and industry, was the need to ensure consumers consider whether a machine is 'fit for purpose' when buying a quad bike. This includes considering the type of terrain the vehicle will be used on as well as the tasks that the vehicle will be used for.

Rollover warning label

Stakeholders' views on a rollover warning label were varied. Technical experts, government organisations and the research and medical sectors provided general support for an additional label, but noted warning labels alone would be unlikely to provide a safety benefit and should be implemented in addition to design changes to increase safety.

There were mixed views within the industry sector, with some manufacturers such as Honda and Polaris stating they would not be opposed to a requirement for an additional label and others stating similar warnings already exist and any additional label would not provide a safety benefit.

Stakeholders who supported the requirement for an additional rollover label generally agreed it should be placed in a prominent, highly visible position, include images as well as text and should be complemented with a requirement to include additional information on rollovers in the user's manual.

The main objection raised by stakeholders was that there were already a number of labels and warnings on quad bikes. Proponents of this view stated additional labels may be ignored, may distract from important safety messages included on other labels, or could result in information fatigue.

Operator protection device (OPD)

There was widespread support for some form of OPD to prevent crush injuries provided by the research and medical sectors, government organisations, safety organisations and the farming sector.

Many stakeholders from the research, medical and safety sectors who were supportive of OPDs integrated into the design of general-use model quad bikes stated OPDs would not address the causes of rollovers or stop rollover incidents from occurring. They are of the opinion that OPDs need to form part of the safety solution, in addition to other design changes and complementary measures.

> *'the addition of an OPD to the quad bike is unlikely to have any impact on the incidence of quad bike rollovers as it does not alter the performance of the vehicle, and hence incidents and injuries may still occur even with the presence of an OPD. As such, further design solutions are necessary to improve the safety of the vehicle and reduce the incidence of quad bike-related injuries.'* (joint submission—QUT, JTI, QISU, RACS, Kidsafe Qld)

All representative and peak agricultural bodies who provided submissions to the Consultation RIS, including the NFF and Farmsafe Australia, Tasmanian Farmers and Graziers Association, Safe farms WA, NSW Farmers Federation, Victorian Farmers Federation and Australian Dairy Farmers supported the introduction of mandatory OPDs to improve safety. In addition to their support, many highlighted that OPDs will not stop an incident from occurring but instead are likely to reduce the severity of injury resulting from a rollover incident. Many submissions also referred to the significant reduction in fatalities and injuries that was observed after the introduction of mandatory rollover protection structures (ROPSs) for tractors.

> *'While Operator Protection Devices (OPDs) will not prevent a rollover incident, it has been demonstrated that they will help to minimise the severity of injury received by the operator during a rollover incident when designed and fitted properly.'* (NFF and Farmsafe Australia)

Most of the stakeholders in support of OPDs were also supportive of the proposed performance criteria for such devices, however many noted they did not have the expertise to consider the technical requirements in detail. A common view amongst submissions was that design requirements should be minimal to encourage innovation.

Some of the key feedback on the proposed design requirements for OPDs included:

- requirements for energy absorption should be adopted from the ISO 5700 and include both a lateral and longitudinal loading
- additional requirements for quality of workmanship, fabrication and welding should be included

- OPDs should not interfere with quad bike cargo space
- OPDs should not change a quad bike's towing capacity or abilities
- OPDs should be relatively maintenance free
- OPDs should not impede the ability of operators to actively ride, or their ability to separate from the vehicle in the event of an accident.

The tourism sector, including Quad Bike King and Kuranda Rainforest Journeys, were generally supportive of changes to improve the safety of quad bikes. They supported the fitting of OPDs and also suggested other safety improvements such as wheel spacers to increase the stability of quad bikes.

Conversely, stakeholders from the recreational sector, such as Australian Off Road Vehicle Association (AORVA) and Quadriders SA, did not support the proposed changes and stated mandating OPDs on quad bikes would have a negative safety impacts for recreational users.

Some individual farmers and stakeholders from the industry and recreational sectors raised some potential issues with the fitting of OPDs including:

- they could catch on low hanging branches
- they could reduce the carrying space available
- they are not convenient when spraying or carrying cargo
- fitting of OPDs can cause damage to carrying racks.

The quad bike industry sector, including the FCAI and major quad bike manufacturers, strongly oppose the requirement for general-use model quad bikes to be fitted with an OPD. Some of the main points opposing OPDs raised by industry stakeholders include:

- there is no evidence that OPDs increase safety
- they may impede the riders' ability to separate from the vehicle
- they could make the vehicle less stable by raising the centre of gravity
- they may prevent active riding
- mandating OPDs could result in severe market disruption if manufacturers cease supplying quad bikes to the Australian market.

> *'The FCAI will not endorse fitment of CPDs as the evidence is firmly in opposition to them'* (FCAI)
>
> *'Suzuki will not engineer the inclusion of, nor recommend the fitment of OPDs.'* (Suzuki)
>
> *'There is currently no evidence to suggest that any currently available so-called 'operator protection device' (OPD) or 'crush protection device' (CPD) are safe, or will provide a net safety benefit to an unrestrained ATV (quad bike) rider in the event of a rollover.'* (Polaris)

See section 10.4 for further discussion and analysis of these issues.

Some submissions stated government intervention should go beyond the proposed requirements and should extend to requiring all existing quad bikes to be fitted with after-market OPDs.

Minimum performance requirements

There was widespread support for the proposed requirement for quad bikes to meet minimum performance standard for mechanical suspension, stability and dynamic handling, however the majority of industry stakeholders questioned the availability of evidence in support of the proposal.

Some submissions that were supportive of the requirements commented that they would address some of the shortcomings in the US Standard. Other supportive submissions stated the proposed requirements would significantly improve quad bike safety. Many submissions noted that while they were supportive of the minimum performance requirements, they should be introduced in conjunction with passive protection and improved information to ensure the greatest net safety benefit.

The FCAI stated its members do not have any existing quad bikes that meet all of the proposed minimum requirements. This view was shared by QB Industries, who submitted it could be impractical to introduce minimum performance criteria that would exclude all current quad bike designs. Some submissions suggested that instead of introducing all minimum performance requirements from a certain date, an alternate approach could be gradually phasing in achievable requirements, and substantially increasing the minimum requirements over time.

Some submissions from quad bike distributors noted the minimum performance criteria required testing that was prohibitively expensive to conduct and noted this could lead to a reduction in the number of quad bike models available on the Australian market.

The TRG proposed setting minimum performance criteria as a requirement with a safety star rating system to encourage manufacturers to strive for a higher safety rating over and above the minimum. In this system, points could be awarded to manufacturers for configurations that meet or exceed the minimum requirements. Conversely, a common suggestion from other stakeholder groups was the need for minimum performance criteria to be separate from any safety star rating system. Many stated this was because the requirements were proposed to address distinct and separate outcomes (improved safety and reduced information asymmetry).

Submissions from technical experts, Intersafe and the TRG, were supportive of the proposed minimum requirements. The TRG further stated that the minimum performance requirements would be most effective if supported by a safety star rating system where results were published and available to consumers.

> *'The stability test procedure, vehicle handling test requirements supported by the differential features are necessary and sensible design innovations that will reduce the chances of quad bikes becoming unstable and rolling over.'* (Roger Kahler, Intersafe)

A third technical expert, Roy Deppa, provided support for the testing of lateral stability, however he noted that the majority of quad bikes on the market would not meet the TTR values proposed in the Consultation RIS. He also suggested that an understeer to neutral steering response is preferable to oversteer characteristics as this provides more predictable cornering.

A number of recreational quad bike groups commented that the proposed options would have no safety benefits and some submitted the requirements would bring negative outcomes through increased quad bike costs and bureaucratic processes. AORVA also suggested that the requirements were aimed at increasing safety of quad bikes in farming contexts, and the same requirements may be hazardous in recreational contexts.

> *'It is also possible that injury and fatality outcomes may be increased for recreational users by the related engineering suggestions of Options 3, 4 and 5 (where OPD's/CPD's and open differentials are suggested).'* (AORVA)

Submissions from the medical and research sectors, government organisations, and the legal sector were all in support of introducing minimum performance requirements to improve safety, although many noted they did not have the technical expertise to consider the proposed minimum requirements in detail.

Many submissions provided by the medical and research sector were of the view that the proposed minimum requirements should be applied to youth model quad bikes as well as general-use model quad bikes.

In addition, several submissions identified a need for design features that prevented young riders from operating adult quad bikes and preventing the carriage of passengers on single user quad bikes.

Lockable differentials

Submissions from agricultural representative and peak bodies were supportive of the proposed requirement for all four wheels of the vehicle to rotate at different speeds (open differentials). Although it was noted by many submissions that when operating quad bikes on loose or uneven surfaces or mud, the differential also needs to be able to be locked.

Feedback from some individual farmers who provided submissions to the Consultation RIS stated it was important quad bikes had visual signals alerting operators whether the differential was in the locked or open position.

Intersafe and the TRG supported the requirement for a lockable differential and suggested that this design change would improve the handling and stability of quad bikes. In contrast, Roy Deppa stated that adding a lockable differential would significantly increase the costs of quad bikes and would be detrimental to the performance and safety of quad bikes, particularly when operating on slippery or off-road terrain.

Open differentials were not supported by the majority of manufacturers and distributors, many of whom submitted that a lockable differential would require substantial redesign and would not increase safety. The FCAI stated that lockable differentials greatly reduce the mobility of quad bikes and make the vehicles less safe when ridden on off-road surfaces.

> *'Option of 'all wheels…able to rotate at different speeds' could potentially have adverse effects on safety, as well as on practical ride-ability.'* (FCAI)
>
> *'Honda cannot support open rear differentials on ATVs (quad bikes) as they are not a safe device for off-road use.'* (Honda)

The FCAI, Suzuki, Honda and Polaris all submitted that there would not be improved safety outcomes from having all wheels of the quad bike able to rotate at different speeds. Honda argued open rear differentials on quad bikes are not a safe device for off-road use and may lead to a loss of traction in off-road conditions.

Polaris stated that while it offers an open differential on one of its models, it is specifically for smooth turf surfaces, and in its owner manuals there is a warning against using the feature in off-road conditions.

Complementary measures

Many submissions to the Consultation RIS contained recommendations for measures that fall outside the ACCC's powers. The ACCC refers to these as 'complementary measures', because they should be pursued in association with design solutions to improve quad bike safety.

A number of submissions called for a holistic and nationally consistent approach to improving quad bike safety, and advocated that any design changes should be complemented by a range of measures to influence and improve user behaviour.

The key complementary measures discussed and supported by submissions were:

- mandating helmets and training
- banning children on adult sized quad bikes
- banning passengers on single seat quad bikes.

Stakeholders from the medical and research sector strongly advocated for the banning of children on adult quad bikes and discussed the outcomes achieved by the introduction of Sean's Law in Massachusetts, US.[82] Several of these stakeholders also suggested children under 16 should not ride

82 In 2010, 'Sean's Law' banned children under 14 from riding quad bikes in Massachusetts (unless supervised and involved in a racing event that had been approved by a municipal permitting authority). In addition, Massachusetts has mandated training for children 14–17 years old, required registration and helmets and restricted children to vehicles with engine displacements <30 cm^3. It also increased penalties for adults who allow children to ride quad bikes.

quad bikes of any size, and referenced research that indicates children do not have the mental or physical ability to safely operate quad bikes.

In addition, many submissions strongly advocated for the introduction of national measures to improve incident data collection and consistency of quad bike injury and fatality statistics.

Many manufacturers, distributors and retailers advocated that helmets should be mandatory, children under 16 should be banned from riding adult quad bikes, passengers on single seat quad bikes should be prohibited and training should be mandatory. Some referenced coronial recommendations in support of these safety measures. The FCAI's submission to the Consultation RIS stated the introduction of these measures could reduce fatalities by over 50 per cent, although did not provide evidence to support this claim.

Submissions from agricultural representative and peak bodies and government organisations supported the introduction of compulsory personal protective equipment for quad bike riders and minimum age requirements. Agricultural representative and peak bodies advocated for a national government rebate schemes for the retrofitting of safety equipment or the purchase of alternate vehicles. The agricultural sector expressed support for the rebate schemes currently available in NSW and Victoria to be implemented in other jurisdictions to improve the safety of existing quad bikes.

Many submissions stated that complementary measures on their own would not be effective in significantly reducing fatalities and injuries and should be implemented in addition to design changes (engineering controls) to increase quad bike safety.

10. Informing the options

Key points

- Feedback from submissions and the independent consultant has led to a refinement of the options presented in the Consultation RIS to ensure the recommendation addresses the priority areas for quad bike safety through streamlined and efficient regulation.
- Requirements that should be introduced through the ACL to increase quad bike safety include:
  - rollover warning information
  - providing stability information at the point of sale
  - adopting the US and EN Standard for quad bikes
  - requiring operator protection devices for general-use model quad bikes
  - introducing minimum lateral stability requirements for general-use model quad bikes.
- More work is required to pursue other safety requirements for quad bikes, including youth quad bikes.

10.1 International standards

Overview

The Specialty Vehicle Institute of America (SVIA) developed a voluntary industry standard for quad bikes, which was approved by the American National Standards Institute in 1990. Compliance with the standard became mandatory in the US in 2006 under federal regulation. The standard is continually reviewed and updated and the current version is the ANSI/SVIA 1–2017 (US Standard).

The US Standard addresses design, configuration and performance aspects of quad bikes and imposes requirements including, but not limited to, the following:

- brakes
- mechanical suspension
- throttle, clutch and gearshift controls
- engine and fuel cut off devices
- lighting
- tyres and parking brake mechanisms
- operator foot environments
- pitch stability
- speed-limiting restrictions for youth vehicles
- owners' manual, hang tags and compliance certification labelling.

The European standard EN 15997:2011 (EN Standard) includes the requirements of the US Standard, as well as some additional requirements for noise and carbon dioxide emissions.

The reports arising from the Queensland, Tasmanian and New South Wales coronial inquiries included recommendations that work commence to develop an Australian Standard based on the US Standard.

Approximately 90 per cent of quad bikes sold in Australia are manufactured to meet the requirements of the US or EN Standard.[83]

83 Submission by Australian Centre for Agricultural Health and Safety for the Consultation Paper on *Motor Vehicle Standards Act 1989* and discussions with quad bike manufacturers.

Stakeholder feedback

There was significant stakeholder support for the adoption of the US Standard in Australia. However, the majority of stakeholders were of the view the US Standard is not sufficient as a stand-alone measure to improve quad bike safety and should be adopted in conjunction with engineering controls.

All industry stakeholders that provided a submission to the Consultation RIS supported the adoption of the US Standard. All major manufacturers also stated that their quad bikes already comply with this standard or the EN Standard.

Review by Troutbeck and Associates

Troutbeck and Associates support adopting the US and EN Standard for quad bikes in Australia. However, the Troutbeck report states the standards alone would be ineffective in reducing fatalities and serious injuries given the majority of quad bikes supplied in Australia already comply with these standards.

The report also states the standards do not include requirements for minimum lateral or forward pitch stability, and identifies this as a major shortcoming of the standards.

Finding

The ACCC recommends that the safety requirements of the US and EN standards be adopted to provide a well-established basis on which to build additional safety requirements to reduce the risk of injury associated with quad bike operation. The adoption of these standards will also align Australia with other global markets.

10.2 Additional rollover warning label

Overview

The US Standard requires a number of warning labels to be affixed to quad bikes, including a general warning label. The general warning label includes a dot point at the bottom of the label stating, 'Always: use proper riding techniques to avoid vehicle overturns on hills and rough terrain in turns'.

Given that over half of the fatal quad bike incidents that occurred in Australia from 2011–18 involved a rollover, the ACCC considers the general warning label does not adequately alert the operator to the relative risk of rollover when operating a quad bike.

The general warning label required under the US voluntary standard for SSVs, ANSI/ROHVA 1–2016, includes information about avoiding loss of control and rollovers and an image of a SSV rolling over. Many of the major manufacturers have stated their SSVs comply with this voluntary standard and include this warning label.

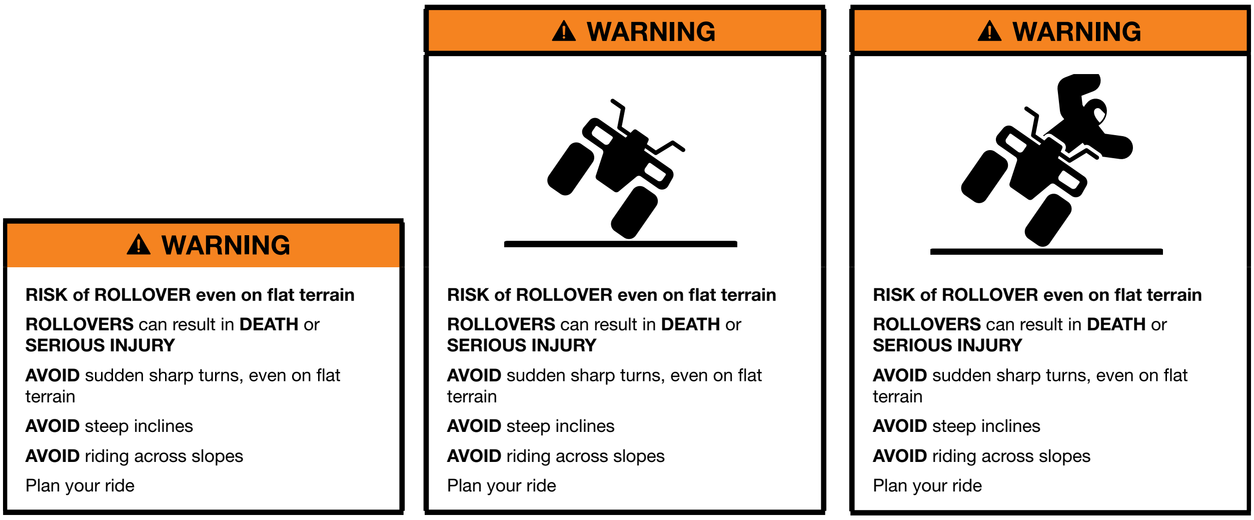
Stakeholder feedback

Feedback received through consultation with stakeholders was generally supportive of the requirement for a warning label to alert operators to the risk of rollovers. There were some dissenting views, including from the FCAI, which stated there was already a rollover warning label on quad bikes, referring to the general warning label discussed above. Most manufacturers with large market share saw little merit in the warning label, but two stated they did not oppose the requirement for an additional warning label.

Many submissions noted there are already a number of warning labels on quad bikes and stated warning labels are largely ignored. The majority of stakeholders in support of an additional warning label supported it in combination with design changes (engineering controls).

The ACCC conducted further consultation with key stakeholders on the specific wording and image included on a warning label to ensure the intended message was clear.

Figure 11: Draft labels used in consultation for development rollover warning label



Key feedback from stakeholders indicated a warning label with an image was preferred over a text-only label. The majority of respondents preferred the image of a quad bike with a rider. Respondents generally indicated the proposed wording was clear and included sufficient information. A small number of stakeholders again raised concerns that warning labels may have little impact on improving safety.

Manufacturers generally had a preference for an image of a quad bike without a rider for consistency with the ANSI/ROHVA standard. The FCAI and Honda also suggested that the first line highlighting the risk of rollover should be removed as it is too general and not factually correct.

Review by Troutbeck and Associates

Troutbeck and Associates considered the safety benefits of requiring a specific rollover warning label on quad bikes and considered whether it should form part of a mandatory safety standard. Its report states that while the safety benefit of having an additional label is unclear, the cost of including an additional label is minimal and given the propensity of quad bikes to roll over, the requirement to affix a roll over warning was recommended.

Finding

The ACCC recommends that an additional label be affixed to all quad bikes and information be contained within operator manuals alerting operators to the risk of rollovers, including when the risk of rollover is increased, and how to best operate the vehicle safely in higher risk conditions.

The recommended label below has been developed in line with existing international standards for product safety signs and symbols, and with regard to current warning label research. The requirements for the general format and durability of the label are consistent with other warning labels currently required under the US Standard.

Figure 12: Recommended rollover warning label

10.3 Five Star Safety Rating System

Overview

The five star safety rating system proposed in the Consultation RIS was commissioned by SafeWork NSW and developed by the UNSW TARS Project. The main purpose of a five star safety rating system is to better inform consumers about the relative safety of quad bikes and SSVs and incentivise quad bike and SSV manufacturers to improve designs to gain a higher star rating. The UNSW TARS safety star rating system applies a higher star rating to vehicles that have a higher resistance to rollover and improved operator protection in the event of a rollover incident.

The UNSW TARS system involves testing quad bikes and SSVs for static stability, dynamic handling and crashworthiness:

- static stability is tested to determine the likelihood of the vehicle rolling over in the event an operator loses control using three tests in three directions: lateral (left and right), rearward pitch and forward pitch. As there are five loading conditions for each test, this requires 15 tests in total
- dynamic handling is tested to measure the likelihood of the operator losing control of the vehicle in stressed conditions using three tests: steady state circular driving behaviour dynamic test, lateral transient response dynamic test, and bump obstacle perturbation tests
- the test protocols for evaluating the crashworthiness of quad bikes and SSVs are different. For quad bikes, testing includes ground contact load measures and rollover tests, while SSV testing includes occupant retention systems, rollover outcome and the load strength of rollover protection systems (ROPS).

The UNSW TARS Project's research and testing program involved over 1000 tests carried out at a Crashlab facility in New South Wales, analysis of 109 coronial case files from around Australia, and workplace injury and hospital admissions data. The safety star rating model was applied to 16 quad bikes and SSVs on sale at the time in Australia.

The IDC formed a TRG in late 2017, which reviewed the star rating system and made recommendations to the IDC which provided its assessment of the five star safety rating system to the ACCC. The ACCC considered the IDC's advice alongside submissions in response to the Consultation RIS, to inform this Final Recommendation.

Stakeholder feedback

There was general support for a five star safety rating system to better inform consumers at the point of sale. It was highlighted that a key aspect of any safety rating system should be that it enables consumers to choose a vehicle that is fit for purpose.

The NFF, Farmsafe Australia and their member affiliates, are strong advocates for a five star safety rating system and would like to see one implemented as soon as possible. Medical and research sectors were also supportive of a safety star rating system that alerted consumers to the relative safety of vehicles on the market.

The lead researchers of the UNSW TARS Project estimated the cost of the five star safety rating system testing to be approximately $50 000 per model, with additional costs of $300 000 to $400 000 annually to set up and manage the system.

Feedback received from submissions and consultations suggests these costs are prohibitive, particularly for smaller importers and models with less sales volume. One supplier who distributes seven models of quad bikes and SSVs commented that the required outlay of $350 000 would mean his business would no longer be financially viable. The loss of small suppliers could limit the quad bike and SSV models available to consumers, particularly vehicles at a lower price point. Smaller suppliers also noted that since entering the Australian quad bike market, the retail prices of major manufacturers' vehicles had decreased as a result of the competition from smaller suppliers selling alternate-brand vehicles at lower costs.

After noting the feedback on the potential costs of the UNSW TARS five star safety rating system and the potential effect its introduction could have on the market for consumers, the ACCC liaised with the UNSW TARS researchers, who developed a suite of simplified tests in an attempt to reduce costs to approximately $15 000 per model.

In its submission to the Consultation RIS, the TRG advised that implementation and administration of a five star rating system should be independent of manufacturers, supported by government funding, and based on repeatable and adaptive testing protocols that are capable of aligning with future vehicle technological and engineering advances.

The TRG also proposed a number of refinements to the UNSW TARS system. Some were minor in nature and others were more substantial. For example, the TRG queried whether the dynamic handling circle test may be reproducible at different test facilities due to its reliance on operator input. While it noted some potential ways to improve the testing reproducibility to the ACCC, such observations demonstrated the benefits of working collaboratively with industry to enable a robust testing regime to be developed. The FCAI and individual manufacturers in their submissions to the Consultation RIS provided in principle support for a five star safety rating system, however did not agree with the tests proposed under the model system developed by the UNSW TARS Project. The main issues the FCAI and manufacturers raised in response to the proposed safety rating system framework include:

- the system is not evidence based
- the cost and volume of testing required is excessive
- the system should be managed by a standalone, independent body, similar to ANCAP.

They also expressed a strong view that testing criteria should be developed in collaboration with industry. The ACCC met with the FCAI and some of its member-manufacturers on a number of occasions and in September 2018, the ACCC was presented with an alternate safety star rating system. It proposed a safety star rating system with the following criteria:

- one star: compliance with the US Standard
- two stars: a minimum level of lateral stability (above TTR 0.67 without a test dummy)
- three stars: an increased level of lateral stability (above TTR 0.75 without a test dummy)
- four stars: meeting a maximum bump test result
- five stars: lockable/open differentials.

The system proposed by the FCAI and some of its member-manufacturers was proposed as an interim measure until it becomes possible to develop a five safety star rating system that could correlate an observed or known decrease in injury risk.

The ACCC welcomes this proposal and appreciates there are still a number of factors which require further development before a five star safety rating system can be introduced, including establishing an independent body to oversee its functioning.

Review by Troutbeck and Associates

The ACCC asked Troutbeck and Associates to review the model five star safety rating system developed by the UNSW TARS Project and advise whether its current form is appropriate and whether it should form part of a mandatory safety standard.

Troutbeck and Associates agree there should be a five star safety rating system, however consider the system developed by the UNSW TARS Project to be complicated and the important measures to be not clearly identifiable from the resulting star rating. It was also uncertain whether a high value from the five star rating system would necessarily correlate with the optimum vehicle configuration.

The report noted the difficulty that would arise relying on the proposed five star safety rating system to discriminate between different quad bike models when they have the same star rating. The rating points for general-use model quad bikes range from 28 to 32 points (twostars), whilst SSVs range from 49 to 64 points (three to four stars). The report noted until there is a broader range of ratings, the star rating system will not provide consumers with any reasonable measure to discriminate between models.

The report discussed in detail the testing criteria in the UNSW TARS model star rating system for static stability and dynamic handling and their suitability for inclusion in a five star safety rating system and made the following recommendations:

- Static Stability—only two measures for lateral roll and longitudinal pitch be used
- Dynamic handling
  - *Steady state circular driving behaviour dynamic test*: the dynamic handling assessment need not include a dynamic limit on lateral acceleration as dynamic performance can be predicted with some confidence from the static stability tests
  - *Lateral transient response dynamic test*: given the lack of an established relationship between the steering response times and safety, and because the response times on an asphalt surface are not representative of ground conditions in the field, its use in the star rating system is not recommended
  - *Bump obstacle perturbation test*: the response of the vehicle to a 150 mm bump be used as part of the five star rating system. This recommendation is made even though there is only one bump height and speed, as there is no basis for designing a matrix of tests at present
  - *Minimum wheel articulation*: there was no evidence provided that the wheel articulation requirement of 150 mm will improve safety, a lower bump responses can be achieved on quad bikes with less wheel articulation. Consequently it is not recommended that it form part of a five star rating system.

Finding

The ACCC considers a system that allows consumers to compare the relative safety of quad bikes would be important in reducing information asymmetry in the market. The ACCC agrees with the TRG's view that the management and administration of a star rating system should be independent of manufacturers, supported by government funding, and based on repeatable and adaptive testing protocols that are capable of aligning with future vehicle technological and engineering advances.

The Troutbeck Report identified key safety-related tests included in the UNSW TARS safety rating system. Specifically, the report discusses the importance of stability, vehicle predictability and bump impulse response testing. The Troutbeck Report recommends a safety star rating system should be given further consideration to enable a simple and transparent safety star rating system to be developed and implemented.

The ACCC does not recommend the UNSW TARS Project safety star rating system be included in a quad bike safety standard at this time. The ACCC will continue to support the development of a safety star rating system through its membership on the IDC. This will include presenting the IDC with the evidence and information provided during the investigation, and request it give consideration to alternate avenues for introducing a five star safety rating system.

10.4 Operator protection devices

Overview

Operator protection devices (OPDs) are designed to protect the operator in the event a vehicle rolls over. An OPD for a quad bike may be in the form of a rollover protection structure (ROPS) or a crush protection device (CPD). A ROPS is designed to enclose the rider and be used in conjunction with occupant retention systems. CPDs do not enclose the rider, but instead aim to prevent the weight of the upturned vehicle coming to rest on the rider by holding the upturned vehicle off the ground and creating in effect a 'crawl out' space. Some CPDs are also designed to limit the number of quarter rolls (90 degree rolls) and to avoid the quad bike 'rolling over' the operator.

OPDs are incorporated into a number of vehicles, including golf carts, lawn care equipment, tractors, earthmovers, front-end loaders, bobcats and convertible cars. OPDs have proved to be effective in reducing the number of fatalities and serious injuries resulting from tractor rollovers. Since tractor OPDs were mandated, there has been almost an 87 per cent decrease in tractor rollover fatalities.[84]

Aftermarket OPDs are generally designed to prevent the full weight of the quad bike from being applied to, or coming to rest on, a rider in the event of a rollover. Currently available aftermarket OPDs:

- do not incorporate any rider restraints
- have a minor impact on static stability if light, for example, the Quadbar weighs 8.6 kg[85] (which is less than many accessories available for quad bikes)
- have minimal impact on the ability of a rider to employ active riding techniques.[86]

Australian data indicates approximately 50 per cent of quad bike-related fatalities occur as a result of rollovers on general-use model quad bikes. In many cases, the operator is pinned underneath the vehicle, with crush asphyxiation identified as one of the major causes of death. The available information indicates a third of all quad bike deaths in Australia may be prevented through the addition of an OPD.

This section considers the improved safety outcomes associated with OPDs, leading to a recommendation that OPDs be incorporated into the design of, or fitted to, general-use model quad bikes to help protect the health and safety of operators.

OPD designs available in Australia

Aftermarket OPDs for quad bikes of various designs have been available in Australia for over two decades and it is estimated that there are currently 15 000 OPDs fitted to quad bikes in Australia and New Zealand.[87] Two popular after-market devices available in Australia are the Australian designed 'Quadbar' and the New Zealand designed 'ATV Lifeguard'.

There are two designs for the Quadbar (pictured below). One is a rigid hairpin shaped hoop mounted on the quad bike behind the rider. The other, the 'Quadbar Flexi' is a vertical bar angled at the top, which is designed to flex rearwards to avoid contact with overhead obstacles. They both have a bolt on attachment to the tow bar and rack.

84 InterSafe submission to ACCC Quad Bike Safety: Issues Paper, p. 13.

85 R Grzebieta, G Rechnitzer, K Simmons, University of New South Wales Transport and Road Safety Research Unit, *Static Stability Test Results: Report 1*, provided to WorkCover Authority of New South Wales January 2015, p. 15.

86 Dr Scott Wordley, Department of Mechanical and Aerospace Engineering Monash University, *Quad Bike Crush Protection Devices (CPDs): Updates to ISCRR Snapshot Review* C-I-12–022, p. 7.

87 Australian Centre for Agriculture Health & Safety submission to ACCC Quad Bike Safety: Issues Paper, p. 12.

Linhai produces two general-use model quad bikes with the Quadbar integrated into the design of the vehicle, which are imported by an Australian supplier (Down Under Dirt Bikes).[88]

The ATV Lifeguard is a segmented roll bar, which is flexible and yielding and is designed to absorb and deflect the forces of impact around and away from the operator's body. It is fitted by clamping to a metal rear carrier.

Figure 13: Current OPD designs available in Australia

Quadbar™

Quadbar Flexi™

ATV Lifeguard®

International OPD designs

There are also aftermarket OPDs being designed around the world. For example, in Spain an automatic rollover protection device known as an 'Air-ROPS' is currently being developed to provide crush protection for agricultural machinery, including general-use model quad bikes. The Air-ROPS system is an automatically deployed system, similar to those used for convertible motor vehicles. It activates when the vehicle tilts beyond a 45 degree angle.[89] The inventors of the Air-ROPS report it has a low centre of gravity, low clearance, limits the overturn angle to less than 90º and is also designed to prevent the quad bike from continuously rolling.

88 Down Under Dirt Bikes, discussion with the ACCC, 4 June 2018.

89 'Air Rops (CPD) fitted in Agricultural Quad Bike (English)', *AIRROPS,* available: youtube.com/watch?v=XbvxbauR3uA, and correspondence with Air Rops August 2018.

Air-ROPS

As mentioned in Section 8.1, one of the conditions of registration of quad bikes in Israel is it must have an OPD installed. The OPD is subject to a design standard that, among other things, mandates attachment mechanisms and materials, minimum dimensions and requirements for the frame to withstand loads without residual deformation.[90]

Israeli OPD 'Rear Safety Frame'

90 Manufacturing and Installation of Safety Frames for Quad Bikes Code—72, Specifications Document No.3876 (2005).

In the EU, after-market OPDs are classified as 'safety components', require CE marking, and can be voluntarily retrofitted to quad bikes. The ATV Lifeguard has been awarded a CE marking. Many products require CE marking before they can be sold in the European Economic Area (EEA). CE marking indicates that a product has been assessed and meets EU safety, health and environmental protection requirements. It is valid for products manufactured both inside and outside the EEA.[91]

OPD rebates

The Victorian and New South Wales governments began rebate schemes in July 2016 to encourage the adoption of quad bike safety measures. The rebates include subsidies for farmers to reduce the cost of fitting approved aftermarket OPDs (the Quadbar or ATV Lifeguard) to quad bikes. At October 2018, the schemes had collectively contributed to the installation of 3 111 OPDs.[92]

Until the end of October 2018, South Australian dairy farmers could apply for a rebate of up to $800 for the purchase of an OPD through the South Australian Dairyfarmers' Association. The OPD must be designed and manufactured in accordance with approved engineering standards and independently tested to be eligible for the rebate.[93] The South Australian Dairyfarmers' Association states the Quadbar and the ATV Lifeguard are both eligible.[94]

OPD research and testing

Dynamic Research Inc.

In 2007, major quad bike manufacturers commissioned Dynamic Research Inc. (DRI) to conduct computer simulated tests of the Robertson V-Bar, an earlier version of the Quadbar. DRI simulated 113 quad bike rollover cases from the UK Health and Safety Executive (1994) and the US Consumer Product Safety Commission (1998). The purpose of the computer simulations was to assess the injury risks and benefits that may have arisen in the these instances, had a Quadbar been fitted to the vehicle involved. Earlier versions of the report received criticism and a number of subsequent changes were made to address these, with the latest report dated 2016.[95]

The FCAI's submission states:

> *'for each of the rollover crash types, the simulations were run with and without the Quadbar OPD. In some cases, the Quadbar was found to increase injuries, in some cases the Quadbar was found to reduce injuries, and in some cases the Quadbar had no effect.'*

It further states:

> *'The study showed that for helmeted riders, there was a non-statistically significant Net Benefit of the Quadbar that was negative 3% (i.e., a Net Harm). Furthermore, the Risk/Benefit ratio, a measure comparing the total harm of the Quadbar, for those crash types in which it was harmful, to the total benefit of the Quadbar, for those crash types in which it was beneficial, was found to be 108%, meaning that the injury risks of adding the Quadbar were greater than the injury benefits of adding the Quadbar, though this result was also not statistically significant. With respect to asphyxiation, the Quadbar caused as many asphyxiations as it prevented.'*[96]

There have been a number of criticisms of the DRI simulations, including:

- the number of cases of serious injuries were too small to accurately model these types of injuries[97]

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91 Your Europe European Union, *CE marking,* available: europa.eu/youreurope/business/product/ce-mark/index_en.htm.

92 Correspondence with WorkSafe Vic, October 2018 and correspondence with SafeWork NSW, October 2018.

93 South Australian Dairyfarmers' Association, 'South Australian Dairy Industry Fund Quad Bike Safety Rebate Scheme 2018–19', accessed October 2018, available: sadafresh.com.au/assets/Dairy-Industry-Fund-Information-hand-out.pdf.

94 Ibid.

95 Zellner, J.W., Kebschull, S.A., Van Auken, R.M., Dynamic Research Inc *Updated injury risk-benefit analysis of Quadbar crush protection device (CPD) for all-terrain vehicles (ATVs), Zellner, et al, 3rd Rev,* 2016, available dri-atv-rops-research.com/.

96 Federal Chamber of Automotive Industries submission to the ACCC Quad Bike Safety Consultation RIS, p. 55.

97 McDonald, G, *Overview of Dynamic Research Inc.'s two assessments of the Robertson Quadbar*, Geoff McDonald & Associates. Volume 1, Brisbane Qld, 2014,Retrieved from Dr Tony Lower Australian Centre for Agricultural Health and Safety Sydney Medical School's submission to the ACCC Quad Bike Safety Issues Paper.

- serious injuries cases were simulated into multiple cases, giving false positives[98]
- in 105 of the 113 cases the actual part of the body injured was not injured in the simulation[99]
- the simulations dramatically over-predicted head injuries and virtually eliminated chest injuries. This shift in the nature of injuries predicted by the simulations removed much of the potential for the OPD tested to reduce the simulated rider injuries[100]
- it conflated two separate issues: it compared injury outcomes of a rider wearing a helmet without a Quadbar fitted and an unhelmeted rider with a Quadbar fitted.[101]

The FCAI commissioned Associate Professor Robert Anderson to review the 2007 and 2012 DRI simulations. In its submission to the Consultation RIS, the FCAI said:

> *'Professor Anderson, an independent expert, indicated that readers of these reports can have a great deal of confidence in the validity and the reliability of the DRI methodology and conclusions. Professor Anderson's review suggested additional analyses of the 2012 simulation data, and that was done in the 2016 version of the DRI report.'*[102]

Associate Professor Anderson gave evidence at the Queensland Coronial Inquest in 2015[103] and while recognising merits in the DRI research, he also considered there were deficiencies in DRI's methods and results, including, but not limited to:

- DRI's emphasis on comparing a rider without a helmet with a OPD fitted, to a rider with a helmet but no OPD, was not appropriate as it conflated two separate issues
- DRI focused on the distribution of injury severity in each body region, rather than the distribution of injuries across the body
- DRI concluded a high correlation between injury severities in the UK and US accident database samples and those predicted in the simulations, however Associate Professor Anderson's analysis suggested there were substantial differences between the two, particularly in the case of head injury distributions.

Associate Professor Anderson also cautioned against interpreting DRI's simulation results as confirmation that OPDs had no net benefit, finding DRI's research indicated the Quadbar provides a small, non-statistically significant net benefit to unhelmeted riders.[104]

The FCAI acknowledge the 2007 DRI analysis of the Quadbar had received criticism for some of the modelling assumptions and details and stated the most recent analysis, which was conducted in 2012, with further refinement of that analysis in 2014 and in 2016, addressed all of these criticisms and reached similar conclusions to the 2007 analysis.[105] While the 2016 analysis may have addressed all of the criticisms of the 2007 analysis, it does not address all of the criticisms outlined by Adjunct Associate Professor Anderson and others above.

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98 McDonald, G, *Overview of Dynamic Research Inc.'s two assessments of the Robertson Quadbar*, Geoff McDonald & Associates. Volume 1, Brisbane Qld, 2014,Retrieved from Dr Tony Lower Australian Centre for Agricultural Health and Safety Sydney Medical School's submission to the ACCC Quad Bike Safety Issues Paper.

99 McDonald, G, *Overview of Dynamic Research Inc.'s two assessments of the Robertson Quadbar*, Geoff McDonald & Associates. Volume 1, Brisbane Qld, 2014,Retrieved from Dr Tony Lower Australian Centre for Agricultural Health and Safety Sydney Medical School's submission to the ACCC Quad Bike Safety Issues Paper.

100 Richardson, S, Orton, T, Sandvik, A et. al, 'Simulation of quad bike (ATV) rollovers using PC-Crash to evaluate alternative safety systems', *Delta-V Experts* Paper Number 13-0286, p. 3, available: https://www-esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000286.PDF.

101 Summarised in the Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, http://www.courts.qld.gov.au/_data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

102 Federal Chamber of Automotive Industries submission to the ACCC Quad Bike Safety Consultation RIS, p. 7.

103 Summarised in the Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, pp. 42–44, available courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

104 Ibid.

105 Federal Chamber of Automotive Industries submission to the ACCC Quad Bike Safety Consultation RIS, p. 7.

Troutbeck and Associates found the absence of detailed comparisons between the simulations and incident and field tests meant it could not have confidence in the simulation modelling or its output.[106]

UNSW TARS Research

SafeWork NSW commissioned UNSW TARS to conduct a quad bike workplace safety survey study to better understand the in-field workplace experiences of quad bike riders and their use of helmets and OPDs. The objective of the survey was primarily to identify if the fitment of aftermarket OPDs caused harm to riders in a rollover incident in the workplace environment, and to what extent after-market OPDs provide protection for riders in rollover incidents involving quad bikes.

The survey study was comprised of responses from three workplace sub-studies.[107] The results were:

- Sub-study (1): Case study of 20 years of incident history obtained from a major quad bike tour company with around 25 000 guests annually. This company has very high exposure to quad bikes with OPDs fitted in a workplace environment. In 2005, all quad bikes were fitted with a Quadbar to redress their major injury incidents (70% were rollover) in the prior ten years. After fitting OPDs, the company reported no cases of serious injury resulting from OPDs and their experience is that OPDs are effective in reducing harm to patron riders. The UNSW TARS report states, 'OPDs appear to be effective in reducing the harm to riders, i.e. a reduction of serious injury of between 85–100% has occurred after their fitment to the vehicles.'
- Sub-study (2): Survey of quad bike fleet managers from 12 Australian and 4 New Zealand companies covering a total of 436 quad bikes, with a majority fitted with either a Quadbar (167) or an ATV Lifeguard (150). The intent of the survey was to identify whether OPDs resulted in serious injuries from rollovers amongst users with large exposures to quad bikes. There were 57 rollovers incidents involving a quad bike with no OPD and 12 incidents with an OPD. When managers were asked whether the OPD prevented injury or caused injury, the company managers were reported to state OPDs prevented injury or more serious injury in 10 of the 12 rollover cases.
- Sub-study (3), 'workplace survey': This was the main survey conducted by UNSW TARS and was an internet survey based on responses from 1 546 individual workplace quad bike riders. Around half of respondents reported no incidents and the other half reported a total of 1430 incidents (some respondents reported more than one incident). It found 20 per cent of all rollover incidents resulted in an injury, with 6 per cent of all rollover incidents resulting in a serious injury and hospitalisation. Of the respondents involved in an incident:
  - around 10 per cent (150) had a Quadbar or Lifeguard OPD fitted
  - 963 events were reported to be rollovers, of which 37 reported a Quadbar or Lifeguard OPD was fitted
  - 10 injuries involved a quad bike fitted with an OPD, two were serious injuries resulting in hospitalisation and eight were minor injuries
  - there were no incidents identified in which there were serious injury to the chest or head attributed to the OPD.

  The sample size of OPD incidents was too small to enable statistically significant conclusions to be drawn.

As part of the Quad Bike Performance Project, the UNSW TARS tested the crashworthiness of a quad bike with and without OPDs (Quadbar and ATV Lifeguard). The tests found these OPD devices do increase survivability and crawl out space and change crush loads applied to the operator under certain rollover circumstances. It also found when an OPD was fitted, the full weight of the quad bike did not rest on the rider, whereas without an OPD the full weight of the quad bike could rest on the operator in lateral, rearward and forward pitch rollovers. The Quadbar and ATV Lifeguard were found to be likely to

106 Troutbeck and Associates, 'Evaluation of options to improve safety when using quad bikes and SSVs' Report for the Australian Competition and Consumer Commission, p. 73.

107 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017.

reduce the risk of mechanical asphyxiation when in the inverted position, but not when a quad bike is on its side.[108]

The FCAI engaged Pegasus Economics to critique the Workplace Survey Report.[109] It concluded that the survey has some limitations, including:

- Sub-study (1): is a before and after study which does not take into account changes over time taking place independent of the intervention. Pegasus also states the data is unlikely to be representative of the general population of quad bike users as it is mainly composed of inexperienced recreational quad bike users. The data set is also argued to be flawed as it relies on the recollections and memories of the tour company's senior management.
- Sub-study (2): was also described as flawed because of its reliance on the recollections and memories of fleet managers, its limited scope and it being an observational study, which: 'contain inherent methodologic limitations that generate bias and confounding, which mean that causal inferences cannot reliably be drawn'.
- Sub-study (3): as a self-selection survey, Pegasus stated self-selection bias exists as people are more likely to respond to questionnaires if they see items that interest them and respondents are unlikely to be reflective of the true population. Pegasus also states the statistical techniques used contain 'serious limitations' and suggests the UNSW TARS research was pushing for the adoption of OPDs, rather than being impartial.

University of Southern Queensland testing

Chris Snook, a Mechanical Engineering Lecturer at the University of Southern Queensland Faculty of Engineering and Surveying was funded by QB Industries (the manufacturer of the Quadbar) to conduct an assessment of the effectiveness of the Quadbar in:

- controlling the conditions at the point of sideways roll and backwards flip of a quad bike on inclined terrain
- arresting the roll of a quad bike, or controlling the roll to reduce the likelihood of an operator being trapped under it.[110]

The report concludes the Quadbar is effective in reducing the likelihood of rider injury in a quad bike sideways rollover and backflip and 'should be considered an essential safety feature of ATVs (quad bikes) in the workplace and recreational environment.'[111]

The University of Southern Queensland, Faculty of Engineering and Surveying states a number of important factors and observations from the assessment can be drawn, including in relation to rollover behaviour of quad bikes:

- At low speeds on horizontal ground, there is a strong tendency for quad bikes to rollover sideways to an upside down position. If the rider is not thrown clear of the quad bike during the rollover then there is a high probability that the rider will be trapped under the vehicle and will be at risk of crushing or asphyxiation.
- At low speeds on sloping ground there remains a possibility of the quad bike resting in an upside down position.
- A safe and cautious rider is unlikely to be operating at elevated speeds in a work situation. Rollover can still occur due to unbalance or uneven terrain and so the risks associated with these low speed rollovers are significant.

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108 Grzebieta R, Rechnitzer G, McIntosh A, (2015) 'Rollover Crashworthiness Test Results', Quad Bike Performance Project TARS Research Report No. 3, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia p. 46.

109 FCAI submission to the ACCC Quad Bike Safety Consultation Regulation Impact Statement. Pegasus Review of TARS ATV User Survey. Appendix C. p. C-1.

110 Snook, C, 2009, University of Southern Queensland Faculty of Engineering and Surveying, 'An assessment of passive roll over protection for Quad Bikes', accessed October 2018, available: https://www.quadbar.com.au/page/attachment/3/qb_industries_report.

111 Ibid, p. 17.

- As quad bike speed increases, the likelihood of the quad bike remaining upside down decreases. However, at times during the roll there is little clearance between the quad bike and the ground and the potential for serious injury remains high.
- The square body shape of some quad bike models makes them more likely to rest upside down in low speed sideways rollover. The more rounded body and flexible bodywork of some quad bike models gives these a strong tendency to continue to roll once initiated.
- Low speed back flip of a quad bike on sloping ground demonstrates a tendency to leave the quad bike in an upside down condition, with the concomitant risk of trapping the rider.

The University of Southern Queensland, Faculty of Engineering and Surveying drew from the results that:

- The Quadbar did not impede the operator of the quad bike during normal operation.
- In low speed sideways rollovers, the Quadbar arrests the rollover and prevents the quad bike from resting in a position that could trap and asphyxiate the rider.
- In higher speed sideways rollover, the Quadbar impedes the rollover and prevents the quad bike from resting in a position that could trap and asphyxiate the rider. In all tests the Quadbar provided some clearance between the ground surface and the quad bike seat so the rider would be unlikely to be trapped in this space.
- In all back flip tests, the Quadbar arrested the back flip and the quad bike fell to one side.
- There were no conditions where the quad bike with the Quadbar fitted rested in a position that was more detrimental to rider safety than the quad bike without protection.

Associate Professor Anderson was funded by the FCAI to consider if the methodologies employed in the testing and investigations of Snook were suitable to enable conclusions on the safety risk/benefit of the Quadbar to be drawn. Associate Professor Anderson found the study was a good preliminary study of the Quadbar's impact on rollover dynamics, however should not be considered reliable for generalisation purposes.[112]

Delta-V Experts

A specialist forensic engineering and safety consultancy firm, Delta-V Experts, modelled the effect of quad bike rollovers when OPDs were and were not fitted. The modelling examined quad bikes when: the quad bike had no modifications, the quad bike was modelled with a CPD, the quad bike was modelled with a ROPS and an unrestrained rider and a quad bike was modelled with a ROPS and a restrained rider.

From the 100 simulations for each of the four quad bike configurations, Delta-V found:

1. The number of ¼ turns:
    a. the quad bike with no modifications and unrestrained rider did 24 ¼ turns, 26 ½ turns and 50 ¾ turns
    b. the quad with CPD and unrestrained rider did 34 ¼ turns, 9 ½ turns and 57 ¾ turns
    c. the quad with ROPS and unrestrained rider did 100 ¼ turns
    d. the quad with ROPS and restrained rider did 100 ¼ turns.
2. The rider's torso was impacted with a force greater than 1500 N:
    a. 41 times for the quad bike with no modifications and unrestrained rider
    b. two times for the quad bike with CPD and unrestrained rider
    c. zero times for the quad bike with ROPS and unrestrained rider

112 Anderson, R, November 2014, 'All terrain vehicle engineering/safety issues expert opinion' Hall Technical, pp. 15-16, Attachment G to the FCAI appendices to the Consultation RIS, Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, p. 34 courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

d. zero times for the quad bike with ROPS and restrained rider

3. The rider's torso was impacted with force greater than 3000 N:

   a. 11 times for the quad bike with no modifications and unrestrained rider

   b. zero times for the quad bike with CPD and unrestrained rider

   c. zero times for the quad bike with ROPS and unrestrained rider

   d. zero times for the quad bike with ROPS and restrained rider

4. The rider could have been traumatically or mechanically asphyxiated with a resting torso force of greater than 1000 N if trapped beneath the quad for more than seven minutes:

   a. 32 times for the quad bike with no modifications and unrestrained rider

   b. 17 times for the quad bike with CPD and unrestrained rider

   c. zero times for the quad bike with ROPS and unrestrained rider

   d. zero times for the quad bike with ROPS and restrained rider.[113]

The authors also modelled four known rollover incidents. Delta-V Experts found in all four cases, if the quad bike had been fitted with a CPD or ROPS (with a restrained operator or unrestrained operator), the operator could have survived the rollover in all four cases.[114] The report concluded:

> *…where there is an identifiable risk of serious or fatal injury from quad rollover, consideration should be given to fitting either: CPD, ROPS or ROPS with rider restraint; to mitigate the potential for serious and/or fatal injury due to torso impact or entrapment during a quad bike rollover.*[115]

In its submission to the ACCC Consultation RIS, the FCAI criticises Delta-V Experts' testing:

> *'…this study has little or no validity, realism, or relevance. It did not include an injury monitoring crash dummy, did not attempt to predict injuries; used software intended for vehicle crash reconstruction, not crash injury simulation; did not include a sample of real-world crash conditions; and did not include an ATV (quad bike) with front or rear suspension, steering, or even rotating wheels.'*[116]

During the Queensland Coronial Inquest, Dr Richardson of Delta-V Experts is reported as having noted that his computer simulation tests did have a number of limitations, but that may be said about computer simulations generally, because they rely on the inputting of data and the making of assumptions, many of which are difficult to, or not able to be validated.[117]

Design Research Engineering

In 2012, Design Research Engineering Inc (DRE) undertook research commissioned by the SVIA to examine 129 YouTube videos of real-world quad bike rollover incidents to analyse quad bike rollover dynamics and rider responses. It found rider active dynamics need to be considered when introducing injury prevention strategies that could obstruct, impede, or otherwise contact riders during an attempted separation.

During the Queensland coronial inquest the lead researcher, Dr Van Ee, stated:

- rear mounted OPD may obstruct rider dismount and successful separation
- where riders had minor or non-injury outcomes, the presence of an OPD would likely have resulted in OPD-rider contact, new quad bike rider contact scenarios, and/or a change in the dynamics and roll trajectory of the quad bike

113 Richardson, S, Orton, T, Sandvik, A et. al, ''Simulation of quad bike (ATV) rollovers using PC-Crash to evaluate alternative safety systems', *Delta-V Experts* Paper Number 13-0286, p. 5, available: -esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000286.PDF.

114 Ibid, pp. 9–12.

115 Ibid, p. 13.

116 FCAI submission to the ACCC Quad Bike Safety Consultation Regulation Impact Statement, p. 57.

117 Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, p. 34, courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

- there could be some selection bias inherent in videos that are posted on YouTube and in particular, videos posted would be less likely to include serious injury and fatal scenarios.[118]

DRE were commissioned by the FCAI to conduct a further investigation into the possible obstruction the ATV Lifeguard could provide for active dismounts. It found:

> *'given the current knowledge of the effectiveness of active dismount and separation in rollover situations, and the potential of a CPD to obstruct effective dismount, great caution is warranted in the implementation of any such device. The effectiveness and unintended consequences of CPDs for rollover protection needs to be adequately addressed with reliable field and dynamic test data.'*[119]

In the New South Wales coronial inquest, Adjunct Associate Professor Rechnitzer submitted rider separation was not a legitimate safety strategy and stated OPDs were likely to have as much, or more, of an effect on rider separation as accessories and loads on quad bikes.[120] Mr Zellner, a co-author of an industry-funded critique of the USNW TARS project, provided evidence during the same coronial inquest that where a quad bike, including its load, collectively weighed 400 kg or more, separation was not an effective safety strategy.[121] The vast majority of quad bikes, when loaded within their recommended capacity, weigh above 400 kg.

Coronial inquests and OPDs

State and territory coroners have jurisdiction to investigate sudden and unexpected fatalities, including quad bike fatalities. In the past four years, three major inquests into fatalities arising from quad bike and SSV use have been held in Australia. These were:

- Deputy Coroner Freund's inquest into nine quad bike related deaths in New South Wales in 2015
- Deputy Coroner Lock's inquest into nine quad bike related deaths in Queensland in 2015
- Coroner Cooper's inquest into seven quad bike deaths in Tasmania in 2017.

There has also been an earlier inquest in New Zealand:

- Coroner Shortland's inquest into five quad bike related deaths in New Zealand in 2013.

The FCAI have said to the ACCC on several occasions and in its submission to the Consultation RIS that none of the coroners who investigated fatalities associated with quad bikes issued a finding recommending OPDs.[122] Although technically true, this statement is an over simplification of the Coroners' recommendations.

Queensland inquest

Deputy State Coroner Lock examined the OPD evidence in detail and found:

> *'…the research from all sources has sufficient inherent difficulties and statistical inconsistencies for me to be able to reach a conclusion about the efficacy of CPDs…*
>
> *'That does not mean the research from all sources to date is invalid or should be disregarded. To the contrary, what is needed is for the researchers to collaborate and examine the evidence in a scientific fashion, unhindered by entrenched positions that are so evident in the debate to date.*

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118 Queensland Coronial Inquest into nine (9) deaths caused by Quad Bike accidents, Coroners Court, Brisbane, delivered on 3 August 2015 by John Lock, Deputy State Coroner, p. 41, courts.qld.gov.au/__data/assets/pdf_file/0018/432306/cif-quadbikeaccidents-20150803.pdf.

119 Ibid.

120 Inquest into the deaths of Donald Eveleigh, Angela Stackman, FW, ML, Anthony Waldron, Colin Reid, Bradley Jackson, Robert Beamish and LE. Findings of Deputy State Coroner Sharon Freund, delivered on 26 November 2015 at State Coroner's court, Glebe, p. 59.

121 Ibid.

122 FCAI submission to the ACCC Quad Bike Safety Consultation Regulation Impact Statement, p. 7.

'I am not convinced that CPDs as they currently exist on the market, or as a concept, should be thrown on the scrap heap as would be suggested by the FCAI. The testing does suggest there are a number of circumstances in which rollovers occur where a CPD, especially where low speed features (as occurs typically in a farming context), may save a person from death or from suffering a serious injury. In other circumstances, they may not, and they may even cause serious injuries or death. The sting is that the circumstances where benefit or detriment may or may not occur, cannot be stated at this time in sufficient clarity for me to make a finding.

'Consumers, and in particular, employers, need to be able to receive authoritative information about the potential advantages and disadvantages of CPDs, so they can conduct a risk assessment to determine whether a CPD would be suitable in their circumstance.

'What is now required is for there to be an independent move to develop an Australian Standard for quad bike CPDs. In doing so, there will inevitably be a need to continue on from the existing research and ensure such a design meets the purpose of providing a safety benefit. …I agree that further research should be conducted on the efficacy of currently available CPDs and that research should be independent.'

NSW inquest

Deputy State Coroner Freund, made a number of comments on OPDs, including, but not limited to:

'In my view, what is lacking from the studies to date is any 'real world' study of the incidence of injury and/or fatalities and/or prevented injuries/fatalities resulting from the use of CPDs. There is at present no evidence that any deaths have occurred as a result of the fitting of a CPD. However, in the absence of a study as to fatalities or injuries caused by CPDs, it is not possible to draw any absolute conclusions about the efficacy of CPDs.'

Deputy State Coroner Freund made a recommendation that SafeWork NSW, SafeWork Australia, and the manufacturers of the Quadbar and Lifeguard OPDs collaborate to conduct an independent survey study to assess the benefits, risks and efficacy of OPDs.

Tasmanian inquest

Coroner Cooper appeared to have the most reservations about OPDs and felt it was 'impossible to conclude that…fitment (of OPDs) to all quad bikes should be recommended'. Coroner Cooper went on to comment:

'I am satisfied that it is quite clear on the evidence that it would be inappropriate, and not justifiable, to make any recommendation with respect to the fitment of any operator protection device to quad bikes. I join in the comments of the Deputy State Coroners of Queensland and New South Wales that evidence that all interested parties should be urged to continue to try to develop appropriate alternative safety devices.'

Coroner Cooper interpreted the Deputy State Coroners of Queensland and New South Wales to have found appropriate alternative safety devices should be developed. The ACCC does not agree with this interpretation of the Queensland and New South Wales inquest findings, and instead is of the view that coroners were supportive of OPDs if there was a demonstrable net safety benefit.

Real-world incidence of injuries and fatalities resulting from OPDs

Since the coronial inquiries, the three UNSW TARS sub-studies previously mentioned in this section have provided 'real world' data of injuries resulting from the use of OPDs, outlined above. There have been no quad bike fatalities where an OPD was implicated in the cause of death. There have also been no incidents identified where there were serious injuries to the head or chest attributable to an OPD.

The FCAI commonly refers to two incidents that implicate an OPD in the death of a quad bike rider. The ACCC understands in one case the rider was thrown clear of the quad bike and received fatal injuries, however the OPD did not contribute to those injuries.[123] In the other case it is understood that it was not an OPD, but rather, a large square after-market rack designed to carry fauna.[124]

Stakeholder feedback

Views on OPDs provided in submissions to the Consultation RIS have been discussed in section 9.2. Submissions indicated there was widespread support for some form of operator protection to prevent crush injuries from the research and medical sectors, government organisations, safety organisations and the agricultural sector. Many of these stakeholders were of the opinion that while an OPD would not stop an incident from occurring, it would provide a passive control that would reduce the severity of injuries resulting from a rollover incident. Many submissions to the Consultation RIS were of the view children should be banned from operating all quad bikes, however some submitted youth quad bikes should be subjected to OPDs given the preliminary recommendation for general-use model quad bikes to be fitted with OPDs. Proponents of this view included:

- Sydney Children's Hospital Network
- Maurice Blackburn Lawyers
- Geriatric Angels ATV Club Tasmania (although they supported OPDs for agricultural-use quad bikes only)
- Charles Jennissen and Gerene Denning
- Australian Centre for Health Services Innovation, Queensland University of Technology and Jamieson Trauma Institute, Queensland Injury Surveillance Unit, Orthopaedic Unit, Division of Surgery, Princess Alexandra Hospital and Metro South Health Service and Kidsafe Queensland (joint submission).

The National Farmers' Federation and Farmsafe Australia represent the highest users of quad bikes in Australia (farmers) and are supportive of the fitment of OPDs:

> *'While Operator Protection Devices (OPDs) will not prevent a rollover incident, it has been demonstrated that they will help to minimise the severity of injury received by the operator during a rollover incident when designed and fitted properly.'*[125]

The feedback on OPDs from individual consumers (predominantly farmers) was mixed, some supported the incorporation of mandatory OPDs into the design of quad bikes and others did not. One issue commonly raised was the danger associated with operating with an OPD in an environment with low branches, such as an orchard.

The ACCC has received anecdotal reports from stakeholders demonstrating a safety benefit from fitting OPDs:

- Landcorp, New Zealand reported: 'We have had a number incidents where the life guard device (ATV Lifeguard) has reduced the likelihood of injury towards the operator following a rollover so from that perspective it has been successful.'
- Ag-Tech Industries (the ATV Lifeguard manufacturer) visited a number of quad bike dealerships on a recent visit to Israel, where OPDs are required to be fitted to quad bikes. The dealerships and a manufacturer of the Israeli OPD were reported to have said they had not heard of any fatalities arising from quad bike rollovers since the introduction of the law (1995).

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123 Grzebieta RH, Rechnitzer G, McIntosh A, Mitchell R, Patton D, and Simmons K, (2014). 'Investigation and Analysis of Quad Bike and Side By Side (SSV) Fatalities and Injuries', Quad Bike Performance Project (QBPP) Report 3–2014: Supplemental Report, Transport and Road Safety (TARS) Research Report, submitted to The WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia.

124 FINDINGS, RECOMMENDATIONS and COMMENTS of Coroner Simon Cooper following the holding of an inquest under the Coro*ners Act 1995* into the quad bike related deaths of: Heather Dawn Richardson, Jan Severin Jensen, Kendall Russell Bonney, Vicki Mavis Percy, Jay Randall Forsyth, Jacob Graham Green and Roger Maxwell Larner. p. 23.

125 National Farmers' Federation and Farmsafe Australia submission to the Consultation RIS, p. 5.

Consumers have also provided feedback in support of OPDs mitigating injuries through testimonials provided to Ag-Tech Industries (ATV Lifeguard) and QB Industries (Quadbar). Some are provided for illustrative purposes:

- 'I am so convinced that the quad bar saved me from serious injury or death this week. I hit an unseen small bank at 40 km/h, the quad was airborne for six m until landing upside down facing back towards the bank. I did a face plant and have a very sore back but am truly thankful in being able to send this to you.'
- 'A few weeks ago I was going down a hill on the bike when it rolled, the bike rolled two or three times and I was thrown under the bike with the bike coming down on top of me. Lucky for me the 'Quad bar' took the total weight of the bike leaving a space under the bike where I was laying. I come out with a few scratches but nothing in comparison to what would have happened if the bike would have rolled on me.'
- 'Just a note to tell you that I fitted a quad bar to my bike only a month ago (purchased 24/8/11). Last Saturday I managed to reverse (thought I was in a forward gear) over a sheer bank into a small creek landed on my back on the other side of the creek with bike not having flipped but landing on its side in the creek. There is no question that the quad bar has saved me from a serious injury, but more probably my life! Not only that no damage to the bike. Just a bit of a tear on the sponge rubber. Yesterday I went to see an old mate who is home for a week from Burwood after six months wheelchair bound, and likely to be for the rest of his life, due to a pretty simple rollover, and I asked him if he had any sort of roll bar. The answer was of course no but that if he had had he wouldn't be in a wheel chair today!'
- 'I was herding cows over a dam embankment on my Honda ATV fitted with your 'Quadbar', when suddenly the bank gave way. I slid down the steep bank wall and rolled with the quad bike on top of me. I crawled out between the seat and the top of the bar. It saved my life. The Quadbar stopped the weight of the bike crushing me to death.'
- 'I was loading my UTE and as I was at the top of the ramps, just about onto the UTE, one of the rams gave way, the Quad Bike flipped 180 degrees, and I fell right under the falling Quad Bike, the ATV LIFEGUARD absorbed the impact and rolled the Quad Bike off me, without the ATV LIFEGUARD I would be dead'.
- 'As I ride a Quad Bike a lot, for hunting and general recreation, I have had many 'close shaves', and knew that one day it could be a bit more than just close shave. After installing it at the end of January '13, the Lifeguard has more than paid itself off. I've had a number of slow unexpected rollovers on terrain that wasn't very steep at all, and although the Lifeguard didn't hit me, it stopped my bike from rolling further, and soaked up the impact, and helped protect the bike—the carrier where it was mounted is still in perfect shape. It didn't slow me down or make it hard to get off when the bike did roll, which initially I thought it might. My previous thoughts that a 'Roll-Bar' was more dangerous are now gone after using the Lifeguard—it is really a revolutionary piece of kit, and I'm stoked something like this is now available.'
- 'You don't go out thinking 'I'm going roll a bike' no one does, it's just that accidents happen. Trying to head off some bulls, my quad flipped and that Life -Guard went straight down into the middle of my back, and it was like someone putting their hands down on the middle of ya spine, and within another split second the bike was down in the middle of that swamp, rolled straight back onto its wheels and was still sitting there idling. You can train for something to happen, but an accident, you never know how it's going to be. Without the Life-Guard, the bike would have been on top of me. If you were sitting in hospital, with a broken back, you just wouldn't care what the roll frame cost if you thought that could of prevented it.'

Submissions from stakeholders within the recreational sector generally did not support the fitment of OPDs on general-use model quad bikes, believing they would have a negative safety impact for recreational users.

Major quad bike manufacturers, the FCAI and MTAA oppose the fitment of OPDs to general-use model quad bikes. These stakeholders consider there to be no evidence demonstrating OPDs increase safety.

During consultation, Polaris stated quad bikes landing on their side were associated with more fatalities where the rider was pinned by the quad bike and asphyxiated than any other orientation. Polaris stated OPDs increase the risks posed by quad bikes through encouraging the vehicle to land on its side. The FCAI raised similar concerns in its submission to the Consultation RIS.[126]

Polaris's view that quad bikes landing on their side are more dangerous than any other final orientation (upright or upside down) is based on the assumption the final resting location of a quad bike is significant in determining the severity of an incident. While it is known that quad bikes landing on their sides are more represented in fatalities, the relative frequency of quad bikes landing on their side from a rollover or landing in another position is unknown. This means it is not possible to determine whether quad bikes landing on their side increase the severity of incidents.

Polaris also raised concerns that preventing a quad bike from rolling more than 90°, as the after-market OPD Quadbar is designed to do, may increase the severity of an injury received from a rollover incident.

The ACCC discussed this matter with UNSW TARS authors, who provided further information on fatalities in coronial databases. Over 70 per cent of fatalities from the coronial databases involved the quad bike rolling more than 90°, and most of these fatalities involved the quad bike being in the upside down position or rolling 360° or more (not a 270° rollover).[127] The high frequency of fatalities when the quad bike rolled 360° or more is consistent with the UNSW TARS survey finding that:

> *the risk of any injury when a Quad bike rolls over the rider is around five times compared to the Quad bike not rolling over the rider and around six and half times higher risk of being hospitalised.*[128]

The available information suggests preventing a quad bike from rolling over the operator, including by preventing the vehicle from rolling more than 90° (as is the intended design of the Quadbar), is likely to reduce the severity of a rollover incident.

Requirements for an OPD Standard

Despite the Consultation RIS recommending an OPD must be able to have a lateral energy absorption capacity greater than 1.75 times the vehicle mass, a prescriptive performance requirement was considered by the ACCC to not be practical at this time. While some stakeholders considered the testing protocols of other prescriptive international standards for OPDs a good starting point for a quad bike OPD standard[129], the ACCC has concluded more testing should be undertaken to ascertain their direct relevance to quad bike OPDs.[130]

The ACCC is of the view OPDs should not restrict innovation and should recognise manufacturers are best placed to assess design and structural requirements for OPDs. The requirements for an OPD standard should be flexible and allow manufacturers to develop innovative OPDs, or assess which after-market OPD to attach, based on the specifications and performance of its quad bike models. For these reasons, this general, performance-based requirement is preferred:

126 FCAI submission to the Consultation RIS, pp. 55–56.

127 Fatalities where the number of rolls were unknown were removed, as well as fatalities where there was uncertainty in whether the fatality involved a 90° rollover or a 270° rollover.

128 University of New South Wales Transport and Road Safety Research Unit. Quad bike and OPD workplace safety survey report: Results and conclusions, provided to WorkCover Authority of New South Wales May 2017, p. 35, available: http://www.quadbike.unsw.edu.au/sites/default/files/uploads/Quad_Workplace_Safety_Survey_Report.pdf.

129 Including, ISO 5700:2013 Tractors for agriculture and Forestry—Roll-over protective structures—Static test method and acceptance conditions; ISO 21299: 2009 Powered ride-on turf care equipment—Roll-over protective structures (ROPS)—Test procedures and acceptance criteria.

130 This view was shared by SEA Ltd, Frank Ford and Ross Macmillan (University of Melbourne).

A general use quad bike must have a device fitted, or integrated into its design, that helps to protect operators from the risk of serious injury or death as a result of being crushed or pinned in the event of a rollover.

A general use quad bike must:

a. have one of the following types of device fitted, or integrated into its design, at the date of commencement of the safety standard:
   - Quadbar
   - ATV Lifeguard

or

b. have a device fitted, or integrated into its design that has a substantially similar (or better) level of overall operator protection to the devices listed above.

This performance-based requirement was developed by the ACCC with input from Professional Engineering Consultants Pty Ltd, Troutbeck and Associates and other Commonwealth agencies.

While there are a number of functions the OPD could perform beyond the above requirement, for example, mitigating the risk of the quad bike rolling over the operator, the current priority is addressing the risk of operators being crushed or pinned by the quad bike. UNSW TARS found from examining coronial cases that 69 per cent of the farm workers fatally injured were pinned under the quad bike, with most experiencing crush injuries or asphyxiation, and one third of fatalities involving recreational riders were a result of being pinned under the quad bike.[131] UNSW TARS report in asphyxia cases where a worker was pinned under the quad bike, the worker typically suffered no injury to a body region other than the thorax, and injuries to the thorax were otherwise not likely to be fatal. It reports twenty of the farm workers who died of asphyxia (more than 75 per cent) were likely to have survived the incident if the vehicle did not pin them with a force sufficient in terms of magnitude and duration to cause asphyxia.[132] Taken together, this information indicates more than a third of all quad bike fatalities may be prevented by the addition of OPDs designed to prevent operators from being crushed or pinned.

This performance requirement does not preclude manufacturers from producing OPDs that have additional safety functions and product safety best practice requires consideration of additional safety functions with regard to reasonably foreseeable consumer use and misuse, as discussed at section 6.

Review by Troutbeck and Associates

The ACCC requested Troutbeck and Associates consider the safety benefits of fitting OPDs to general-use model quad bikes and critically review Option 3 presented in the Consultation RIS.

Troutbeck and Associates examined the OPD information and evidence obtained during the investigation and engaged with local and international agricultural engineers and quad bike experts on the efficacy of OPDs.

Troutbeck and Associates found the investigations and surveys consistently show the use of OPDs is beneficial, and concluded that although the case studies and surveys have limitations, the benefits of fitting OPDs outweighs the harm.

Troutbeck and Associates recommended, in accordance with Option 3 in the Consultation RIS, tested and effective OPDs be required to be integrated into the design of general-use model quad bikes.

131 Grzebieta R, Rechnitzer G, McIntosh A, (2015) ‘Rollover Crashworthiness Test Results’, Quad Bike Performance Project TARS Research Report No. 3, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia p. 12.

132 Grzebieta R, Rechnitzer G, McIntosh A, Mitchell R, Patton D, Simmons K, University of New South Wales Transport and Road Safety Research Unit, Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries, provided to WorkCover Authority of New South Wales January 2015, p. 7.

Quad bike case law

McHugh v BKE Pty Ltd as trustee for the B W King Family Trust [2018] QDC 254.

Facts

The plaintiff was mustering cattle and sharing his attention between the cattle and the operation of the quad bike. The plaintiff was driving at around 10km/h when he partially went down a ditch (the right front wheel of the quad bike), and in order to stop the quad bike rolling over, instinctively put his right leg out onto the ground. This caused significant injury, but stopped the quad bike from experiencing a rollover.

Finding

Reid DCJ found that without rollover protection, a seatbelt, and netting, a quad bike was not suitable for the purpose of mustering cattle on the relevant property.

Reid DCJ also found the defendant was negligent through its director, as the director knew, or ought to have known of, the dangers associated with quad bike operation on the relevant property, and failed to provide for the plaintiff's safety when the director did not:

- provide rollover protection, a seatbelt and protection such as by netting
- provide an alternative safe vehicle, such as an SSV
- conduct a safety audit of any kind which would have identified the relevant risk and a practical means of overcoming it.

Additionally, Reid DCJ found the plaintiff to be negligent and responsible for 20 per cent of the incident as he departed from the standard expected of a quad bike rider.

Finding

The ACCC recommends general-use model quad bikes be fitted with, or have integrated into their design, an OPD.

The available information indicates after-market OPDs improve the safety of quad bike operators. There has been no reliable evidence provided to the ACCC that presents an alternate conclusion. While it is noted that in some situations after-market OPDs may contribute to injuries, these are usually minor relative to crush injuries and asphyxiation. Quad bikes with OPDs will improve the safety of consumers and reduce fatalities where an operator would have otherwise been pinned underneath the quad bike with a force sufficient to cause asphyxia or serious chest injuries.

The relative efficacy of after-market OPDs compared to OPDs integrated into the device of a vehicle is not known. The Polaris Ace is an example of a hybrid vehicle that has integrated an OPD into its design and made other design changes to suit the specifications and performance of the vehicle, including fitting seatbelts and a steering wheel.

Manufacturers have a commercial incentive to produce safe and effective OPDs and at the design stage, quad bike manufacturers should consider whether an after-market or in-house developed OPD would best suit the specifications and performance of quad bike models. Other pertinent considerations at the design phase include:

- the centre of gravity of models and whether design changes should be pursued to ensure OPDs do not result in a significant increase to the centre of gravity of models
- the speed capabilities of models and whether speed limiting models may be appropriate
- the height of the preferred OPD and whether it complements the marketed use of the model
- whether the OPD can limit the number of 90 degree rolls a quad bike will experience during a rollover event
- whether other design modifications are appropriate, including the integration of a seatbelt.

While the ACCC is only recommending a performance requirement, design characteristics will remain at the discretion of manufacturers, and should result in OPDs that meet community expectations of safety.

10.5 Stability

Overview

Quad bike static stability refers to the resistance of the quad bike to lateral roll, forward pitch roll and rearward pitch roll. Static stability is dependent on a vehicle's dimensions and weight distribution. Quad bikes need sufficient stability to provide an opposing static force to counteract lateral or longitudinal overturning forces acting on it (for example, gravitational forces from traversing an incline), to avoid rolling over.

The static stability of the quad bike is dependent on two factors:

- the physical make-up of the quad bike itself—including the fundamental geometric properties
- additional effects, for example the size and weight of the driver, cargo (front or rear) and/or attachments (spray tanks, presence of passengers, towing a load, and driver lean (active riding position).

Measurements of static stability

The static stability of a quad bike may be measured in two different ways:

- Stability coefficient (K)
  - K_{st}—Lateral stability coefficient
  - K_{pf}—Forward pitch stability coefficient
  - K_{pr}—Rearward pitch stability coefficient
- Tilt table ratio (TTR)—Values can be determined for lateral, forward pitch and rearward pitch stability
  - A vehicle is placed entirely on a table which tilts and raises one side of the vehicle higher than another. Figure 14 shows a test of lateral stability. The angle between the table and ground is increased until a critical angle is reached at which the high side tyres lift from the table, and the vehicle rolls over if not restrained. The critical angle is called the Tilt Table Angle. The TTR is the tangent of the Tilt Table Angle.

Figure 14: Typical tilt table quad bike lateral roll test[133]

The Consultation RIS proposed tilt table tests be undertaken using a 50th Percentile Adult Male (PAM) Hybrid III (H3) Anthropomorphic Test Dummy (50th PAM ATD). In response to the Consultation RIS concerns were raised about:

- testing repeatability using a test dummy, and it was recommended that testing should be uncomplicated and a defined (simple size, weight, shape) ballast could be used[134]
- the dummy being unrealistically perpendicular to seat (no upper body lean)[135]
- there is no accounting for sideslip and tyre/soil penetration that occurs in actual cross-slope conditions.[136]

Troutbeck and Associates found using a 50th PAM ATD would represent 'average conditions' and as the static stability tests are designed to provide an indicator over a range of conditions, the 50th PAM ATD is appropriate.

133 Grzebieta R, Rechnitzer G, Simmons K 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015). Attachment 2: Crashlab Static Stability Test Report.

134 Down Under Dirt Bike Sales and QB Industries, submissions to Consultation RIS,.

135 FCAI, submission to Consultation RIS.

136 Ibid.

Quad bike characteristics influencing static stability

The physical properties of a quad bike influences static stability. Estimates or definitions of static stability coefficients indicate important characteristics that influence quad bike static stability: [137]

Lateral stability:

$$K_{st} = [Lt_2 + L_{cg}(t_1\text{-}t_2)]/2\ L\ H_{cg}$$

- L is the wheelbase
- t_1 and t_2 are the front and rear track width respectively
- L_{cg} is the location of the centre of gravity (CG) forward of the rear axle
- H_{cg} is the height of the CG above ground

For quad bikes the front and rear track widths are similar in dimension or the same, i.e. (t_1-t_2) is small, so for lateral stability the most significant factors are track width and height of centre of gravity.

Longitudinal stability:

$$K_p = L1/H_{cg}$$

- L_1 is distance of the combined CG from forward or rear axle for forward and reward pitch respectively
- H_{cg} is the height of the combined CG

For longitudinal stability, the key factors are wheelbase and height of centre of gravity.

Performance requirements for static stability

The US standard ANSI/SVIA 1–2017 sets a minimum performance requirement for the rearward pitch stability coefficient (K_{pr}) of 1.0, but sets no performance requirements for forward pitch stability or lateral stability.

The UNSW TARS data indicates all the quad bikes tested would satisfy the static stability requirements of the ANSI/SVIA 1–2017.[138]

The Consultation RIS proposed that static stability testing be included as a component of a safety star rating system and proposed minimum performance requirements for Tilt Table Ratios (TTRs), measured with a 50th PAM H3 ATD, of:

- lateral roll TTR minimum—0.8 (minimum tilt table angle of 38.7 degrees)
- forward pitch TTR minimum—1.10 (minimum tilt table angle of 47.7 degrees)
- rearward pitch TTR minimum—1.0 (minimum tilt table angle of 45.0 degrees).

In its response to the Consultation RIS, Honda reported that a static stability test is fair and reasonable, but the minimum stability tilt table angles proposed in the Consultation RIS were not justified.[139] In its submission to the Consultation RIS, Polaris stated the additional testing requirements in Option 4 (which include static stability testing) are without evidentiary basis.[140]

137 Simmons, K. Australian Safety Requirements and Test Methods for Quad Bikes, Discussion and Justification Document (2018).

138 Grzebieta R, Rechnitzer G, Simmons K, 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015).

139 Honda. Submission to Consultation RIS

140 Polaris. Submission to Consultation RIS

The values proposed in the Consultation RIS were considered to be performance levels that could be achieved[141], based on the UNSW TARS test results of a prototype quad bike[142] (discussed below).

Current static stability levels of quad bikes

The TTR values proposed in the Consultation RIS would not be met by any of the commercial quad bikes tested in the UNSW TARS project[143] or any of the quad bikes tested by SEA Ltd for the US CPSC.[144] Submissions to the Consultation RIS have confirmed that current general-use model quad bikes would not meet the static stability requirements proposed in the Consultation RIS, and no manufacturer or other stakeholder has advised the ACCC of any substantive improvements in the static stability of quad bikes since these tests were undertaken.

UNSW TARS conducted tilt table tests for lateral rollover and forward and rearward pitch rollover, with and without a rider and with combinations of maximum cargo loads positioned on the front and rear of the vehicle. One of the quad bikes tested was a prototype quad bike with modifications to increase its track width.

A summary of static stability results from the UNSW TARS tests is shown in table16. The baseline measurement reported is a test for the vehicle alone (no rider or load). For a given vehicle, the most significant change in TTR (a decrease) occurs when going from no rider to having a rider. When there is a rider present, the addition of loads, for example liquids in spray tanks, impacts on static stability, but to a lesser extent than the presence of a rider. The addition of front or rear loads was found to reduce lateral stability. A front load increased rearward pitch stability, but decreased forward pitch stability by a greater amount, while a rear load increased forward pitch stability but decreased rearward pitch stability by a greater amount.

SSVs demonstrated a significantly higher lateral TTR than quad bikes (0.65–0.96 with 95th PAM ATD, compared with 0.46–0.60 for quad bikes with 95th PAM ATD).

In its response to the Consultation RIS, the TRG commented that the proposed limits may appear high for current vehicles (especially the lateral roll TTR of 0.8), but could be achieved with design changes.[145]

141 Simmons K, Australian Safety Requirements and Test Methods for Quad Bikes, Discussion and Justification Document (2018).

142 Grzebieta R, Rechnitzer G, Simmons K, 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015).

143 Ibid.

144 SEA, Ltd, 'Vehicle Characteristics Measurements of All-Terrain Vehicles'. 1 January 2017

145 Quad Bike Interdepartmental Committee, Technical Reference Group. Submission to Consultation RIS.

Table 17: Static Stability Test Results from UNSW TARS report

	TTR and Load Condition						
Vehicle type	Test	Baseline	Operator only	Operator plus rear load	Operator plus front load	Operator plus front and rear load	TTR Maximum Reduction from base line %
Work Quad	Lateral roll	0.72 to 0.82	0.46 to 0.60	0.44 to 0.56	0.43 to 0.57	0.41 to 0.55	43%
	Rear Pitch	1.13 to 1.31	0.78 to 0.95	0.62 to 0.79	0.81 to 1.01	0.68 to 0.82	40%
	F'ward Pitch	1.12 to 1.34	0.94 to 1.08	0.97 to 1.10	0.82 to 0.94	0.89 to 1.02	30%
SSV	Lateral roll	0.85 to 1.01	0.65 to 0.96	0.64 to 0.83	na	na	25%
	Rear Pitch	1.08 to 1.66	1.04 to 1.49	0.77 to 1.01	na	na	39%
	F'ward Pitch	1.89 to 2.18	1.70 to 1.88	1.81 to 1.95	na	na	14%
Prototype Quad bike	Lateral roll	0.99	0.81	0.76	0.79	0.75	24%
	Rear Pitch	1.19	0.94	0.85	0.97	0.85	28%
	F'ward Pitch	1.18	1.01	1.06	0.94	0.96	11%
Sports/ Rec Quad bike	Lateral roll	0.93 to 1.10	0.56 to 0.78	na	na	na	40%
	Rear Pitch	1.17 to 1.32	0.73 to 0.90	na	na	na	37%
	F'ward Pitch	1.31 to 1.39	0.97 to 1.10	na	na	na	26%

Table 11: Tilt Table TTR Summary of Results. Comparison by vehicle type category and change in TTR with maximum loading. 95th PAM ATD used except for Can-am DS90X youth model where 5th PAF ATD used.

When general-use model quad bike static stability values (Kst) from 1991[146] (US CPSC tests) to 2013[147] (UNSW TARS tests) are compared, the results show that the majority of quad bikes have a static stability coefficient of 0.9 Kst. If the quad bike models tested in 1991 and 2013 were representative of the broader market at the time of testing, the test results indicate the average stability of general-use model quad bikes decreased between 1991 and 2013.

Table 18: Comparison of Kst values for general-use models quad bikes tested in 1991 and 2013

Reference	General-use models tested	Percentage with Kst=0.8	Percentage with Kst=0.9	Percentage with Kst=1.0
Deppa (1991)	27	0	74	26
UNSW TARS (2015), tested by Crashlab in 2013	8	25	75	0

146 Deppa RW, (1991). Engineering Reprt on the Technical Feasibility of ATV Standards. United States Consumer Product Safety Commission (CPSC) COR Exhibit F15. p. 148 of 268.

147 Grzebieta R, Rechnitzer G, Simmons K, (2015) 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia. Attachment 2: Crashlab Static Stability Test Report. p. 28 of 30.

Whether a quad bike will slide or roll over

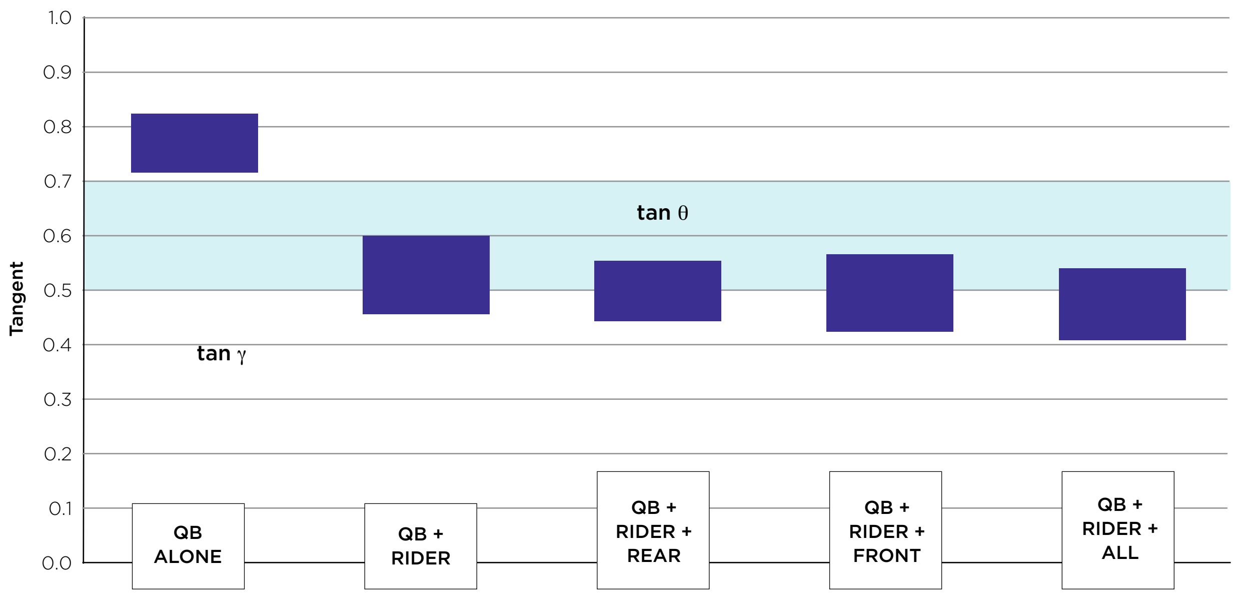
When an operator loses control of a quad bike the quad bike may slide or rollover.[148] Which, if any, of these will occur depends on a number of factors, including the type of terrain the quad bike is operated on.

Macmillan explains that for a quad bike to become unstable and tip instead of slipping/sliding, the sheer strength of the soil/wheel patch (the force resisting slip) must exceed the component of gravitational force at the wheels (the force causing slip).[149]

In figure 15, the black vertical blocks are lateral static stability results (TTR values) for commercially available quad bikes tested by UNSW TARS.[150] The grey horizontal band covers the range of lateral traction coefficients on Australian agricultural soils for tractors (data is not available for quad bikes).[151] A higher lateral traction coefficient is representative of a higher friction surface, for example a hard, dry surface. Below the grey horizontal band, surfaces are more slippery.

The higher the TTR value, the more likely the quad bike will slide rather than roll over. The results indicate that there are situations where the quad bike will slide and situations where it will roll over, and both happen in practice (noting the grey band may be in a different position for quad bike tyres).[152]

Figure 15: Static lateral instability angles (shown as tan ϒ) for the eight general-use model quad bikes and a range of typical lateral traction coefficients (tan θ) for tyres on agricultural soils[153]



Troutbeck and Associates found the research by Macmillan demonstrates:

> *'...the links between static stability, dynamic stability and ground shear conditions. The static stability TTR values are then an indicator and not a predictor of rollover propensity in the field. However, the results are repeatable, within limits, and do indicate stability.'*[154]

148 Macmillan RH, Quad-Bike Operational Instability, Safety 2017, 3, 15.
149 Ibid.
150 Grzebieta R, Rechnitzer G, Simmons K, 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015).
151 Macmillan RH, Private communication, September 2018.
152 Ibid.
153 Macmillan RH, Quad-Bike Operational Instability, Safety 2017, 3, 15.
154 Troutbeck and Associates, 'Evaluation of options to improve safety when using quad bikes and SSVs', provided to the ACCC September 2018, p. 19.

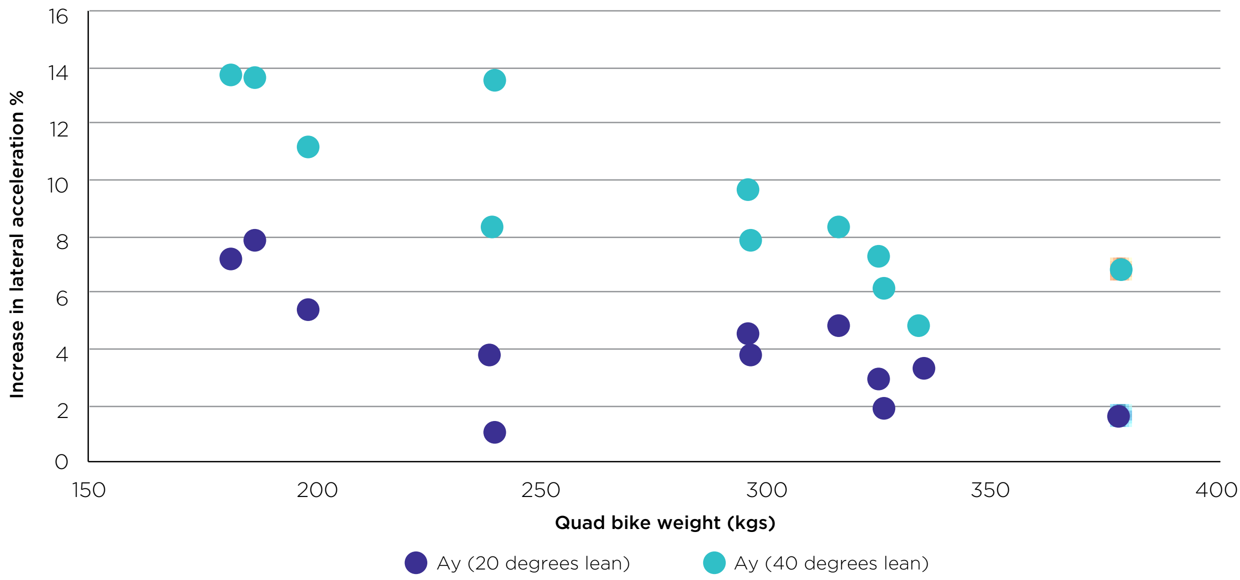
Effects of active riding

The importance of active riding was emphasised in a number of submissions to the Consultation RIS.[155] Active riding contributes to maintaining the stability of the quad bike through adjustments to the centre of gravity of the bike due to the rider's movements.

Research informing the relative contribution of active riding to quad bike stability was undertaken by SEA Ltd for the US CPSC. The tests were conducted using SEA's ATV (quad bike) Robotic Test Driver (97.5 kg in weight) which mitigated the potential for having the test results influenced by using different human drivers.[156] Three different driver lateral lean angles were evaluated, one representing an upright driver (0° lateral lean angle), one representing a driver with a 20° lateral lean angle, and one representing a driver with a 40° lateral lean angle.

The impact of different rider lean angle is illustrated in the results for lateral acceleration measured in the 20 mph (32 km/h) Left Turn Dropped Throttle J-Turn Tests. The results showed, as lean angle is increased, the lateral acceleration level at which the inside wheels lift, (two-wheel lift/tip-up) also increases. This is shown in figure 16 (plotted using SEA data). It also indicates the impact of active riding decreases as the weight of the quad bike increases. This latter observation is of significance in relation to general-use model quad bikes most commonly used in Australia, which typically weigh from 300–400 kgs unladen.

Figure 16: Effect of driver lean angle and quad bike weight on lateral acceleration for 2-wheel lift



Source: SEA Ltd.

All of the information provided to the ACCC indicates active riding is not likely to be an effective safety strategy as:

- it relies on the operator being able to understand when to actively ride; if a bump or terrain change surprises the operator they may not be able to quickly compensate by active riding
- the effect of active riding is determined in part by the quad bike/consumer's weight, so active riding may not be an effective safety strategy for some lighter consumers (lighter operators will be less able to move the centre of gravity of the quad bike), and for all consumers operating heavier quad bikes
- it assumes operators are willing and able to actively ride at all times
- it is impacted by the operator's physical abilities and level of fatigue

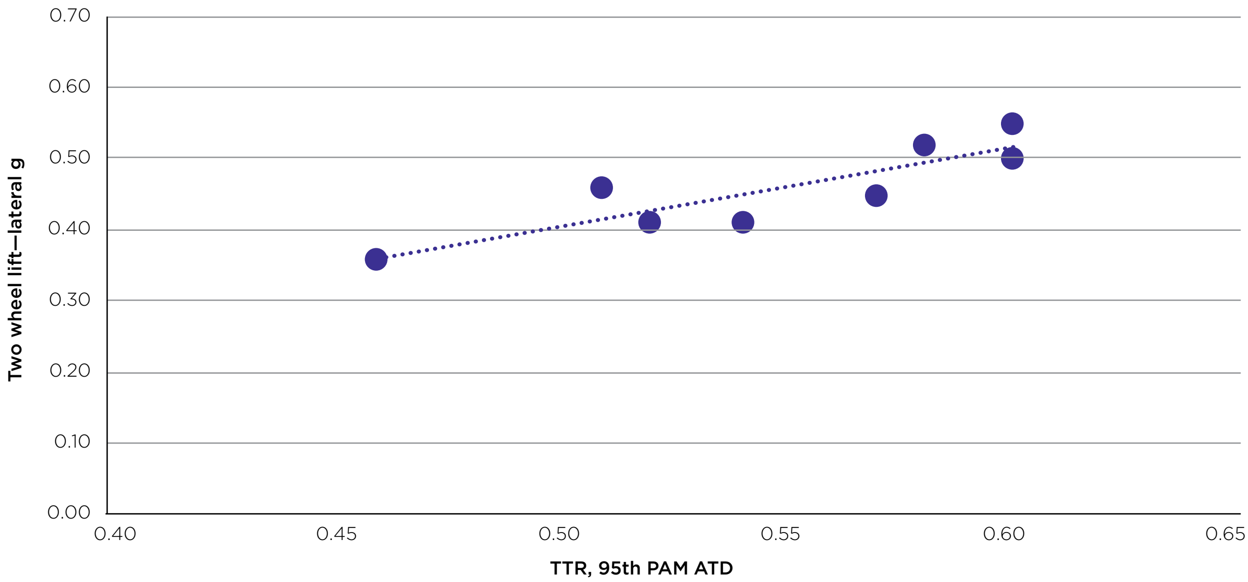
155 FCAI. Submission to the Consultation RIS.
156 SEA Limited. 'Effects on ATV Vehicle Characteristics of Rider Active Weight Shift'. 1 January 2018

- it may not be possible to actively ride at the same time as safely completing tasks that are within the foreseeable use of the product, such as mustering livestock[157].

The importance of static stability in practice

Tests conducted on quad bikes by UNSW TARS[158] and SEA Limited[159] show a strong relationship between lateral static stability (TTR) and lateral acceleration (Ay) at which two-wheel lift occurs (figures 17 and 18). As static stability increases, Ay increases. This was shown in two different types of tests, the steady state circle test (UNSW TARS), and the J-Turn test (SEA Limited). Two-wheel lift occurs at a lateral acceleration value of around 0.1g less than the TTR in both sets of tests. These tests show a clear relationship between static stability and the tendency for the vehicle to rollover.

Figure 17: Plot of lateral acceleration at 2-wheel lift vs TTR



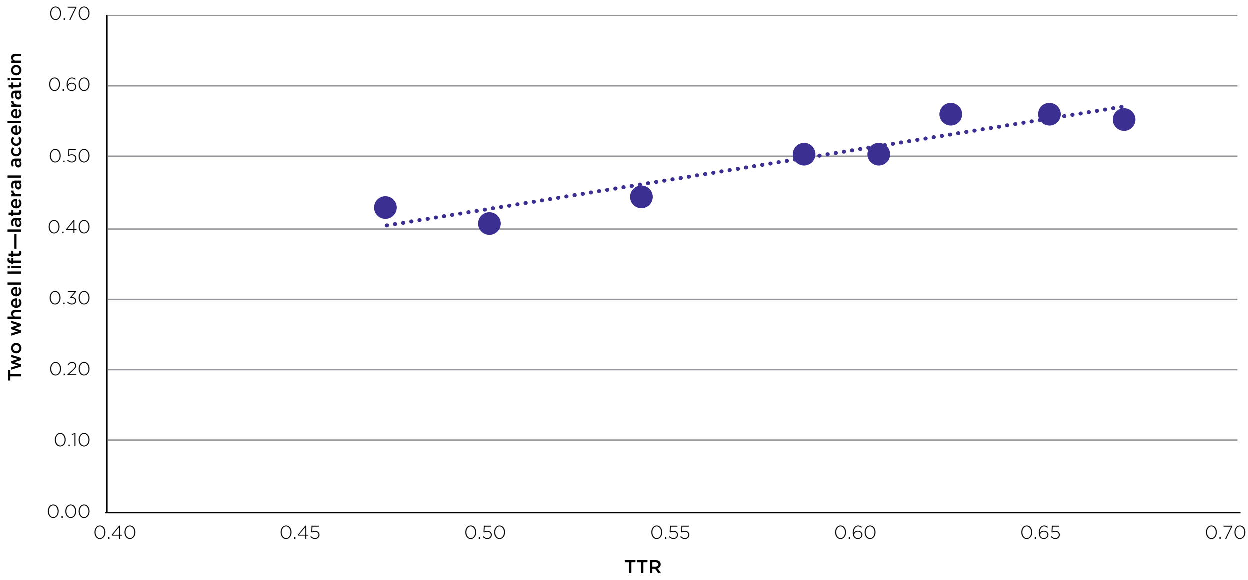
Source: UNSW TARS stead state circle test.

157 Over 57 per cent of quad bike incidents in the UNSW TARS workplace survey occurred while mustering (including incidents that did not result in injury).

158 Grzebieta R, Rechnitzer G, Simmons K, 'Dynamic Handling Test Results', Quad Bike Performance Project TARS Research Report No. 2, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015).

159 SEA, Ltd, 'Vehicle Characteristics Measurements of All-Terrain Vehicles'. 1 January 2017. Vehicle Characteristics Measurements of ATVs Tested on Groomed Dirt'. 23 February 2018.

Figure 18: Plot of lateral acceleration at 2-wheel lift vs TTR



Source: SEA Ltd J-turn test data.

In his submission to the Consultation RIS, Roy Deppa, the former Chief Engineer of All Terrain Vehicles for the CPSC, states the current lateral stability of quad bikes will mean a continuation of the current levels of fatalities and injuries. His submission discusses the CPSC staff's proposal to the CPSC Commissioners to require an increase in the stability coefficient of quad bikes. To introduce regulation, the CPSC staff were required to show (using empirical data) that the minimum stability coefficient would result in a finite reduction in the number of fatalities and injuries attributable to quad bikes. Deppa states the proposal was 'doomed' because there were no quad bikes available on the market with stability coefficients significantly above the recommended level, and therefore no data for the regression analysis.

In its submission to the Consultation RIS, the FCAI interprets this as indicative that the risk of injury increases from increased stability.[160] However, a staff proposal paper in 1991 on the feasibility of engineering standards to address quad bike safety states:

> *'Engineering judgement and experience run counter to these findings (that increased stability will not increase safety) because the results of engineering work indicate that higher stability should result in fewer rollovers. Specifically, the physics underlying the dynamic conditions indicate that even within the ranges of variables studied, increasing values of K_{st} (stability) can result in vehicles with lower propensity to rollover during certain operations.'* [161]

Scheers reported in 1991 there was a lack of a consistent relationship between increasing K_{st} and decreasing rate of injury.[162] Data is shown in table 19. Most of the quad bikes used by riders in the survey are lighter than general-use model quad bikes currently sold in Australia.

Troutbeck and Associates found the available data was unable to show a statistically significant relationship between lateral stability and vehicle safety. However, for injury data to produce statistically significant results for a change in vehicle stability, large data sets would be required because of the number of potential variables in an incident.

160 FCAI submission to the Consultation Regulation Impact Statement, pp. 59–60.

161 'United States Consumer Product Safety Commission, The feasibility of engineering standards to address all terrain vehicle safety' Roy W Deppa, Directorate for Engineering Sciences, United States Consumer Product Safety Commission, p. 13.

162 Scheers NJ, Newman R, Polen C, Fulcher D, The risk of riding ATVs: A comparison from 1985 to 1989. Consumer Product Safety Commission, Directorate for Epidemiology, February 1991.

Table 19: Exposure (E) and injury (I) observations for quad bikes

Vehicle weight		K_{st} range			
		0.87 to 0.90	0.91 to 0.94	0.95 to 0.99	1.00 to 1.08
<181 kg	Injuries (I)	23	59	7	0
	Exposure (E)	77	156	5	15
	I/E	0.30	0.38	*	0.0
181–226 kg	Injuries (I)	17	8		0
	Exposure (E)	52	28		26
	I/E	0.33	0.29		0.0

* This entry had small sample sizes and multiple injuries in one or more events.

Source: Scheers et al., 1991.

Improving the static stability of quad bikes

In the ACCC's view, a quad bike safety standard which stipulates minimum performance requirements for stability is preferred over prescribing specific design requirements. Minimum performance requirements allow manufacturers to meet performance requirements through design modifications (if necessary) at their discretion. Quad bike stability has been shown to be improved by certain design modifications, including: increasing track width for lateral stability, increasing wheelbase for longitudinal stability or reducing the height of centre of gravity for stability in all directions. Any of these design modifications, or others, may be pursued by manufacturers to meet the proposed minimum stability performance requirements.

In its submission to the Consultation RIS, Kuranda Rainforest Journeys reported it had been conducting tour operation services for two and a half years without experiencing a rollover. In 2017, it replaced its quad bike models, but all other aspects of its operation remained the same. However, rollovers began to occur.[163] In order to prevent rollovers from occurring with the new quad bike model, Kuranda Rainforest Journeys:

- acquired one set of lower profile rear tyres (it could not effectively source front tyres) to try on one quad bike and reported this made some difference
- fitted after-market hub spacers, which fit in behind the wheel, effectively increasing the wheel width of the quad bike by 100 mm (50 mm per spacer) to all four wheels.

Since the above adjustments to improve stability were undertaken, the organisation reports it has not had a rollover occur:

> *'In fact, since fitting the spacers I have personally observed a customer getting into exactly the same situation in exactly the same spot as a previous rollover and whilst the bike did tip precariously it did not roll!'*[164]

The wider track width prototype quad bike tested by UNSW TARS[165] was found to have a significantly higher lateral TTR (0.81 with 95th PAM ATD) compared with all of the other general-use model quad bikes tested (0.46–0.6 with 95th PAM ATD).

163 Kuranda Rainforest Journeys. Submission to Consultation RIS.

164 Ibid.

165 Grzebieta R, Rechnitzer G, Simmons K, 'Static Stability Test Results', Quad Bike Performance Project TARS Research Report No. 1, submitted to the WorkCover Authority of New South Wales, University of New South Wales, Sydney, Australia (2015).

In its submission to the Consultation RIS Heavy Fix NQ (an inventor of an after-market quad bike sway bar release mechanism) reported that increasing wheel track width, wheel base length or lowering the centre of gravity would be an advantage for stability, but is not a perfect solution:

- on increasing wheel track width or wheel base length: 'In some situations a wider or longer quad bike would be a lot safer, but in other places either extra dimension would be a distinct disadvantage. Examples include tight tree-lined ridges, washed out tracks, fitting between rocky outcrops, going over steep humps in the ground or logs or obstacles on the road. A bike with a longer wheel base would bottom out in many places and have a larger turning circle. The reality is that no single design can accomplish all required functions'.[166]
- on lowering the centre of gravity: 'most quad bike manufacturers have got the engine transmission and diffs as low as possible now. If you lower the bike physically, the unit will be more stable but ground clearance will be sacrificed. I feel there should be a stipulated ratio of ground clearance to track width so that the greater the ground clearance, the wider the track width'.[167]

In its submission to the Consultation RIS, the FCAI reported a number of potential issues associated with increasing the static stability of quad bikes:

- Such a test and criterion (high TTR requirements) would result in quad bikes with longer wheelbase, wider track and/or lower ground clearance.
- From the viewpoint of user ride-ability, all of these changes result in reduced quad bike mobility (i.e., their clearance ratios would decrease and they would be less capable/useable in rough terrain). There would be more undercarriage 'ground strikes', which are annoying, potentially damaging to crucial safety-related components, expensive to repair and also hazardous.
- From the viewpoint of effects on fatalities, this is unknown as there are no sufficiently detailed data sets available. According to the 1989 CPSC revised study, a 24 per cent increase in static stability resulted in a non-statistically significant increase in fatality rate of 62 per cent. Potential mechanisms are (a) the greater speeds and slopes at which overturn occurs, thus increasing injury potential; (b) increased undercarriage 'ground impact', which in itself can result in rider ejection from the quad bike, quad bike overturn, and/or damage to safety-related vehicle components (suspensions, tyres, wheels, brake system, etc.); and (c) reduced ability of the quad bike to roll away and separate from the rider due to its flatter (wider, longer, lower) shape.

The FCAI also stated in its submission to the Consultation RIS that vehicles with greater stability could overturn at greater slopes and higher speeds which could lead to increased injury severity.[168] The FCAI did not provide any evidentiary support for this view and the ACCC is not aware of any evidence which suggests consumers will begin operating quad bikes on different slopes and speeds due to increased stability. Additionally, as an agency with product safety responsibility, the ACCC cannot accept any line of reasoning that suggests safety intervention should not be pursued on the basis of a hypothetical increased potential for consumer misuse. Instead, the ACCC is of the view that in reasonably foreseeable conditions and uses, consumers' safety will be increased due to operating more stable vehicles.

Review by Troutbeck and Associates

Troutbeck and Associates examined the proposed minimum performance requirements for static stability as part of its review of the options proposed in the Consultation RIS. It found engineering and physics demonstrate making the vehicles more stable will reduce the vehicle's propensity to roll over and the general incident statistics show that lateral rollover has a significant risk of fatality, and the potential for lateral rollover is reduced with more stable vehicles. Consequently, Troutbeck and Associates conclude actions to improve lateral stability should be supported even if the data cannot show statistically significant beneficial trends at this time.

166 Heavy Fix NQ submission to Consultation RIS, p. 4.
167 Ibid.
168 FCAI submission to the Consultation Regulation Impact Statement, p. 60.

Testing requirements

Troutbeck and Associates consider that an important part of the testing requirements is that the tests be repeatable at one test site and reproducible at other test sites. Accordingly, simplifying the tests, where appropriate, is important. They concluded that a reduced number of loading configurations would simplify the subsequent analysis.

Troutbeck and Associates also concluded:

- A simpler testing program than proposed in the original UNSW TARS five star safety rating system is recommended, using the minimum longitudinal and the minimum lateral TTR values to define static stability.
- For vehicles travelling across slopes, the stability of the vehicle going in each direction needs to be considered. The lateral static stability TTR values are not necessarily the same for vehicles orientated in the two directions across a slope. Accordingly, it is reasonable to consider the minimum tilt table ratio (TTR values) for tests with the vehicle facing to the left or right across the tilt table.
- The reason for requiring the minimum longitudinal and the minimum lateral measures is that vehicles need to both climb and descend slopes and they need to drive across slopes in both directions. There would be no point in having a vehicle being able to descend a slope without being able to ascend it again.

Troutbeck and Associates also observed it is impossible to design a representative or worst-case load and conclude that it is not informative to use TTR values from a loaded quad bike. In all testing, Troutbeck and Associates recommend a 50th PAM ATD rider be attached but no other loads.

For static stability, Troutbeck and Associates recommend two measures be used:

- for lateral roll—measuring the tilt table ratio (TTR values) for tests with the vehicle facing to the left and to right across the tilt table, and determining the minimum value of the two
- for longitudinal stability—the minimum TTR of forward and rearward pitch tilt table tests.

Recommended performance levels

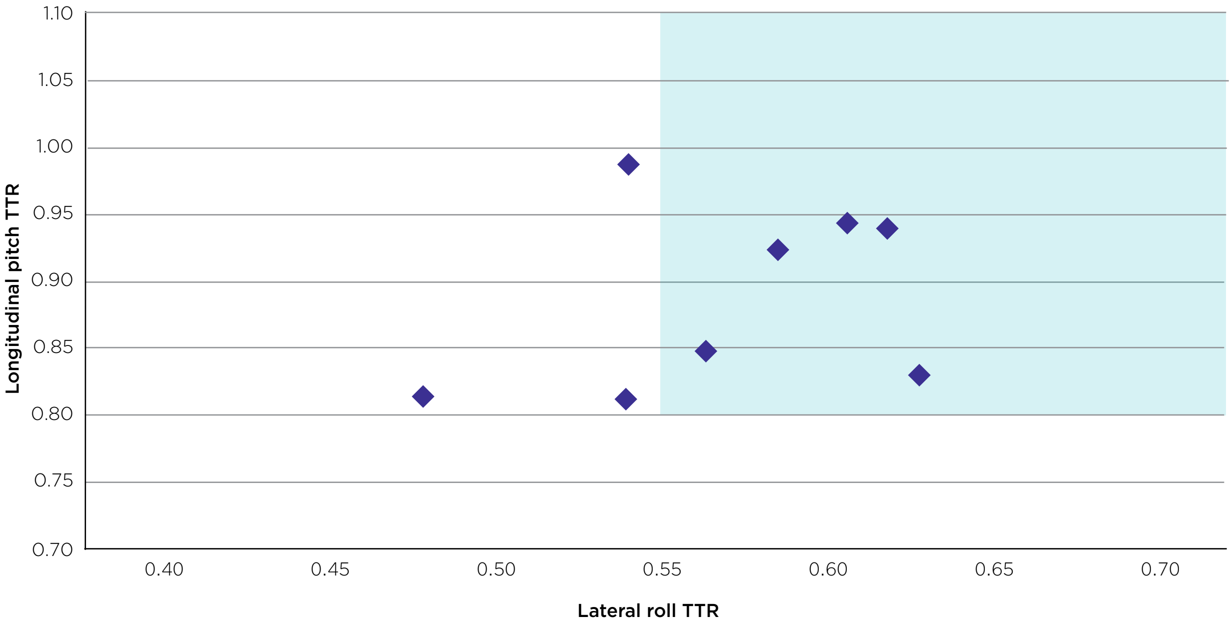
Troutbeck and Associates found the research by Macmillan indicates vehicles with TTR values higher than 0.7 would slide rather than roll over in a quasi-static state, but may still roll over. It also found significantly higher TTR values give diminishing returns.

It is recommended that in the first instance:

- the minimum lateral TTR value be 0.55, and
- the minimum longitudinal pitch be 0.80.

Five out of the eight general-use model quad bikes tested by UNSW TARS meet this proposed standard (see figure 19).

Figure 19: Expected Lateral roll TTR and Longitudinal pitch TTR values using a 50th PAM ATD



Source: Troutbeck and Associates report.

Authors of the UNSW TARS project papers, Professor Grzebieta, Adjunct Associate Professor Rechnitzer and Mr Simmons (Professional Engineering Consultants Pty Ltd) were asked by the ACCC to make refinements to the UNSW static stability test requirements, in line with recommendations from Troutbeck and Associates. Professional Engineering Consultants Pty Ltd also commented on the recommended performance levels:

> *'…the Authors accept the specified threshold values from a pragmatic perspective for the time being. However, in our opinion, these should be revised in future to progressively require higher TTR threshold values, thus increasing stability factors. The Authors suggest the following be considered in future: for lateral rollover a minimum value of 0.7; for forward pitch a value of 1.05; and for rearward pitch a value of 0.95. This would significantly improve the stability of these vehicles and subsequently increase the safety margins for rollover events.'* [169]

Finding

The ACCC recommends general-use model quad bikes be required to meet minimum stability requirements.

The ACCC considers a requirement that improves the static stability of general-use model quad bikes is reasonably necessary to reduce the risk of rollovers and consequent injuries. Rollovers are a common occurrence and were associated with 60 per cent of all quad bike fatalities between 2011 and 2018. Data reported in the UNSW TARS workplace survey also indicates 26 per cent of rollovers lead to injury, and 9 per cent lead to serious injury.[170]

The available information demonstrates increased static stability increases rollover resistance (for lateral, forward and rearward rollovers), though at this time there is no empirical information available that demonstrates a direct relationship between increased static stability and reduced injury rate. It seems rational however, to assume that the adoption of measures that reduce the propensity of quad bikes to rollover will result in lower injury and fatality rates of quad bike riders.

169 Report on Review of Test Procedures for Quad Bike Safety: Review of static stability test procedures for determining the Tilt Table Ration (TTR) to be recommended by the Australian Competition and Consumer Commission', Professional Engineering Consultants Pty Ltd, received 2 November 2018 at 25.4.

170 University of New South Wales, Transport and Road Safety Research Centre, *Quad bike and OPD workplace safety survey report: results and conclusions,* for SafeWork New South Wales, May 2017 p. 145, 'rollover'.

The ACCC agrees with the recommendation of Troutbeck and Associates to use a simplified testing regime, and to set the following initial performance requirements, measured with a 50th PAM ATD:

- minimum lateral TTR value of 0.55
- minimum longitudinal pitch TTR value of 0.80.

Extrapolating the UNSW TARS and SEA testing, and assuming the quad bikes tested are representative of the market, it is estimated that approximately a third of currently available quad bikes would either be removed from sale, or required to be redesigned to improve lateral stability.

Vehicles with TTR values higher than those proposed can still roll over and are still associated with fatalities. Substantive improvements in safety may be achieved at higher levels of static stability, up to the level where the quad bike becomes more likely to slide than roll over.

10.6 Providing stability information to consumers

Consumers can play a role in creating a safer quad bike fleet through their purchasing decisions. This requires consumers to be able to make a judgment about the relative safety of quad bike models prior to purchase. The information asymmetry present in the quad bike market means consumers are not currently provided with enough information on the relative safety of quad bikes to be able to make informed purchasing decisions. Providing consumers with information about the lateral stability of quad bike models will better inform consumers and encourage them to purchase more stable quad bikes.

Troutbeck and Associates discussed the need for transparency when communicating safety information to consumers. The angle a quad bike tips at on a tilt table is easy to communicate to consumers in a simple format. The angle number also transcends literacy and language barriers. While comprehension of the stability representation may not be possible for all consumers, the hang tag may create conversations with dealer staff, who can help communicate the messaging.

The US CPSC recommended the Recreational Off-Highway Vehicle Association include a hang tag which graphically illustrates a side-by-side vehicles' stability in the ANSI/ROHVA 1–2011 standard. The example hang tag was one of a number of recommendations in order to improve SSVs lateral stability, dynamic handling and occupant protection.

Figure 20: CPSC commissioned focus group hang tag for SSV

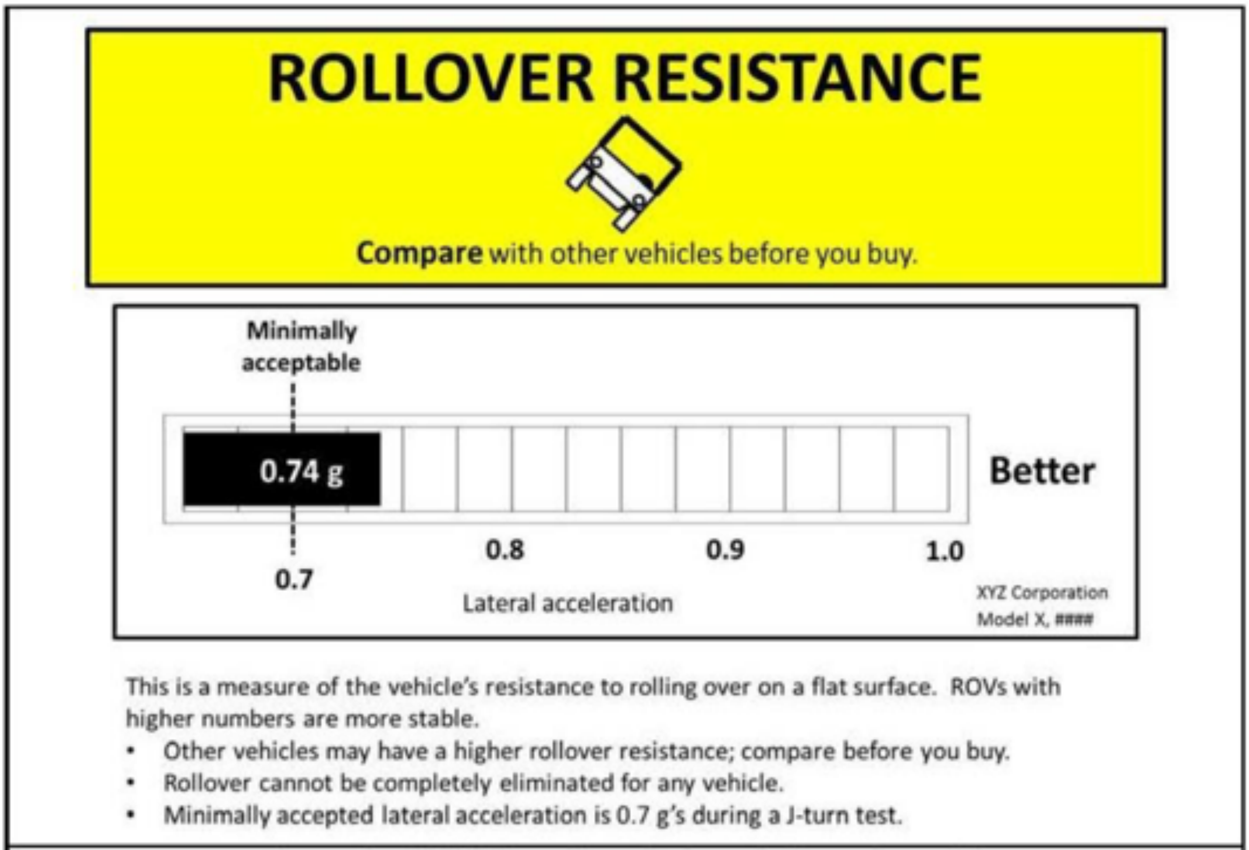


Figure 1. ROV Hang Tag (note: not shown to scale)

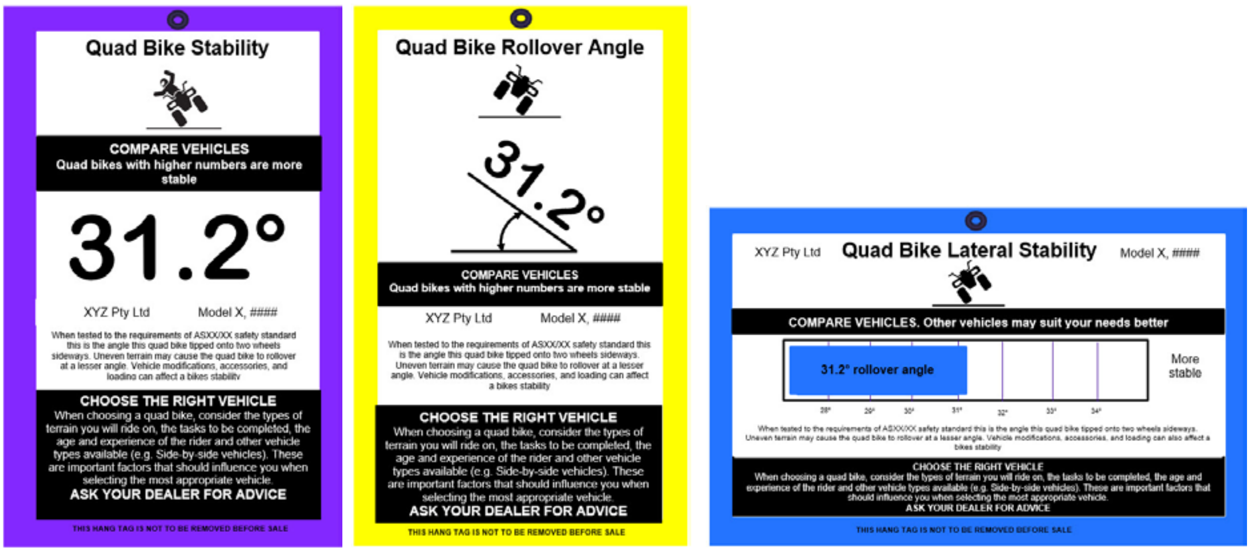
The ANSI/ROHVA 1–2017 Standard requires SSVs to be offered for sale with a hang tag that, amongst other things, communicates the result of the lateral static tilt table test.[171] A similar example of a hang tag requirement to communicate the relative lateral stability is found in the ANSI/OPEI B71.9–2016 Standard for Multipurpose Off-Highway Utility Vehicles.

171 American National Standard for Recreational Off-Highway Vehicles ANSIROHVA 1–2016, section 4.17.

Figure 21: Hang tag required under ANSI-OPEI B71.9–2016 Multipurpose Off-Highway Utility Vehicle Standard

The ACCC developed three versions of a hang tag and undertook short and targeted consultation through an online survey which sought feedback on different formats for presenting stability information to consumers.

Figure 22: Hang tag examples used in consultation for development of a quad bike stability hang tag



The targeted consultation indicated the preference of respondents was a stability hang tag that:

- captures the attention of the audience through the heading 'quad bike rollover angle' and a yellow border
- includes an image of a quad bike with a rider
- presents the stability information through indicating the angle in a number format and a graphic of an angle.

Some respondents also indicated the stability hang tag was trying to do too many things and the information provided should be simplified to ensure the key message is not lost.

Feedback provided by the FCAI and Polaris was that stability is impacted by a number of factors, including operator's handling characteristics and active riding techniques, which are not considered in the tilt table tests. Polaris also stated publishing the tilt table angle will encourage riders to attempt to ride on higher angles of terrain they would not otherwise attempt, in the mistaken belief that the vehicle is unlikely to tip until it reaches the published angle. Polaris did not provide any evidentiary support for this view. The ACCC is not aware of any evidence which suggests consumers will begin operating quad bikes on different slopes and speeds due to a better understanding of the vehicle's stability.

Polaris also submitted publishing the static tilt angle would contradict the current Polaris quad bike manual that warns: 'Operating on excessively steep hills could cause an overturn. Never operate on hills too steep for the ATV (quad bike) or for your abilities. Never operate the ATV (quad bike) on hills steeper than 15/25[172] degrees.' In the ACCC's view, providing an indication of the lateral stability of all quad bikes available on the market is unlikely to contradict Polaris's recommendations on safe use practices. The recommended hang tag provides stability guidance at the point of sale for comparison purposes, but is not proposed to be a substitute for safety information in the operator's manual.

Testing adult quad bikes for stability using a 50th percentile adult male (PAM) Hybrid III ATD was supported by both Troutbeck and Associates and Professional Engineering Consultants. Using an ATD is preferred as it provides an indication of the tip angle in practice. An ATD is not preferred when testing youth quad bikes however, because:

- youth quad bikes are designed for children aged 6 years up to 16 years and the average weight of children within this wide age range is not likely to be representative or reliable for use across all ages
- requiring a number of different ATDs to test youth vehicles designed for different age groups may be burdensome for suppliers
- an appropriate youth ATD for each age category is not known. For the UNSW TARS testing, the youth quad bike was tested using a 5th percentile adult female ATD.[173] The appropriateness of this ATD is not known.

It is noted that not using an ATD for youth quad bikes may inflate the TTRs achieved by these vehicles and provide a tip angle not achievable in practice. If a reliable ATD for testing youth quad bike stability is developed, the safety standard may be updated to specify an ATD requirement. In the interim, the TTR achieved without an ATD provides consumers with an indication of the lateral stability of youth vehicles and allows comparison between models.

Finding

The ACCC recommends a safety standard for quad bikes includes a requirement for a hang tag to be attached to all quad bike models (general-use, sport and youth models) at the point of sale, displaying the angle at which the model tipped on to two wheels when tested for lateral static stability on a tilt table (see figure 23 for an example of the hang tag).

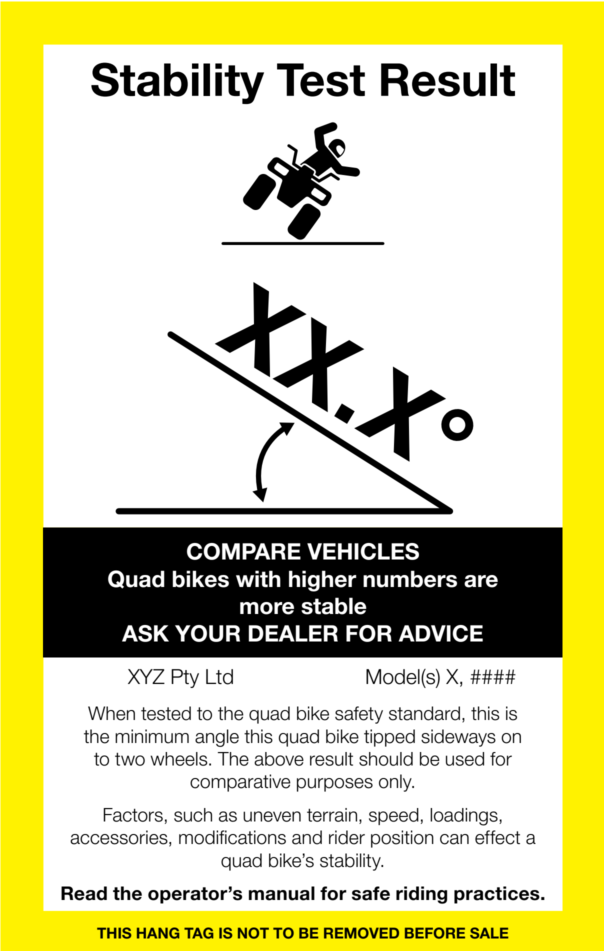
172 Depending on whether the quad bike is designed for one or two passengers.

173 Grzebieta R, et al., University of New South Wales Transport and Road Safety Research Unit, *'Final Summary Project Report: Test Results, Conclusions, and Recommendations'*, Quad Bike Performance Project TARS Research Report No. 4, submitted to the WorkCover Authority of New South Wales, University of New South Wales, 2015, p. 36.

Providing consumers with more transparent and objective information about the relative lateral stability of quad bike models at the point of sale will allow consumers to play a role in creating a safer quad bike fleet through informed purchasing decisions.

A stability hang tag may also drive manufacturers to improve the stability of quad bike models, and introduces an incentive for manufacturers to compete on models' stability. After the New Car Assessment Program (NCAP) was introduced and included rollover resistance information in the NCAP rating, the stability of automobiles was found to increase for all vehicle types.[174]

Figure 23: Recommended hang tag



10.7 Mechanical suspension

Overview

A quad bike's suspension is the system of springs, shock absorbers and linkages that connects the vehicle's chassis to its wheels. The suspension serves three critical purposes:

- contributes to the handling and braking of the quad bike
- contributes to the comfort of the quad bike rider by mitigating the effects of bumps and vibrations
- helps to protect the vehicle from damage and wear.[175]

174 United States Consumer Product Safety Commission *Supplemental Information on Recreational Off-highway Vehicles (ROVs)*, Memorandum of the United State Consumer Product Safety Commission, 17 October 2014, p. 14, available: cpsc.gov/s3fs-public/pdfs/blk_pdf_SupplementalInformation-ROVs.pdf.

175 Shijil P, Vargheese A, Devasia A, Joseph C, Jacob J, Design and analysis of suspension system for an all terrain vehicle. IJSER, 7, 3 March 2016.

Quad bikes typically have either a rigid or an independent suspension system. In a rigid suspension system, the wheels are joined by a rigid single axle with either one or two shock absorbers and when one wheel traverses over an object, the other wheel is also affected.

Rigid suspension systems are generally cheaper to manufacture and are more commonly fitted to middle of the range quad bike models. Independent suspension systems are comparatively more expensive to manufacture and are more commonly fitted to higher-end quad bike models.

In an independent suspension system, the wheels are connected to the central frame by two independent axles, so that when one wheel traverses an object, the other wheel is largely unaffected.

Most quad bikes are designed with sway bars on the rear axle to reduce the risk of the quad bike rolling over and these are frequently used on quad bikes with independent rear suspension systems. However, they limit wheel articulation (up and down movement in response to bumps or obstacles). Heavy Fix NQ noted that the sway bar limits rear wheel travel dramatically. The sway bar helps the vehicles to negotiate corners at speed, but creates instability in uneven and/or steep terrain, making it one of the main design limitations of independent rear suspension on quad bikes.[176]

Impact with bumps or other objects can be the initiator of events that can result in a risk to the safety of the operator. Rollovers are known to occur when a quad bike is traversing an incline or in an unstable condition, for example after impact with a bump. The coronial files examined by UNSW TARS, show that a significant number of incidents where a loss of control resulted in a fatality, were caused by the quad bike running over or impacting with an object alone or with another factor (while traversing a slope or turning).

UNSW TARS found of the 109 incidents investigated, around 40 per cent reported 'loss of control involving an object' as the incident initiator (table 20). Often the cause of incidents was multifaceted, for example, running into or over an object in combination with speed, slope or turn.

Table 20: Initiators of incidents causing fatalities

109 fatalities investigated	Reason for loss of control				
	Object	Speed and object	On slope with object	In turn with object	Other
Number	21	5	9	4	70
Percentage	19%	5%	8%	4%	64%

Source: UNSW TARS Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries, table 1.19.

A quad bike travelling across rough ground impacting with bumps, hollows, rocks or other sources of unevenness results in an impulse to the quad bike. The quad bike's mechanical suspension helps moderate the effects of rough ground so the operator experiences a smooth ride and the quad bike maintains stability.

Bump response test

The bump response test developed by the UNSW TARS involves a quad bike being towed at 25km/h over a 150 mm semicircular half pipe. The extent of wheel lift and the acceleration of the pelvis of the test dummy due to contact with the half pipe is measured. This test is repeated six times (three times on each side of the vehicle). The average acceleration in the test dummy's pelvis for each side is calculated and the maximum value recorded.

The test is designed to be indicative of how a quad bike will react when traversing a bump in off-road environments. The minimum performance requirement proposed in the Consultation RIS was: a maximum vertical acceleration measured at the pelvis of 2.0 g in response to being driven over a 150 mm bump at 25 km/hr.

176 Heavy Fix (NQ) Pty Ltd, submission to the Consultation RIS.

Wheel articulation

Wheel articulation refers to how far up and down the wheel is able to move, which is largely determined by the suspension. Articulation is impacted by the type of axle (rigid or independent) and the damping system.

Manufacturers typically provide details of the wheel articulation for a quad bike's front and rear suspension systems as part of the vehicle's specifications. The US standard for quad bikes, ANSI/SVIA 1–2017, sets a minimum wheel articulation of 50 mm for quad bikes.[177] The Consultation RIS proposed increasing the minimum wheel articulation to 150 mm.

The UNSW TARS research found the minimum wheel articulation of the quad bikes tested varied between quad bike models, ranging from 110 mm to 175 mm. Five of the eight general-use model quad bikes would not meet the minimum articulation proposed in the Consultation RIS of 150 mm.

Stakeholder feedback

Submissions to the Consultation RIS provided varied views on the safety impact of different rear suspension systems. For example, it was reported that a rigid suspension is more stable and safer[178, 179], but conversely it was also reported that independent suspension would reduce the risk of incidents.[180]

On rough, rocky or uneven ground, independent rear suspension may often be the optimum choice to maintain control, provide a smoother ride and improve safety. However, when carrying large cargos or towing on more even ground, the swing-arm (swing axle) rear suspension system ensures constant wheel camber and may be preferred.

The centre of gravity of the quad bike may also be lower with the swing-arm system. The swing-arm system is also cheaper to manufacturer and service and requires less cleaning and maintenance.[181] It is likely the optimum choice for a rear suspension system will depend on the predominant use of the quad bike.

The FCAI raised concerns on the inclusion of the bump test in a safety standard and states the bump test tended to 'over tune' the results to a single condition and also submitted that the test dummy is not representative of a human and would distort the test results. Honda in its submission to the Consultation RIS states it believes the bump test is not appropriate as there are several risks in setting targets based on only one bump:

- if the suspension is tuned to achieve the target for this one bump, it may be set artificially soft to absorb the 150 mm bump
- a larger bump could result in a much worse reaction than a system designed for a wide range of performance
- regulating specific items that have a big effect on the tuning of the system can greatly compromise the intended character of the vehicle.

In its submission to the Consultation RIS, Honda commented on the 150 mm wheel articulation requirement:

- this criteria has a significant impact on how ATV (quad bike) suspension is tuned
- it will limit the suspension setting on vehicles (initial travel must be soft enough to meet the test and the stabiliser bar must be at least as soft)
- it will also limit the ability to tune roll movement distribution and roll stiffness

177 American National Standard for Four Wheel All-terrain Vehicles: ANSI/SVIA 1–2017.
178 Harris R, submission to Consultation RIS.
179 Circular Head Motorcycles, submission to Consultation RIS.
180 University of Iowa, Department of Emergency Medicine, submission to Consultation RIS.
181 Ibid.

- it would likely eliminate swing-arm vehicles, which offer high roll stiffness that provides lateral stability in a loaded condition.[182]

Review by Troutbeck and Associates

Troutbeck and Associates considers the inclusion of only one bump height and speed in the testing proposed could create an opportunity for manufacturers to tune vehicle suspension in order to achieve better test results. Troutbeck and Associates also discusses that heavier quad bikes have lower vertical accelerations in response to bumps, which could encourage manufacturers to import heavier quad bikes into Australia, which may not necessarily correlate to safer vehicles. Despite these limitations, Troutbeck and Associates concluded that the need to address the propensity of quad bikes overturning is a priority and recommends manufacturers be asked to assist in refining this test to create a matrix of tests to reduce the risk of vehicles being tuned to a single test condition.

Although the preference is to have a simple limited matrix of tests, until such time as one is developed Troutbeck and Associates recommends the current test developed by the UNSW TARS should be used, however with an increase to the maximum vertical limit to 2.5 g.

For wheel articulation, Troutbeck and Associates found there was no information available that illustrated the wheel articulation requirement of 150 mm would improve safety and did not recommend it be incorporated into a safety standard for quad bikes.[183] The report also notes performance specifications are preferred over design dimensions.

Finding

Although Troutbeck and Associates recommended to use the existing bump test, in the absence of an acceptable matrix of bump height and impact speed configurations, the ACCC recommends the bump impulse response test be subject to further research and exploration before inclusion in a safety standard.

Based on feedback from submissions to the Consultation RIS and the findings of Troutbeck and Associates, it is no longer recommended quad bikes have a minimum wheel articulation of 150 mm.

10.8 Constant radius tests

Overview

The constant radius test proposed in the Consultation RIS involved a quad bike being ridden around a circular path and gradually accelerated until: the two inside wheels lifted from the pavement and tipped up, the vehicle could not continue on its path and was driven wide out of the circle, or the vehicle could not go any faster. The vehicle was operated by a person, not autonomously controlled, and outriggers were used to decrease the likelihood of the vehicle toppling over. The instrumentation in the tests collect the yaw rate, steering angle, vehicle velocity and the vertical distance above the ground on each side of the vehicle. The data are collected at 100 Hz and filtered through a 10-step moving average filter. The tests present a plot of the steering angle against lateral acceleration to identify understeer and oversteer characteristics. In the extreme, an understeering vehicle will tend to continue straight ahead and be less manoeuvrable, while a vehicle with extreme oversteer will slide.

The Consultation RIS proposed performance requirements of:

> The understeer gradient obtained from the testing shall be positive for values of ground plane lateral acceleration from 0.10 g to 0.50 g. Negative understeer gradients (oversteer) shall not be exhibited by the vehicle in the lateral acceleration range specified.

182 Honda Australia, submission to Consultation RIS.

183 Troutbeck and Associates, 'Evaluation of options to improve safety when using quad bikes and SSVs', provided to the ACCC September 2018, p. 58.

The Consultation RIS did not propose to extend these requirements to sports or youth model quad bikes.

Stakeholder feedback

The FCAI in its submission to the Consultation RIS states:

> *'Requiring dynamic handling changes that eliminates oversteer will make ATVs (quad bikes) less agile, less manoeuvrable, and less able to negotiate tight turns without going wide. Previous research indicates that under real off-road conditions (in contrast to the sealed surfaces used in the UNSW TARS tests) riders prefer ATVs (quad bikes) that have an 'understeer-oversteer' characteristic over ATVs (quad bikes) that have understeer throughout the range of lateral accelerations. Recent research indicates that vehicles on off-road surfaces with an oversteer characteristic are easily controlled and stable for all forward speeds.'*[184]

Polaris Industries in its submission to the Consultation RIS states:

> *'Polaris also rejects the proposition that there should be a requirement for off-road vehicles to exhibit an understeer characteristic when ridden on off-road tyres, but on a hard, smooth, sealed surface. The handling characteristics of off-road vehicles (including understeer, neutral-steer and oversteer) may change substantially, even on a single ride, depending on rider position, ground surface, tyre compatibility and compliance with the current ground surface, accelerator input, brake input, vehicle loading and many other factors. Polaris engineers conduct substantial off-road testing on each and every model to ensure that the transitions from one handling characteristic to another (such as from oversteer to neutral-steer, to understeer or vice versa) are smooth and predictable for the rider.'*[185]

Honda Australia in its submission to the Consultation RIS states:

> *'The claim that oversteer is unsafe is an opinion. There is no consensus in discussions with the CPSC about this claim. From the opposite perspective, on occasion, excessive understeer may lead to dangerous incidents in scenes such as obstacle avoidance. Therefore, we believe that the relationship between understeer/oversteer and safety cannot be uniquely determined. If such a relationship is to be evaluated, Honda stresses the predictable characteristic is important, and recommend checking the transient steering characteristics.'* [186]

The feedback from manufacturers and the FCAI provides a consistent view that handling predictability is more important than whether the quad bike oversteers or understeers. This argument is supported by others:

- the UNSW TARS researchers found predictable and forgiving handling characteristics to be a desirable quad bike design objective[187]
- Roy Deppa reported all oversteer or understeer was less important than whether quad bikes shifted steering responses unpredictably from understeer and oversteer and back[188]
- some submissions to the Consultation RIS argued a solid rear axle was superior to independent suspension because it made the vehicle more predictable which was an important quad bike safety feature.[189]

Review by Troutbeck and Associates

Troutbeck and Associates found oversteer and understeer are both acceptable steering attributes if the vehicle does not have excessive oversteer or excessive understeer. It states oversteering vehicles have

184 FCAI, submission to the Consultation RIS, p. 51.
185 Polaris Industries, submission to the Consultation RIS, p. 15.
186 Honda Australia, submission to the Consultation RIS, p. 16.
187 Grzebieta R, et al., University of New South Wales Transport and Road Safety Research Unit, *'Final Summary Project Report: Test Results, Conclusions, and Recommendations*', Quad Bike Performance Project TARS Research Report No. 4, submitted to the WorkCover Authority of New South Wales, University of New South Wales, 2015, inferred from 'Conclusion 9'.
188 Roy Deppa, submission to the Consultation RIS, p. 4.
189 Paul Hannigan, submission to the Consultation RIS, p. 2, and Brownwigg, Submission to the Consultation RIS, p. 1.

been considered to be more hazardous, but reports unpredictable steering characteristics are more likely to be hazardous. Troutbeck and Associates does not recommend using the constant radius test in a standard and instead recommends testing be developed around predictable vehicle handling.

Emeritus Professor Troutbeck discussed predictable vehicle handling tests with Dr Heydinger from SEA Ltd, and the yaw rate ratio test was discussed as a possible test that could be used in the development of a standard for quad bike handling predictability. Troutbeck and Associates recommends collaboration with manufacturers to develop appropriate quad bike handling predictability test requirements.

Finding

The information provided to the ACCC confirms that quad bike handling predictability is an important consideration in improving consumer's safety when operating quad bikes. A test for predictability requires additional development and the information provided demonstrates that a dynamic handling requirement based on the constant radius test is not an appropriate interim measure for inclusion in a safety standard.

Based on the feedback contained in submissions in the Consultation RIS and the findings of Troutbeck and Associates, the ACCC does not recommend a safety standard require quad bikes be tested to the constant radius test.

10.9 Rear differentials

Overview

The Consultation RIS proposed that general-use model quad bikes should be constructed such that each of the wheels can rotate at different speeds at all times, in order to allow safe cornering on hard surfaces. If the vehicle was equipped with a lockable differential, it recommended it be designed to be normally unlocked.

An open differential allows the wheels to rotate at different speeds so that the outer wheel, which travels a greater distance, rotates at a faster rate than the inner wheel during cornering. On firm ground, this type of differential provides for greater control while cornering by producing an understeer characteristic and reduces the need for active riding in a corner.

A locked differential forces the wheels to rotate at the same speed and is preferred when riding on soft, slippery or uneven terrain. On hard surfaces it may lead to a loss of control of the vehicle and subsequent rollover as cornering speed increases by producing an oversteer characteristic.

Stakeholder feedback

The IDC's TRG advised that the open centre differential is a key design change to enhance the ride-ability and stability of quad bikes without the need to constantly actively ride a general-purpose quad bike in the work environment, which may involve several hours of riding per day.[190]

The FCAI stated the benefits of a lockable differential on safety were unknown, and lockable differentials are likely to: '…greatly reduce the mobility of ATVs (quad bikes) and make ATVs (quad bikes) less safe when ridden on off-road surfaces'. The FCAI also stated open differentials were inappropriate and hazardous on rough terrain, which was known and discussed in the Consultation RIS as the basis for requiring both open and lockable differentials. There is a large consensus amongst manufacturers, the FCAI and technical experts that a closed differential is essential when a quad bike is in slippery or rough terrain.[191]

The FCAI also stated having an open differential may make riding on sealed surfaces easier, which may encourage riders to: 'engage in this dangerous, warned-against behaviour'. The ACCC is not aware of

190 Inter-Departmental Committee Technical Reference Group, submission to the Consultation RIS.

191 Troutbeck and Associates, 'Evaluation of options to improve safety when using quad bikes and SSVs', provided to the ACCC September 2018, p. 76.

any evidence which suggests consumers will begin operating quad bikes differently as a result of any requirement for a differential.

Polaris has a quad bike model on the Australian market with a lockable differential. In its submission to the Consultation RIS, Polaris stated its testing demonstrates that open differentials produce different steering characteristics as the rider's aggressiveness increases and moves toward the limit of grip. Troutbeck and Associates found that at the limit of grip, any significant impulse into the vehicle will be destabilising, which is a potential safety issue.

Review by Troutbeck and Associates

Troutbeck and Associates reported vehicle predictability is an important handling characteristic for safety and Polaris has indicated quad bikes become more unpredictable if operated in an open differential configuration. Troutbeck and Associates also found there to be no indication whether the open differential would significantly reduce the incident rate as the open differential would only assist on smooth hard ground, which is not typical of rural properties:

> *'The safety benefits accrued on hard firm surfaces would be a maximum of 6.7 per cent if all sealed road crashes and injuries were eliminated from the use of an open differential. The potential risk of harm associated with using an open differential on unsuitable surfaces is not known, but at least 75 per cent of serious injuries occurred on surfaces where an open differential is unlikely to be useful.'*[192]

Troutbeck and Associates also reported that assuming some riders may use the unlocked differential on unsuitable surfaces, the potential risk of harm is likely to outweigh the benefits of using an unlocked differential on hard surfaces. This view is supported by other manufacturers' submissions to the Consultation RIS.

Finding

Based on feedback contained in submissions to the Consultation RIS and the findings of Troutbeck and Associates, the ACCC does not recommend a safety standard require quad bikes to have the capacity for all wheels to rotate at different speeds.

10.10 Banning quad bikes

The ACL provides the responsible Minister with powers to impose bans on consumer goods if satisfied they will or may cause injury to consumers. A ban could impose significant costs and disruption on the agriculture sector, and on other operations involving quad bikes. However, a ban on quad bikes is an option that will be explored further if other regulatory measures have been pursued, and fatalities and injuries continue to occur at rates that do not meet community expectations of safety.

10.11 Second hand quad bikes

Feedback from stakeholders was that it would be overly burdensome if second hand quad bikes were required to meet any safety standard introduced. Many stakeholders expressed the view that the quad bike fleet would naturally upgrade to quad bikes that meet the safety standard over time, and this was preferred to requiring second hand quad bikes to comply.

Requiring second hand quad bikes to meet the requirements of a safety standard could lead to a situation where retailers are unable to buy and sell second hand vehicles, however many consumers could continue to do so, as the safety standard is unlikely to apply to quad bikes sold privately. This may place restrictions on retailers without increasing the safety of the fleet, as consumers are likely to continue buying and selling quad bikes privately.

192 Troutbeck and Associates, 'Evaluation of options to improve safety when using quad bikes and SSVs', provided to the ACCC September 2018, p. 78.

The ACCC's preferred approach is to exempt second hand quad bikes from a safety standard, but this approach will be reviewed if the second hand exemption is having an unreasonably negative effect on overall quad bike safety. As for all existing quad bikes, consumers are encouraged to improve the safety of these vehicles through aftermarket products, education and training. The ACCC strongly recommends a continuation of the current rebate schemes offered in New South Wales and Victoria, and a continuation of education and safety campaigns.

Honda raised concerns during consultations that second hand quad bikes could be imported to avoid having to meet the requirements of a safety standard, if an exemption for second hand vehicles was provided. To ensure such a situation is avoided, imported second hand vehicles should be required to meet any safety standard introduced.

10.12 Other vehicles types

Side by side vehicles

In the Consultation RIS it was proposed that SSVs should be subject to a safety star rating system. Feedback provided by many stakeholders and the report by Troutbeck and Associates demonstrate there is general agreement that any safety star rating system developed should be different for different vehicle types.

Since publication of the Consultation RIS, the ACCC has received information that indicates there have been 13 fatalities involving SSVs since 2011. As outlined in section 5.1, SSV sales are increasing and these vehicles are becoming a popular additional or replacement on-farm vehicle. The ACCC will continue to collate information on Australian fatalities involving these vehicles and while it does not propose any policy interventions at this stage, this does not preclude it from proposing changes in the future.

The ACCC encourages stakeholders with a specific interest in farm safety to conduct education and awareness activities that will highlight the risks of not wearing seat belts and protective equipment when operating SSVs.

Youth quad bikes

The ACCC received compelling information from medical associations and child advocacy groups demonstrating children have insufficient physical and cognitive abilities to operate quad bikes safely.

Sean's Law was introduced in 2010 in Massachusetts, US and restricted the use of off-road vehicles, including quad bikes, to those aged 14 and older and regulated the use of these vehicles when used by those between the age of 14 and 18 years. Since its implementation, Sean's Law has contributed to a sustained decrease in the rates of quad bike related ED visits and inpatient hospitalisations in children younger than 18 years old, including:

- ED discharges declined by 33 per cent in children aged zero to nine years
- ED discharges declined by 50 per cent in 10 to 13 year olds
- ED discharges declined by 39 per cent in 14 to 17 year olds
- hospital discharges were reduced by 41 per cent in zero to 17 year olds.[193]

The ACCC has not received adequate information to determine the magnitude of risk children are exposed to when operating youth quad bikes. There was one fatality involving a child on a youth quad bike over the 2011–18 period. All other child fatalities involved a child operating an adult sized quad bike, or operating a quad bike designed for an older age group. Injury data indicates that between 2009 and 2013, more than 27 per cent of all hospital quad bike related ED presentations and 23 per cent of all hospitalisations in Queensland involved children below the age of 14 years. The type of quad bikes involved in these incidents was generally not recorded.

193 Flaherty M R, Raybould T, Kelleher C M, et al., Age Legislation and Off-Road Vehicle Injuries in Children. Pediatrics. 2017;140(4):e20171164.

The ACCC does not have powers to regulate user behaviours, including banning children from operating adult-sized quad bikes.

Under the ACL, the Minister is able to ban the supply of youth quad bikes if satisfied they present a risk of harm from foreseeable use or misuse. While it is unlikely youth quad bikes serve sufficient utility to warrant their continued availability (children below a certain age are unlikely to require them for workplace use, and there are alternate recreational activities), the consequences of a ban are unknown to the ACCC. One outcome could be an increase in children operating adult-sized quad bikes, which is likely to result in an increase in quad bike incidents involving children. The ACCC also has concerns that banning the supply of youth quad bikes could lead to an increase in youth motorbike sales, or other similar vehicles. The relative safety of these vehicles in not known, and banning the sale of youth quad bikes could drive consumers to other vehicles, without improved safety outcomes.

The ACCC is not aware of any research or information that provides evidentiary support for design changes to youth quad bikes. Some of the design changes proposed for general-use model quad bikes could be applied to youth vehicles, particularly OPDs or a minimum static stability requirement, although there is no evidentiary support for this. To illustrate this point, UNSW TARS tested one youth quad bike. It is difficult to justify and develop a minimum static stability for youth vehicles without some understanding of the broader market. Similarly, requiring OPDs to be integrated into the design of youth vehicles is difficult to validate given there has been no testing of after-market OPDs designed for youth vehicles.

The ACCC considers the introduction of the US and EN Standard and a stability hang tag an appropriate first step. This will require suppliers of youth quad bikes to correctly identify the appropriate age group for which the youth quad bike is suitable and may encourage consumers to purchase safer youth quad bikes and manufacturers to increase the stability of quad bike models. The ACCC will also continue to follow, and where possible, contribute to research into the development of increased safety characteristics for youth vehicles.

11. Cost to the Australian economy

Fatalities

Guidance is published by the Office of Best Practice Regulation (OBPR) on how to treat the benefits of regulations designed to reduce the risk of physical harm or death. This guidance uses an estimate of $4.2 million (2014) for the value of a statistical life, based on empirical evidence. Updated to June 2018 dollars, this figure becomes $4.48 million.

The ACCC acknowledges that in reality, it is not possible to allocate a value to the life of a person, however for cost and benefit comparison purposes, has adopted this figure in the following calculations.

Over the period 2011–18, there was an average of 16 fatalities per year in Australia associated with the operation of quad bikes.

- Cost of lives lost per year = value of a statistical life x average number of fatalities per year ($4.48 million x 16 fatalities)

The total cost of lives lost per year was calculated to be $71.7 million.

Injuries

The cost of an injury can vary greatly depending on its severity. In estimating the total cost of injury and for the purposes of this Final Recommendation, the costs associated with the following descriptions of injuries have been considered:

- disabling injuries that require hospitalisation and which result in long term impairment
- serious injuries that require hospitalisation but which do not result in long term impairment
- minor injuries that require ED presentation only and do not result in hospitalisation

The OBPR uses an estimate of $182 000 (2014 value) for the value of a statistical life year. Updated to June 2018 dollars, this figure becomes $194 200 per year.

The OBPR suggests the use of a Disability Adjusted Life Year (DALY) which provides a measure of the level of disability associated with an injury, where a weight of one represents one year of healthy life lost.[194]

The cost of an injury is calculated below.

Cost of Injury = DALY weight x value of statistical life year x average duration of injury.

As there is no central repository for quad bike injury data in Australia, the average range of costs of different types of quad bike injuries has been estimated from the data available, as set out in table 21.

194 The DALY ranges from zero to one depending on type and severity of injury.

Table 21: Summary of average quad bike injury cost estimates[195, 196, 197, 198, 199, 200]

Injury severity	Minor (ED)	Hospitalisations	Disabling
Range of average cost estimates	$1000–$19 400	$39 800–$352 800	$351 200–$4 117 400

Given the range of estimates, and the uncertainty of the number of injuries that involve a permanent impairment, it is difficult to assess the average cost of an injury. The ACCC has referred to a number of data sources to estimate the average cost of a quad bike injury requiring hospitalisation at $176 800. This estimate was derived from:

- data provided by CARRS-Q[201] to determine the nature and severity of injuries (table A5.1, hospitalised injuries)[202]
- the OBPR value of a statistical life year
- Bureau of Transport Economics[203] and Safe Work Australia[204] estimates on community and workplace costs
- ambulance attendance data and aero recovery data.[205, 206]

The estimated total annual cost of injuries was calculated by combining the cost of each injury category.

Average cost of hospitalised injury x average number of hospitalised injuries per year) + (average cost of a minor injury x number of ED injuries not hospitalised)

= ($176 800[207] x 654[208]) + ($10 200[209] x 1646[210]).

The estimated total cost of injuries per year was $132.4 million.

195 Safe Work Australia, *The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012–13,* November 2015, viewed 28 February 2018, safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf.

196 Department of Infrastructure and Regional Development, Early Assessment: Regulation Impact Statement, *Advanced Motorcycle Braking Systems for Safer Riding*, April 2017, viewed 7 February 2018, infrastructure.gov.au/roads/motor/design/files/Consultation_RIS-Advanced_Motorcycle_Braking_Systems_for_Safer_Riding.pdf.

197 IDC Technical Reference Group submission in response to the ACCC Quad Bike Safety: Issues Paper.

198 ACCC estimates, including an analysis of quad bike injury severity.

199 InterSafe submission in response to the ACCC Quad Bike Safety: Issues Paper.

200 For consistency, the costs have been adjusted (where necessary) using the ABS CPI Inflation Calculator abs.gov.au/websitedbs/d3310114.nsf/home/Consumer+Price+Index+Inflation+Calculator.

201 Vallmurr K, Watson A, Catchpoole J, Centre for Accident Research and Road Safety—Queensland, *Quad bike-related injuries in Queensland: Final Report,* August 2017, viewed 19 February 2018, https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0020/152219/carssq-quad-bike-research-final-report.PDF.

202 Permanent injury cases were estimated from the fraction of spinal cord injuries reported (0.4 per cent) and traumatic brain injuries (10.8 per cent, which excludes open wound cases). In its submission to the Issues Paper, InterSafe estimated the cost of injury assuming 6–7 per cent of (1400) cases result in permanent impairment, and using an estimated average whole body impairment of 5 per cent.

203 Bureau of Transport Economics, *Road Crash Costs in Australia: Report 102,* 2000, viewed 19 Feburary 2018, https://bitre.gov.au/publications/2000/files/report_102.pdf.

204 Safe Work Australia, *The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012–13,* November 2015, viewed 28 February 2018, safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf.

205 Franklin R, submission in response to the ACCC Quad Bikes Safety: Issues Paper, Vallmurr K, Watson, A Catchpoole J, Centre for Accident Research and Road Safety—Queensland, *Quad bike-related injuries in Queensland: Final Report,* August 2017, viewed 19 February 2018, worksafe.qld.gov.au/__data/assets/pdf_file/0020/152219/carssq-quad-bike-research-final-report.PDF.

206 Ibid.

207 ACCC estimate, including an analysis of quad bike injury severity.

208 This estimate may include a small number of SSV-related injuries.

209 Mid-point of the minor injury average cost estimates (table 5). This estimate may include a small number of SSV-related injuries.

210 Mid-point of the estimated injuries presented to ED and not hospitalised per year.

Total costs of fatalities and injuries

The total annual cost of quad bike fatalities and injuries in Australia was estimated to be approximately $204 million (2018 dollars).

This estimate does not cover the full impact of fatalities and injuries and only takes the number of recorded injuries into consideration. As such, it is likely that a significant number of injuries incurred by riders that were not presented to hospital were not recorded. Additionally, the estimate does not include additional costs associated with fatalities and injuries, including but not limited to, the pain and suffering of family and friends, costs to emergency workers and affected communities. The estimate may also include a small number of SSV-related injuries.

12. The regulatory options

Key points

- There are three options analysed to increase consumer safety when operating quad bikes.
- Option 1 is a baseline option and does not include any regulatory changes.
- Option 2 requires **all quad bikes** supplied to meet the US or EN Standard, provide rollover warning information, display vehicle stability information at the point of sale and also requires all **general-use model quad bikes** to be fitted with operator protection devices.
- Option 3 requires Option 2 and additionally stipulates minimum stability requirements **general-use model quad bikes** must meet.

12.1 Assessing the regulatory options

There is a large degree of uncertainty around the costs and benefits of the proposed options and a full monetisation of costs and benefits is not practical or reliable. Specifically, it is not possible to estimate the monetary costs associated with each option, as it will depend on the specific course of action pursued by manufacturers. Despite the requests for information in the Consultation RIS and during more targeted consultation, manufacturers, with few exceptions, did not provide any predictive costings. Additionally, while the benefits are known, the extent to which the benefits will be realised will depend on the action taken by manufacturers; for example, if manufacturers meet the proposed minimum requirements, the benefit will differ greatly from what might occur if they exceed the minimum requirements. This led to a qualitative assessment of the options, with consideration given to:

- **consumer safety**—requiring quad bikes meet a minimum standard in Australia is fundamental to decreasing quad bike fatalities and injuries.
- **consumer choice**—if the costs required to comply with a safety standard are too high, manufacturers may no longer supply quad bikes to Australia. If the costs are balanced, it is likely there will be a reduction in the number of quad bike models available in Australia.
- **affordability**—introducing a safety standard will increase the costs of quad bikes in Australia. These costs are likely to be passed on to consumers in the form of increased prices of quad bikes, subsequently making them a less affordable vehicle.
- **costs to government**—a safety standard will have upfront and ongoing compliance and monitoring costs to the Australian Government, these costs need to be proportionate to the benefits.
- **flexibility and openness to innovation**—technology is rapidly changing and a safety standard needs to be sufficiently flexible to allow consumers to benefit from new innovations.

The ACCC has used a comparative analysis scale to assign each option a rating against each consideration. Table 22 shows the scale used to indicate an option's comparative advantage or disadvantage compared with the baseline (Option 1). The analysis is informed by supplementary information, where available, including:

- information provided on the costs of fitting OPDs aftermarket
- information provided by one manufacturer on the costs of developing a new quad bike model
- information on the costs of quad bike fatalities and injuries to the medical sector
- information provided throughout the investigation on the benefits of after-market OPDs.

Table 22: Comparative analysis scale

Very negative impact	Negative impact	Neutral	Ambiguous/ uncertain	Improvement	Large improvement
The option would likely result in a large decline compared with the baseline option	The option would likely result in some (limited or moderate) decline compared with the baseline option	The option would likely have a negligible impact compared with the baseline option	The option could result in an improvement or decline compared to the baseline option	The option would likely result in some (limited or moderate) improvement compared with the baseline option	The option would likely result in a large improvement compared with the baseline option

Consumer safety criteria

The information presented to the ACCC indicates the largest risk posed by quad bikes are injuries and fatalities caused by rollovers. Information has also led the ACCC to conclude that the information asymmetry present in the quad bike market means consumers are unlikely to be able to make a judgment about the safety of quad bikes before purchase and use. Consumer safety will be assessed against the criteria that the option:

- reduces the likelihood of a rollover incident
- protects the operator in the event of a rollover
- provides safety information at the point of sale, allowing consumers to have access to safer quad bikes through purchasing decisions.

Consumer choice criteria

Consumer choice may be impacted by regulation through manufacturers no longer supplying quad bikes to Australia, or reducing the number of models available to the Australian market. Consumer choice will be assessed against the criteria that the option:

- reduces the number of quad bike models available on the Australian market
- reduces the range of quad bike features available on the Australian market
- reduces quad bike functionality (excluding the value of safety).

Affordability

Regulating quad bikes to ensure better safety outcomes are met is likely to result in manufacturers increasing research and development to pursue design and technological improvements for safety. These upfront costs are likely to be passed on to consumers through an increase in the price of quad bikes. Affordability will be assessed against the criterion that the option:

- increases the cost of purchasing a quad bike.

Cost to government criteria

As a safety standard will have upfront and ongoing compliance and monitoring costs to the Australian Government, these costs need to be proportionate to the benefits. Costs to government will be assessed against the criterion that the option has:

- ongoing costs associated with enforcing the safety standard.

Flexibility and openness to innovation

Regulation should not be a barrier to technological improvements and a safety standard for quad bikes should be flexible and based on performance principles, rather than specific design requirements, enabling consumers to benefit from technological advancements and updates. New technologies that may be available to enhance the performance and safety of quad bikes are currently unknown and regulation needs to be sufficiently flexible to allow for this uncertainty and must be able to respond and adapt to new innovations. The criteria for flexibility and openness to innovation will be assessed against:

- technology neutral regulation which enables different technology and designs to be used to meet general safety principles or minimum requirements, rather than prescribing design requirements
- allows flexibility for government in addressing emerging safety risks
- builds on international standards.

Assumptions of the assessment

Quad bikes are not manufactured in Australia and any costs imposed by regulation will not be directly felt in Australia at the manufacturing level. The impact is likely to be indirect, with manufacturers passing regulatory costs on to consumers and suppliers. The focus of the analysis is the impact the options are likely to have for consumers, which will capture this transfer of costs from the perspective of the consumer.

It will take a number of years for the Australian quad bike fleet to be comprised of vehicles that meet the proposed requirements. The assessment analyses each option from the perspective that the fleet is substantially comprised of quad bikes that meet its requirements.

Increasing the safety of consumers operating quad bikes will have considerable savings for government through reducing the number of quad bike incidents, these costs include savings associated with:

- first responders
- emergency department and hospitalisation costs
- investigations of incidents, including coronial investigations
- loss of income
- pain and suffering.

While these costs are substantial, in order to avoid 'double counting', they have been considered as part of the consumer safety criteria.

Quad bike sales may:

- increase due to new safety features offered by the option
- decline due to an increase in costs, reduction in their utility or reduction in demand due to other technological uptakes (drones, virtual fencing, etc.).

The assessment analyses the option assuming current sale level will be maintained.

12.2 Option 1

Take no action to address quad bike safety—status quo.

Overview

Option one represents the baseline option and would result in no regulatory intervention to address quad bike safety. This would be likely to result in a continuation of an annual average of 16 fatalities, 1646 ED presentations and 654 hospitalisations, amounting to an estimated $200 million per year loss to the economy from quad bike fatalities and injuries.

Table 23: Assessment of Option 1

Consumer safety	Reduces the likelihood of a rollover	This option represents the baseline option
	Protects the operator in the event of a rollover	This option represents the baseline option
	Provides safety information at the point of sale	This option represents the baseline option
Consumer choice	Reduces the number of quad bike models available on the Australian market	This option represents the baseline option
	Reduces the range of quad bike features available on the Australian market	This option represents the baseline option
	Reduces quad bike functionality (excluding the value of safety)	This option represents the baseline option
Affordability	Increases the cost of purchasing a quad bike	This option represents the baseline option
Cost to government	Increases costs to government through the enforcement of a safety standard	This option represents the baseline option
Flexibility and openness to innovation	Provides technology neutral regulation and enables different technologies and designs to be used to meet general safety principles or minimum requirements, rather than prescribing design requirements	This option represents the baseline option
	Enables flexibility for government in addressing emerging safety risks	This option represents the baseline option
	Builds on international standards	This option represents the baseline option

12.3 Option 2

Introduce a quad bike safety standard that requires

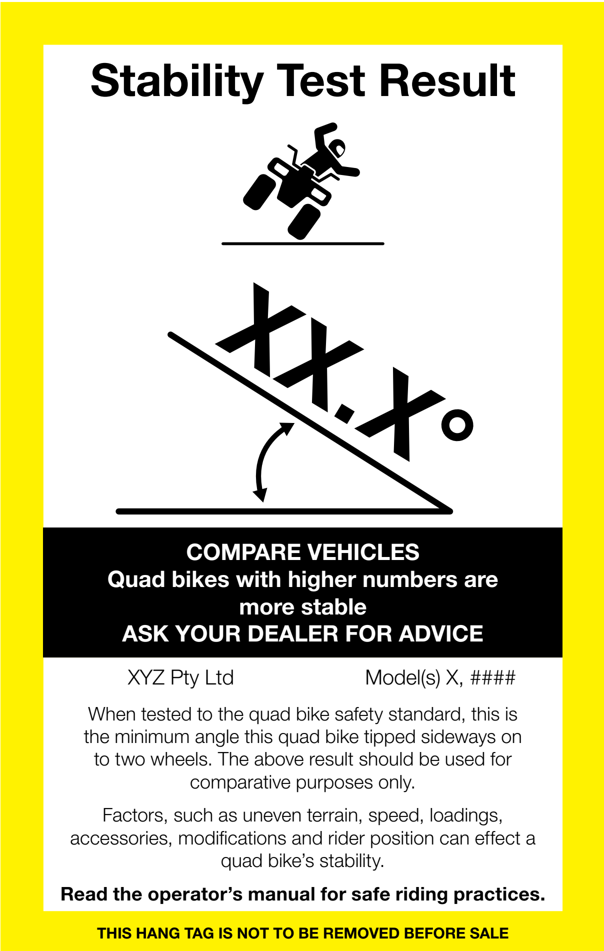
- **all quad bikes** to:
  - meet certain requirements of the US Standard or EN Standard
  - have a durable label affixed and visible when the quad bike is in operation, alerting the operator to the risk of rollover
  - be tested for lateral static stability using a tilt table test and display the angle at which it tips on to two wheels on a hang tag at the point of sale
- **general-use model quad bikes** to be fitted with, or have integrated into the design, an operator protection device.

This option requires all quad bikes to comply with the safety requirements of the US or EN Standard. Both the US Standard and EN Standard have requirements for design, configuration, performance and the provision of safety information to consumers.

Option 2 also requires all quad bikes to be tested for lateral stability and have the angle at which the quad bike tipped on to two wheels displayed on a hang tag at the point of sale.

As discussed at Section 10.6, an ATD is not preferred when testing youth quad bikes because they are designed for children aged 6 years up to 16 years and requiring a number of different ATDs to test youth vehicles designed for different age groups may be burdensome.

Figure 24: Proposed lateral stability hang tag



Option 2 also requires a warning label, alerting riders to the risk of rollover, to be affixed to all quad bikes in a prominent position and safety information to be supplied in the owner's manual. The safety information in the owner's manual should alert consumers to the risks of rollovers, including when the risk of rollover is increased and how to best operate the vehicle safely in higher risk conditions.

Figure 25: Proposed quad bike durable label warning of the risk of rollover

Option 2 also requires all **general-use model quad bikes** to have an operator protection device integrated into the design of, or fitted to, quad bikes that helps to protect operators from serious crush injuries in the event of a rollover.

The proposed definition of an OPD is sufficiently broad to ensure the device is not restricted to one specific OPD design. Quad bike manufacturers and designers will be able to decide on the type of OPD best suited for each quad bike model. This allows the design of OPDs to be considered within the original production specifications of the vehicle and enables other design or performance characteristics of the quad bike to be refined to ensure optimum vehicle safety and performance.

The requirement for OPDs may result in a number of outcomes, including:

- some manufacturers/suppliers ceasing supply of general-use model quad bikes in Australia
- manufacturers/suppliers fit after-market OPDs to general-use model quad bikes
- manufacturers re-design general-use model quad bikes, and integrating an OPD into the design of the vehicle
- a combination of the above points.

The ACCC considers it most likely that there will be varied responses:

- manufacturers/suppliers with a small market share may cease supply of general-use model quad bikes in Australia
- some manufacturers may take this opportunity to increase their market share
- some manufacturers may re-design general-use model quad bikes and integrate an OPD into some (but not all) models
- other manufacturers/suppliers may fit after-market OPDs to their general-use model quad bikes.

The assessment of Option 2 is based on the assumption there will be varied responses from manufacturers/suppliers.

Table 24: Assessment of Option 2 against assessment criteria

Criteria		Discussion	Overall assessment
Consumer safety	Reduces the likelihood of a rollover	Option 2 may reduce the likelihood of a rollover to a small extent through: ▪ encouraging consumers to purchase safer vehicles through their purchasing decisions ▪ increasing the awareness of rollovers.	The option would likely result in a **large improvement** compared with the baseline option
	Protects the operator in the event of a rollover	Option 2 would ensure general-use model quad bikes supplied in Australia have operator protection devices that protect the operator in the event of a rollover.	
	Provides safety information at the point of sale	Stability is a key safety characteristic for quad bikes. Option 2 provides stability information to the consumer at the point of sale, enabling safer vehicles through consumers' purchasing decisions.	
Consumer choice	Reduces the number of quad bike models available on the Australian market	Option 2 is likely to result in a reduction in the number of quad bike models available in Australia as it is unlikely general-use model quad bikes will be supplied with OPDs where a redesign is not economical.	The option could result in an **improvement or decline** compared to the baseline option
	Reduces the range of quad bike features available on the Australian market	Option 2 requires an increase in features to general-use model quad bikes through the requirement for OPDs.	
	Reduces quad bike functionality (excluding the value of safety)	Option 2 may result in general-use model quad bikes that have less carrying space and/or less clearance height. This will largely depend on the OPD design manufacturers incorporate on models and are important considerations at the design phase.	
Affordability	Increases the cost of purchasing a quad bike	Option 2 may result in an increase in the cost of purchasing a quad bike, as manufacturers are likely to seek to recover the costs of the regulation directly from consumers (including research and development, materials, manufacturing and transport costs).	The option would likely result in **moderate decline** compared with the baseline option

Criteria		Discussion	Overall assessment
Cost to government	Increases costs to government through the enforcement of a safety standard	The impact of Option 2 is uncertain. Costs associated with enforcing a safety standard may result in a small increase in costs to the Australian Government, however these costs may be offset by payment of pecuniary penalties for non-compliance.	The option could result in an **improvement or decline** compared to the baseline option
Flexibility and openness to innovation	Provides technology neutral regulation and enables different technologies and designs to be used to meet general safety principles or minimum requirements, rather than prescribing design requirements	Option 2 is likely to provide consumers with innovative OPDs through stipulating general safety requirements, rather than specific designs. As the baseline is no regulation, overall Option 3 will have a negligible impact.	The option would likely result in **limited improvement** compared with the baseline option
	Enables flexibility for government in addressing emerging safety risks	Option 2 would result in a safety standard being introduced. This would allow the ACCC to take enforcement action where suppliers have failed to meet the minimum requirements. A safety standard, as a legislative instrument is also easy to update and does not require parliamentary processes, enabling the government to flexibly address any emerging safety risks associated with quad bikes. The responsible Minister must be satisfied the requirements are reasonably necessary to reduce the risk of injury to consumers.	
	Builds on international standards	Option 2 builds on the US/EN Standard for quad bikes.	

Overview

This option will ensure a minimum safety standard for all quad bikes sold in Australia is introduced and will also provide key safety information to consumers to better inform their purchasing decisions and raise awareness of the risks posed by these vehicles. Option 2 will also ensure consumers have protection that reduces the severity of injury in the event of a rollover when operating general-use model quad bikes. Although there are likely to also be rollover incidents where an OPD will not mitigate the injury, and incidents where an OPD may cause an injury.

Option 2 is likely to provide a large improvement to consumer safety. Option 2 is also likely to have an uncertain impact on consumer choice and costs to government, and a moderate decline in quad bike affordability. Option 2 would introduce regulation that is flexible and open to innovation.

12.4 Option 3

Introduce a quad bike safety standard that requires quad bikes to meet the requirements of Option 2, and additionally requires **general-use model quad bikes** to also meet the minimum stability performance requirements of:

- lateral stability—a minimum TTR of 0.55
- front and rear longitudinal pitch stability—a minimum TTR of 0.8.

Option 3 amounts to a safety standard that:

- requires **all quad bikes** supplied in Australia to:
  - meet the specified requirements of the US quad bike Standard, ANSI/SVIA 1-2017 or the EN 15997:2011 Standard
  - be tested for lateral static stability and display result in the form of a hang tag at the point of sale
  - have a label affixed in a visible position whilst the quad bike is being ridden that alerts riders to the risk of rollover
  - include rollover safety information in the owner's manual
- requires **general-use model quad bikes**:
  - to be supplied with operator protection devices
  - to meet minimum stability requirements of:
    - lateral stability—a minimum TTR of 0.55
    - front and rear longitudinal pitch—a minimum TTR of 0.8.

Option 3 uses a combination of control approaches across the hierarchy of controls framework, including substitution, engineering controls and administrative controls to reduce the risk of death or injury.

Option 3 may result in a number of outcomes:

- manufacturers cease supply of general-use model quad bikes in Australia
- manufacturers fit after-market OPDs to general-use model quad bikes:
  - that meet the stability requirements of Option 3; and/or
  - make design changes to quad bike models to meet the stability requirements of Option 3.
- manufacturers re-design general-use model quad bikes, integrating an OPD into the design of the vehicle:
  - where models already meet the stability requirements; and/or
  - make design changes to meet the stability requirements of Option 3.
- a combination of the above points.

The ACCC considers it most likely that there will be varied responses and the assessment of Option 3 is based on this assumption.

Table 25: Assessment of Option 3 against the assessment criteria

Criteria		Discussion	Overall assessment
Consumer safety	Reduces the likelihood of a rollover	Option 3 may reduce the likelihood of a rollover through: ▪ encouraging consumers to purchase safer vehicles through their purchasing decisions ▪ increasing the awareness of rollovers ▪ improving the stability of general-use model quad bikes to make rollover events less likely to occur.	The option would likely result in a **large improvement** compared with the baseline option
	Protects the operator in the event of a rollover	Option 3 would ensure general-use model quad bikes supplied in Australia have operator protection devices that protect the operator in the event of a rollover.	
	Provides safety information at the point of sale	Stability is a key safety characteristic for quad bikes. Option 3 provides stability information to the consumer at the point of sale, enabling safer vehicles through consumers' purchasing decisions.	
Consumer choice	Reduces the number of quad bike models available on the Australian market	Option 3 is likely to result in a reduction in the number of quad bike models available in Australia as it is unlikely general-use model quad bikes will be supplied with OPDs where a redesign is not economical.	The option could result in an **improvement or decline** compared to the baseline option
	Reduces the range of quad bike features available on the Australian market	Option 3 requires an increase to general-use model quad bike features through the requirement for OPDs. Option 3 may also result in a minor decline in the range of features if the number of quad bike models available on the market is reduced.	
	Reduces quad bike functionality (excluding the value of safety)	Option 3 may result in general-use model quad bikes that have less carrying space and/or less clearance height. This will largely depend on the OPD design manufacturers incorporate and are important considerations at the design phase.	

Criteria		Discussion	Overall assessment
Affordability	Increases the cost of purchasing a quad bike	Option 3 may result in an increase in the cost of purchasing a quad bike, as manufacturers are likely to seek to recover the costs of the regulation directly from consumers (including research and development, materials, manufacturing and transport costs).	The option would likely result in **moderate decline** compared with the baseline option
Cost to government	Increases costs to government through the enforcement of a safety standard	The impact of Option 3 is uncertain. Costs associated with enforcing a safety standard may result in a small increase in costs to the Australian Government, however these costs may be offset by payment of pecuniary penalties for non-compliance.	The option could result in an **improvement or decline** compared to the baseline option
Flexibility and openness to innovation	Provides technology neutral regulation and enables different technologies and designs to be used to meet general safety principles or minimum requirements, rather than prescribing design requirements	Option 3 is likely to provide consumers with innovative quad bike models through stipulating general safety requirements, rather than specific designs. As the baseline is no regulation, overall Option 3 will have a negligible impact.	The option would likely result in **limited improvement** compared with the baseline option
	Enables flexibility for government in addressing emerging safety risks	Option 3 would result in a safety standard being introduced. This would allow the ACCC to take enforcement action where suppliers have failed to meet the minimum requirements. A safety standard, as a legislative instrument is also easy to update and does not require parliamentary processes, enabling the government to flexibly address any emerging safety risks associated with quad bikes. The responsible Minister must be satisfied the requirements are reasonably necessary to reduce the risk of injury to consumers.	
	Builds on international standards	Option 3 builds on the US/EN Standard for quad bikes.	

Overview

This option will ensure a minimum safety standard for all quad bikes sold in Australia is introduced and will also provide key safety information to consumers to better inform their purchasing decisions and raise awareness of the risks posed by these vehicles. Option 3 will also provide a minimum level of stability for general-use model quad bikes, increasing the safety of these vehicles supplied in Australia, and will ensure consumers have protection that reduces the severity of injury in the event of a rollover when operating general-use model quad bikes. Although there are likely to also be rollover incidents where an OPD will not mitigate the injury, and incidents where an OPD may cause an injury.

Option 3 is likely to provide a large improvement to consumer safety. Option 3 is also likely to have an uncertain impact on consumer choice and costs to government, and result in a moderate decline in quad bike affordability. Option 3 would introduce regulation that is flexible and open to innovation.

12.5 Comparison of all options

The analysis shows that both of the proposed options result in an overall large improvement compared with the baseline option (Option 1). However, Option 3 is likely to have increased safety benefits to consumers through setting a minimum lateral stability requirement for general-use model quad bikes. Over time this will likely result in less rollover incidents occurring as older quad bikes with less stability are retired from the market and quad bikes with increased stability become more prevalent.

Option 3 provides large improvements to quad bike safety, balanced with a moderate decline to affordability, a limited improvement to flexibility and innovation, and an uncertain impact on consumer choice and costs for government.

12.6 Summary of assessment and preferred option

Key points

- The ACCC assigned a high qualitative value to consumer safety benefits.
- Option 3 is the preferred regulatory option to improve quad bike safety.

The large degree of uncertainty associated with the assessment of the above options makes a quantitative analysis unreliable. Instead, the regulatory options are analysed against a multi-criteria qualitative assessment of the likely benefits and costs.

The assessment of the options did not provide different weighting to the assessment criteria. Given the high community value of life and health, the ACCC assigned a high qualitative value to strong consumer safety benefits, and Options 3 was consequently viewed more favourably than Option 2.

The ACCC is of the view Option 3 is the preferred option to introduce quad bike regulation. Option 3 is most likely to considerably improve the safety characteristics of quad bikes, while imposing a moderate decrease in quad bike affordability, and its impact on consumer choice and costs to government is currently uncertain. Option 3 provides regulation that is flexible and open to innovation and technological changes.

Attachment A: Models involved in Australian fatalities 2000–12

Vehicle	Make	Model	Size [cc]	Year	Type
QB	Barossa	Unknown	50	Unknown	Youth
QB	Bombardier	800 HO	800	2007	General-use model
QB	Bombardier	Outlander 800	800	Unknown	General-use model
QB	Bombardier	Rotax	640	2001	Unknown
QB	E-Ton	Challenger CXL-150	Unknown	Unknown	General-use model
QB	Honda	400EX Quad Runner	400	Unknown	Sport model
QB	Honda	Big Red	Unknown	Unknown	General-use model
QB	Honda	Big Red 300R TRX300FW	300	Unknown	General-use model
QB	Honda	Foreman	500	Unknown	General-use model
QB	Honda	Foreman 400	400	Unknown	General-use model
QB	Honda	Foreman ES	500	Unknown	General-use model
QB	Honda	Fourtrax	Unknown	Unknown	General-use model
QB	Honda	Fourtrax AT	Unknown	Unknown	General-use model
QB	Honda	FourTrax ES (TRX350 FE)	350	Unknown	General-use model
QB	Honda	Fourtrax Foreman ES 450SE	450	Unknown	General-use model
QB	Honda	Fourtrax TRX400 FX	400	1999	General-use model
QB	Honda	Fourtrax TRX400EX	400	Unknown	General-use model
QB	Honda	TRX 250	Unknown	Unknown	General-use model
QB	Honda	TRX300	300	1997	General-use model
QB	Honda	TRX350FWM	350	Unknown	General-use model
QB	Honda	TRX350TEY	350	Unknown	General-use model
QB	Honda	TRX400	400	Unknown	Sports model
QB	Honda	TRX400fa	400	Unknown	General-use model
QB	Honda	TRX420FM7	420	Unknown	General-use model
QB	Honda	TRX450R	450	2005	Sports model
QB	Honda	Unknown	650	Unknown	Unknown
QB	Honda	Unknown	350	Unknown	Unknown
QB	Honda	Unknown	Unknown	Unknown	Unknown
QB	Honda	Unknown	Unknown	Unknown	Unknown
QB	Kawasaki	KFX 400	Unknown	Unknown	Sports model

Vehicle	Make	Model	Size [cc]	Year	Type
QB	Kawasaki	KLF 300	Unknown	Unknown	General-use model
QB	Kawasaki	KVF Workhorse 360	360	Unknown	General-use model
QB	Kawasaki	KVF360	360	2003	General-use model
QB	Kawasaki	Unknown	400	Unknown	Unknown
QB	Kawasaki	Unknown	Unknown	Unknown	Unknown
QB	Kawasaki	Workhorse 300	300	Unknown	General-use model
QB	Kawasaki	Workhorse 400	400	Unknown	General-use
QB	Kawasaki	Workhorse 400	400	Unknown	General-use model
QB	Kazumi Kazuma	Mini	Unknown	Unknown	Youth model
QB	Motoworks	Unknown	Unknown	Unknown	Unknown
QB	Polaris	3400	400	1996	Unknown
QB	Polaris	Magnum 325	325	Unknown	General-use model
QB	Polaris	Magnum 425	425	Unknown	General-use model
QB	Polaris	Sportsman	Unknown	Unknown	General-use model
QB	Polaris	Sportsman X2 500	500	2006	General-use model
QB	Polaris	Trail Boss 330	330	Unknown	General-use model
QB	Polaris	Twin Sportsman	Unknown	Unknown	General-use model
QB	Polaris	Unknown	325	1999	Unknown
QB	Polaris	Unknown	500	Unknown	Unknown
QB	Suzuki	275 RVG	500	Unknown	Unknown
QB	Suzuki	Kin Quad 750AXI	750	Unknown	General-use model
QB	Suzuki	KingQuad	750	Unknown	General-use model
QB	Suzuki	KingQuad	300	Unknown	General-use model
QB	Suzuki	KingQuad LT-A700c	Unknown	Unknown	General-use model
QB	Suzuki	LT 250F	250	Unknown	General-use model
QB	Suzuki	LTF 250K Quad Runner	250	1989	General-use model
QB	Suzuki	Quad Master 300	300	1996	Unknown
QB	Suzuki	Quad Runner	500	2000*	General-use model
QB	Suzuki	Quad Runner 160	Unknown	Unknown	General-use model
QB	Suzuki	Quad Sport	80	Unknown	Youth model
QB	Suzuki	Twin Quad 300	300	Unknown	Unknown
QB	Suzuki	Unknown	500	Unknown	Unknown
QB	Suzuki	Unknown	450	Unknown	Unknown
QB	Yamaha	250YFM225	250	Unknown	Unknown
QB	Yamaha	Banshee	350	Unknown	Sports model

Vehicle	Make	Model	Size [cc]	Year	Type
QB	Yamaha	Banshee 350	350	Unknown	Sports model
QB	Yamaha	Banshee 350	Unknown	Unknown	Sports model
QB	Yamaha	Bear Tracker	250	Unknown	General-use model
QB	Yamaha	Bear Tracker	250	2001	General-use model
QB	Yamaha	Big Bear	250	Unknown	General-use model
QB	Yamaha	Big Bear	350	Unknown	General-use model
QB	Yamaha	Big Bear	350	Unknown	General-use model
QB	Yamaha	Big Bear	350	Unknown	General-use model
QB	Yamaha	FZ450	450	2004	Sports model
QB	Yamaha	Grizzly	Unknown	Unknown	General-use model
QB	Yamaha	Kodiak	400	Unknown	General-use model
QB	Yamaha	Kodiak	Unknown	Unknown	General-use model
QB	Yamaha	Kodiak	400	Unknown	General-use model
QB	Yamaha	Kodiak	400	2003	General-use model
QB	Yamaha	Kodiak Ultramatic	Unknown	Unknown	General-use model
QB	Yamaha	Kodiak YFM 400F	400	2002*	General-use model
QB	Yamaha	Moto 4	225	1987	General-use model
QB	Yamaha	Moto 4	250	Unknown	General-use model
QB	Yamaha	Moto 4	Unknown	Unknown	General-use model
QB	Yamaha	Raptor	90	Unknown	Youth model
QB	Yamaha	Raptor	700	Unknown	Sports model
QB	Yamaha	Timber Wolf	200	Unknown	Unknown
QB	Yamaha	Ultramatic Grizzly	350	Unknown	General-use model
QB	Yamaha	Unknown	Unknown	Unknown	Unknown
QB	Yamaha	Unknown	350	2005	Unknown
QB	Yamaha	Unknown	450	Unknown	Unknown
QB	Yamaha	Unknown	250	Unknown	Unknown
QB	Yamaha	Unknown	Unknown	1991*	Unknown
QB	Yamaha	Unknown	350	Unknown	Unknown
QB	Yamaha	Unknown	Unknown	Unknown	Unknown
QB	Yamaha	Warrior 4	350	Unknown	Sports model
QB	Yamaha	YFZ	350	Unknown	Sports model
6x6	Polaris	Sportsman	500	2000	6x6
SSV	Kawasaki	Mule	600	Unknown	SSV
SSV	Yamaha	Rhino 700	700	Unknown	SSV

Source: R Grzebieta, G Rechnitzer, A McIntosh, R Mitchell, D Patton, K Simmons, University of New South Wales Transport and Road Safety Research Unit, *Supplemental Report: Investigation and Analysis of Quad Bike and Side by Side Vehicle (SSV) Fatalities and Injuries,* provided to WorkCover Authority of New South Wales January 2015, appendix A.

Results:

General-use models	57 fatalities
Sport models	11 fatalities
Youth models	4 fatalities
SSV models	2 fatalities
6x6 models	1 fatality
Unknown models	25 fatalities

Attachment B: Summary of Coronial Inquest recommendations

State and territory coroners have jurisdiction to investigate sudden and unexpected deaths, including quad bike deaths. In the past two years, three major inquests into deaths arising from quad bike or SSV use have been held in Australia. These were:

- 2015 Deputy Coroner Freund's inquest into nine quad bike related deaths in New South Wales
- 2015 Deputy Coroner Lock's inquest into nine quad bike related deaths in Queensland
- 2017 Coroner Cooper's inquest into seven quad bike deaths in Tasmania.

There has also been an earlier inquest in New Zealand:

- 2013 Coroner Shortland's inquest into five quad bike related deaths in New Zealand.

Common recommendations from all inquests include:

- introducing legislation to require mandatory licencing. Queensland and New Zealand also recommended consideration be given to mandating training through certification or licencing
- endorsing the use of helmets at all times when a quad bike is in use.

The Australian coroners' findings all included recommendations for:

- the implementation of a safety rating system, with the Queensland coroner recommending the UNSW TARS Quad Bike Performance Program be used as a starting point
- the introduction of legislation making training packages mandatory. The Queensland coroner recommended the training be subsidised. The New Zealand coroner strongly endorsed training, but did not go so far as suggesting legislating training requirements. The New Zealand Coroner also recommended better information be given to the public on correct tyre pressures and general vehicle maintenance, which could be incorporated in training and education programs
- a standard for quad bike be developed with Standards Australia. The Queensland and Tasmanian coroners recommend the standard be initially based on the US Standard
- introducing legislation to prohibit any child under the age of 16 from operating an adult sized quad bike. The Queensland coroner recommended prohibiting children under the age of seven from being passengers on adult quad bikes (which has since been adopted). The Tasmanian coroner recommended children under the age of six be banned from operating any quad bike.

The New South Wales and Queensland coroners both recommended:

- the development of an Australian standard specifically for quad bike helmets
- implementing a public media campaign and awareness campaign for children's safety.

The Queensland and Tasmanian coroners both recommended:

- standardising approaches across Australia for investigating quad bike deaths
- introducing legislation to prohibit the carrying of passengers on single-rider quad bikes and limiting the number of passengers to the vehicle's design intentions.

Additionally:

- the New Zealand coroner recommended regular testing of after-market attachments and products, specifically trailers and spray units, to better understand the limitations and risks of quad bike stability
- the New South Wales coroner recommended the introduction of an Australian Standard specifically for SSVs which should include a requirement for seatbelts and recommended legislation should follow requiring seat belts to be used when operating SSVs

- the Queensland coroner recommended that an Australian Standard should be developed for Operator Protection Devices (OPDs) used in the workplace. The New Zealand coroner recommended closely following the Australian developments on Rollover Protection Structure (ROPS)
- the New South Wales, Queensland and New Zealand coroners recommended conducting an independent study to assess the benefits, risks and efficacy of OPDs or ROPS. These three coroners also recommended considering warning signals that activate on slopes when a quad bike is potentially at a tipping point or reversing, or personal locator beacons that activate should a quad bike roll over.

Recommendation	New South Wales	Queensland	Tasmania	New Zealand
Implement a safety rating system to help consumers compare safety of vehicles	✓	✓	✓	✗
Implementing a standardised, nationally accredited training package	✓	✓	✓	Training was strongly recommended but not a nationally accredited package
Quad bike mandatory design standard	✓	✓	✓	✗
SSV mandatory design standard	✓	✗	✗	✗
CPD mandatory design standard	x	✓	✗	NZ should closely monitor Australia's approach
Quad bike helmet safety design standard	✓	✓	Helmets should be used but no recommendation of an Australian standard	A quad bike helmet design standard has been in force since 2002
Commission an independent study of ROPS and CPDs	✓	✓	✗	NZ should closely monitor Australia's approach
Implementation of an awareness campaign for children's safety	✓	✓	✗	✗
Implementation of a public media campaign	✓	✓	✗	✗
Requirement for mandatory licencing	✓	Certification or licencing	✗	✓
Introduction of legislation restricting children's use of quad bikes	✓	✓	✓	✗
Introduction of legislation regarding carrying passengers	✗	✓	✓	✗
An investigation of consumer practices that contribute to accidents	✗	✓	✓	✗

Attachment C: Quad bike static stability tilt table test procedure

1 General

1.1 Static Stability of Type I, Category G (General-Use Model), Category S (Sport Model) and Type II quad bikes are to be measured using a tilt table or tilting platform, with a 50th%ile male Anthropomorphic Test Device (ATD) simulated rider positioned in a standardised seating position as described in Section 4.

1.2 Static Stability of Type I, Category Y (Youth Model) and Category T (Transition Model) quad bikes are to be measured using a tilt table or tilting platform without an ATD.

1.3 The Static Stability Factor for each direction (forward or rearward pitch, or lateral roll) is calculated as Tan (Tilt Table Angle at two wheel lift).

1.4 Type I, Category G and Type II quad bikes are to be tested for each direction (forward and rearward pitch and lateral roll) and must meet the minimum performance standards in Section 8.

1.5 Type I, Category S, Category Y and Category T quad bikes are to be tested for lateral roll only.

2 Tilt Table

2.1 Adjustable slope single plane tilt-table structure, range of 0° to 80° from horizontal.

2.2 Surface shall be rigid, flat and large enough to support all four wheels.

2.3 Surface shall support a load cell under each of the four vehicle wheels

2.4 A high friction surface is to be installed on the top surface of the downhill side load cells to prevent the low side tyres from slipping (anti slip tape or expanded mesh may suit)

2.5 Tilt rate of nominally less than 1.0 degree per second (for at least the last 20 degrees before tyre lift-off)

3 Test Vehicle Set-up

3.1 Vehicle is to be prepared to kerb mass ie. all standard equipment fitted and vehicle fluids to be filled to maximum capacity (engine oil, transmission and differential fluids, coolant, brakes and fuel)

3.2 Tyres are to be inflated to the manufacturers recommended pressures. Where more than one pressure is specified, the lowest pressure is to be used.

3.3 Adjustable suspension is to be set at the value specified at dealer delivered configuration.

4 Anthropomorphic Test Device (ATD)

4.1 For Type I Category G, Category S and for Type II quad bikes, use the 50%ile adult male (PAM) ATD (nominal mass 78 kgs) clothed in form fitting cotton clothing and shoes equivalent to those specified in MIL-S13192 rev P

4.2 ATD is to be secured to the seat so as to prevent independent movement.

4.3 The ATD pelvis is to remain parallel with the plane of the rider seat during tilting. (nominally, this is achieved by securing each leg downward toward the footrest. Hands are to be secured to the hand grips)

4.4 ATD is to be positioned such that each hand is gripping the hand controls with the web of the hand in contact with the inner ridge of the hand grip. The arms are to be fully extended, the pelvis is centred laterally on the seat and located longitudinally such that the back angle (measured flat from the spine box) is vertical (±2.5°); the head roll angle is to be horizontal (±0.5°). The thighs are to be in contact with the fuel tank/cowling and the feet are to be positioned on the footrest with the leading edge of the heel in contact with the rear edge of the footrest.

4.5 The ATD Pelvis angle and H point dimensions are to be recorded relative to the rear upper edge of the footrest (vertical (y) and horizontal (z) dimensions)

4.6 ATD limb joint stiffness is to be set at one g.

Note: If the HIII 50 PAM ATD cannot straddle the cowling, a pedestrian sit/stand pelvis may be required to be fitted to the device.

5 Determination of Centre of Gravity (CoG) Location

5.1 Record vehicle wheelbase and track width (front and rear). Check against manufacturer documentation to confirm sample vehicle is within manufacturer tolerances.

5.2 In test condition, weigh the vehicle on flat, level surface to obtain the four individual wheel masses and calculate the vehicle longitudinal CoG and lateral CoG position.

6 Tilt Test Procedure

Lateral Roll

6.1 Position test vehicle on Tilt Table with each wheel centred on a load cell.

6.2 Quad Bikes are to be tested facing in both directions, to account for offset CoG location where this occurs. **Both results should be reported**. The vehicle characteristic lateral roll stability result is to be the lower of the two results achieved from testing in both roll directions.

6.3 Align the test vehicle so that a line passing through the outer edges of the two downhill tyres is parallel to the line of the tilt axis of the table or platform.

6.4 Set the steering mechanism in the straight ahead position.

6.5 Apply park brake or park mechanism to stop the vehicle from rolling.

6.6 Affix two catch straps (of less than one kg mass) between the vehicle and the tilt platform with sufficient slack to allow full decompression (extension) of the uphill suspension and minimal wheel lift at tip over.

6.7 Raise the Tilt Table until both uphill tyres have lost contact with the ground (ie. both uphill load cells show no load).

6.8 Record the Tilt Table angle at moment of second uphill wheel lift (tip over).

6.9 Return the Tilt Table to the horizontal position.

6.10 The static rollover threshold of the vehicle in g's of lateral acceleration (1g = acceleration due to gravity), often referred to as the Tilt Table Ratio (TTR) is calculated as Tan of tilt platform angle at second wheel lift (Tan Ø). The TTR is approximately equal to the Static Stability Factor (SSF) with variation due to CoG displacement due to vehicle body roll and suspension articulation, compliance in steering and suspension joints and deformation of the wheels and tyres.

Pitch

6.11 Quad Bikes are to be tested in both forward and rearward pitch directions.

6.12 Position the test vehicle on the Tilt Table with each wheel centred on a load cell.

6.13 Align the test vehicle so that a line passing through the centreline of the contact patches of the two downhill tyres is parallel to the line of the tilt axis of the table or platform.

6.14 Set the steering mechanism in the straight ahead position.

6.15 Apply park brake or park mechanism, or fix the wheel or the brake assembly (if required) to stop the vehicle from rolling.

6.16 If the low side tyres slip on the load cell surface prior to uphill wheel lift, affix a ratchet strap over each low side wheel such that the line of action of the strap passes through the contact patch of the tyre and the axle centreline, whilst still allowing the tyre to roll about the contact patch when the vehicle tips.

6.17 Affix two catch straps (of less than 1 kg mass) between the vehicle and the tilt platform with sufficient slack to allow full decompression (extension) of the uphill suspension and minimal wheel lift at tip over.

6.18 Raise the Tilt Table until both uphill tyres have lost contact with the ground (ie. both uphill load cells show no load).

6.19 Record the Tilt Table angle at moment of second uphill wheel lift (tip over).

6.20 Return the Tilt Table to the horizontal position.

6.21 The static pitch-over threshold of the vehicle in g's of lateral acceleration (1g = acceleration due to gravity), often referred to as the Tilt Table Ratio (TTR) is calculated as Tan of tilt platform angle at second wheel lift (Tan Ø). The TTR is approximately equal to the Static Stability Factor (SSF) with variation due to CG displacement due to vehicle body pitch and suspension articulation, compliance in steering and suspension joints and deformation of the wheels and tyres.

7 Instrumentation

7.1 Four load cells with at least 700kg load capacity and resolution of at least 0.5 kg.

7.2 Tilt angle sensor with a range of at least 80° and a resolution of at least 0.1°

7.3 Data acquisition system acquisition rate of at least 100 samples per second (100 Hz)

7.4 Rear time videography (front 45° view)

Attachment D: Troutbeck and Associates Report

Evaluation options for improving safety of using quad bikes and side-by-side vehicles in Australia

Report for the Australian Competition and Consumer Commission (ACCC)

Report by

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August 2018 Final Version

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1. Background

Safe Work Australia reported that there were 114 fatalities attributable to the use of quad bikes in Australia from 2011 to 2017 [1]. In the same period, there have been 13 fatalities reported associated with SSVs [2]. Hospital emergency departments have recorded over 650 hospitalisations each year resulting from the use of quad bikes and side-by-side vehicles (SSVs) [3].

Wundersitz et al (2018) indicated that from July 2002 to 30 June 2013, there were at least 7194 hospitalisations that involved injuries from the use of quad bikes or SSVs. This is a substantial cost to the community.

The Australian Competition and Consumer Commission (ACCC) is investigating possible long-term solutions to reduce fatal and non-fatal injuries attributable to the operation of quad bikes and SSVs in Australia. The ACCC released the "Quad Bike Safety Issues Paper" [4] (ACCC Issues Paper) for public comment on 14 November 2017. Following a review of the 56 submissions received in response [5] the ACCC released the "Quad Bike Safety: Consultation Regulation Impact Statement (Consultation RIS) for public comment on 22 March 2018. The Consultation RIS examines a number of policy options that could be introduced through a mandatory safety standard to improve the safety characteristics of quad bikes and side-by-side vehicles (SSVs) [6].

The options for improving safety for quad bikes and SSV's presented in the Consultation RIS are:

> ***"Option 1****: take no action at all (status quo)*
>
> ***Option 2****: make a mandatory safety standard in relation to quad bikes and SSVs that:*
>
> - *adopts the ANSI/SVIA 1–2017 US Standard for quad bikes*
> - *requires post manufacture testing for quad bikes and SSVs in accordance with the requirements of a safety star rating system and the disclosure of the star rating at the point of sale*
> - *requires an additional warning on quad bikes alerting the operator to the risk of rollover*

1 Safe Work Australia 2017, Australian Government, https://www.safeworkaustralia.gov.au/quad-bike-fatality-data#2001

2 AgHealth Australia. Note to ACCC, July 2018.

3 ACCC Quad bike safety, Consultation RIS. https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/

4 https://consultation.accc.gov.au/product-safety/quad-bike-safety-investigation/

5 https://consultation.accc.gov.au/product-safety/quad-bike-safety-investigation/consultation/published_select_respondent

6 ACCC Quad bike safety, Consultation RIS. https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/supporting_documents/Quad%20Bike%20Safety%20%20Consultation%20Regulation%20Impact%20Statement.PDF

> ***Option 3**: make a mandatory safety standard that satisfies all of the requirements of option 2, and in addition requires general-use model quad bikes to be fitted with an operator protection device (OPD)*
>
> ***Option 4**: make a mandatory safety standard that satisfies all the requirements of option 2, and in addition requires general-use model quad bikes to meet minimum performance tests for mechanical suspension, stability and dynamic handling. It also requires that all wheels be able to rotate at different speeds*
>
> ***Option 5**: make a mandatory safety standard that satisfies all of the requirements of Options 2, 3 and 4."*

From the submissions to the ACCC on the Consultation RIS, there was not a clear preference of one option over another. In the Consultation RIS, the ACCC *"considers that **Option 5** is likely to prevent more deaths and injuries to quad bike operators than all of the other options by significantly reducing the frequency of incidents and mitigating the severity of injury when an incident occurs.*"

Sections 2 and 3 of this report discuss the safety record of quad bikes, and side by side vehicles to a lesser extent, and the means to mitigate the risks with these vehicles. In Sections 4 to 13, the basis of the requirements for Options 2 to 5 are discussed. Finally, recommendations based on a critical review of the Options are given in Sections 14 to 18.

2. Safety record of quad bikes

The ACCC (2017) Issues Paper has documented the fatalities associated with quad bikes recorded by Safe Work Australia between 1 January 2011 and 16 October 2017 . The report has identified there were 114 fatalities in this period and that 55 per cent of the fatalities relate to rollover and a further 30 per cent involved a collision. The report states:

> *"Rollovers typically occurred when operators attempted to ride up or down an incline, ride across a slope, navigate tight corners or hit hidden objects or rough terrain".*

The fatality statistics indicate that the frequent cause of death following rollovers is from asphyxiation or from being crushed; the rider is often trapped under the quad bike.

The data, quoted by Grzebeita et al (2015e), indicated that of the 109 fatalities identified 77 (70 per cent) involved the quad bike rolling over. This data included both farm work and recreational activities. More importantly, after eliminating the 47 cases in which the roll direction was unknown, 22 out of 30 cases involve lateral rollovers and in 15 of the 22 lateral rollover cases, the quad bike finished up on its side [7].

When addressing injuries, the ACCC (2017) Issues Paper continues:

> *"It is more difficult to identify the cause for each specific reported quad bike injury. In respect of emergency department presentations from quad bike injuries in Victoria from 1 July 2011 to 31 June 2016, approximately 13%*

[7] Refer to McIntosh and Patton (2014) for a more in-depth description of the data analysis

were attributed to rollover and another 13% attributed to collisions. Causes of injury were reported to be unknown in 61% of cases."

With this significant number of "unknown" cases, the proportion that can be attributable to rollovers could be significantly larger if more details about the incidents were available.

As reported in the Consultation RIS, Wundersitz et al (2018) indicated that from July 2002 to 30 June 2013, there were at least 7194 hospitalisations that involved injuries from the use of quad bikes or SSVs. The Consultation RIS stated:

"ED data for Queensland indicates the most common cause of injury was falling from the vehicle (over 40 per cent) and fractures accounted for approximately half of the hospitalisations. Rollovers accounted for 17.5 per cent of ED presentations and 34.8 per cent of ambulance attendances.

A number of these injuries result in a permanent disability. The majority of these injuries are likely to be traumatic brain injuries and a small number are likely to be spinal cord injuries that result in paraplegia or quadriplegia. Further, a number of injury related amputations are attributed to incidents involving the use of these vehicles."

Understandably, the common injuries involved the head, neck, cervical spine and chest. These injuries accounted for 81 per cent of all injuries. For work-based activities, chest injuries predominated, and for recreation activities, head injuries were most common.

The US Consumer Product Safety Commission (CPSC) published the 2016 Annual Report of ATV-related deaths and injuries [8]. The report states:

"As of December 31, 2016, CPSC staff received reports of 14,653 ATV-related fatalities occurring between 1982 and 2016. CPSC staff received reports of 337 ATV-related fatalities occurring in 2016, 484 occurring in 2015, and 581 occurring in 2014. Reporting for the years 2014 through 2016 is ongoing; these numbers are expected to increase in future reports.

…

From 1982 through 2016, CPSC staff received reports of 3,232 ATV-related fatalities of children younger than 16 years of age. This represents 22 percent of the total number of reported ATV-related fatalities (14,653)

…

In 2016, there were an estimated 101,200 ATV-related, emergency department-treated injuries in the United States. An estimated 26 percent of these involved children younger than 16 years of age."

Quad bike safety is an issue in the US as well as in Australia and potentially world-wide. There is clear evidence that lateral rollover incidents are a significant safety concern often resulting in serious injuries and fatalities.

[8] https://www.cpsc.gov/s3fs-public/atv_annual_Report_2016.pdf?vIcLfTM9VNDc23qe6FQyhJq7A7454xCr Published in December 2017. Site Accessed 9 July 2018.

3. Mitigating the risk of rollover

Risk is evaluated using two basic dimensions; namely the likelihood, or frequency, of an event occurring and the severity of the outcome from that event. Risk can be associated with economic loss, reputation loss and most commonly trauma. The likelihood of vehicle rollover, can be reduced by:

- Improving vehicle configurations and suspensions.
- Reducing and controlling speeds.
- Providing driver or rider education and training programmes (including prohibiting some users).

Once a rollover has commenced then injuries may be reduced by:

- The use of rider or driver personal protection equipment (including appropriate helmets).
- The use of rollover protection structures (ROPS) [9] or Crush Protection Devices (CPDs) [10].
- Providing a "crawl-out" space for riders.

In managing any risk, it is generally better to eliminate or significantly reduce the chances of the event occurring rather than solely reduce the severity. Unless a risk can be eliminated, most measures will be to reduce the likelihood of the event. This is not to say that means of reducing the severity of the outcome should not be undertaken, as both strategies are required. It may not be possible to reduce the likelihood of an event occurring and additional effort to reduce the severity of the outcome is required.

It is not easy to identify the proportion of incidents that may be eliminated by a change in the vehicle's design or the number of measures needed to achieve a required or an acceptable level of safety performance.

This report focuses on the characteristics of quad bikes, their stability and handling predictability. Each of the proposed design features will be examined to establish whether they are likely to reduce the risk principally associated with rollovers and the associated trauma.

[9] The ACCC Quad Bike Safety Issues Paper defines a Rollover protection device as *"A protective structure that encloses the rider and should be used in conjunction with seatbelts. Most commonly used on SSVs"*

[10] The ACCC Quad Bike Safety Issues Paper defines a crush protection device as *"A device mounted to quad bike to minimise the risk of the rider being crushed by vehicle if it rolls over. Does not enclose the rider, but instead holds the upturned vehicle off the ground, creating a 'crawl out' space for the rider in the event of the vehicle rolling over"*.

4. US and European standards

4.1 ANSI/SVIA 1-2017

The Speciality Vehicle Institute of America (SVIA) developed a voluntary industry standard for ATVs under the procedural auspices of the American National Standards Institute. Deppa [11] indicated staff of the US Consumer Product Safety Commission (CPSC) *"participated in its [the standard] development."* Later on in 2006, the standard was mandated as a federal regulation. The current edition is now referred to as the ANSI/SVIA 1-2017 standard.

In the US, quad bikes are classified by their ability to carry a passenger and the operator or only the rider. The Consultation RIS indicates that quad bikes for only the rider are classified as Type I ATVs in the US under ANSI/SVIA 1-2017. Quad bikes for more than one rider are Type II ATVs.

ANSI/SVIA 1-2017 covers:

- brakes
- mechanical suspension including minimum wheel travel
- throttle, clutch and gearshift controls
- engine and fuel cut off devices
- lighting
- tyres and parking brake mechanisms
- operator foot environments
- pitch stability
- owners' manual, hang-tags and compliance certification labelling.

A number of quad bike manufacturers are based in the USA to serve the US market. These companies manufacture quad bikes to the ANSI/SVIA 1-2017 standard for export to Australia. There are other companies supplying quad bikes to the Australian market that have been tested to the European standard EN 15997 which has the same stability requirements to those in ANSI/SVIA 1-2017 standard.

The ANSI/SVIA 1-2017 standard for quad bikes does not specify the lateral stability requirements, but does specify a rearward pitch stability coefficient (K_p) based on the formula [12]

$$K_p = \frac{L_1 tan\alpha}{L_1 + R_r \, tan\alpha} \tag{1}$$

where L_1 is the projected distance from the rear axle to the centre of gravity (CoG)

α is the tip angle and

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11 Submission by Roy Deppa to the ACCC on the Consultation RIS. https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

12 The equation for K_p provides a numerical process to estimate the tip angle if all wheels were positioned on the tilt table. In this test the rear wheels are not locked or have the brakes applied. In the standard tilt test when all wheels are on the platform, the wheels are locked to prevent rotation.

R_r is the vertical distance from the rear axle to the ground

Figure 1 illustrates the testing configuration showing the rear wheels of the quad bike on level platform and the measured angle α. R_r is approximately the wheel radius assuming that the tyre does not distort relative to its distortion when the quad bike is on level terrain and without a load. The standard requires that K_p shall be at least 1.0. The minimum tan α value to produce a K_p of 1 is dependent on the quad bike's geometry and specifically a function of the ratio of R_r/L_1. The tan α value is not a specified minimum.

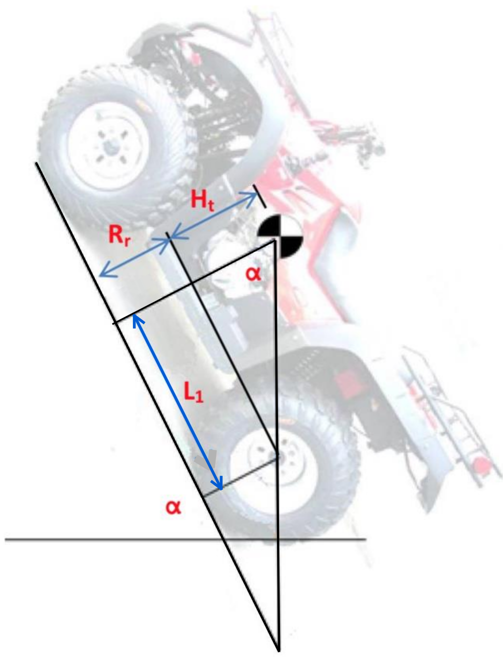

Figure 1. Rear pitch test in the ANSI/SVIA 1-2017 standard showing the dimensions used to calculate K_p (Source: Grzebeita 2015b)

Grzebeita et al (2015b) stated:

> *"In regard to the ANSI/SVIA Standard's Kp requirement for Quad bikes, these were measured by Crashlab according to the recommended test procedure in ANSI/SVIA Standard and found to range from 1.3 to 1.5, all complying with the ANSI/SVIA 1-2010 requirement of Kp>1.0."*

Usefulness of this standard for evaluating stability

The consensus from quad bike manufacturers and retailers is that the adoption of the current ANSI/SVIA 1-2017 standard would be acceptable. The Federal Chamber of Automotive Industries (FCAI) submission to ACCC on the Consultation RIS stated:

> *"Instead, as a starting point, the FCAI would like to see the American National Standards Institute / Specialty Vehicle Institute of America (ANSI/SVIA) Standard or equivalent standard mandated in Australia in order*

> *to ensure all ATVs brought into the country meet an internationally established standard. "*

The ANSI/SVIA 1-2017 is a standard developed with US speciality vehicle industry support and directed towards the US market. While the standard does not specify a maximum vehicle width, the US National Parks do have a maximum vehicle width for vehicles that access their paths.

As most quad bikes now comply with this standard (ANSI/SVIA 1-2017), there has been no concern from major manufacturers and limited concern from distributors about requiring compliance with it and its future updates, provided an adequate transition period is implemented.

A standard to address the safety issues outlined in Section 2 needs to go beyond the requirements in ANSI/SVIA 1-2017. A major limitation with this standard is that it does not address lateral vehicle stability and while it does evaluate rearward pitch stability, it does not address forward pitch stability. Further in addressing rearward pitch, ANSI/SVIA 1-2017 does not specify a minimum stability but uses the values for K_p; this gives a minimum limiting static stability that is a function of the quad bike's geometry and the measured tip angle. A more extensive standard is required to improve the lateral stability of quad bikes. This will be discussed below in Section 17.

The adoption of the current US Standard alone is unlikely to reduce injury rates as it will not significantly affect the current fleet. A submission to the ACCC on the Consultation RIS by Roy Deppa [13], who was previously the Chief Engineer on the US Consumer Product and Safety Commission's All Terrain Vehicle Task Force, stated:

> *"While I agree with the ACCC view that adopting the ANSI standard is a good idea, I cannot help but point out the obvious: it will have no or very little effect on the safety issues associated with Quad Bikes."*

However, a number of submissions to the Consultation RIS agree that the ANSI/SVIA 1-2017 is a good starting point. However, in its current state it does not provide static or dynamic stability testing, except for static rearward stability. This a major shortcoming in the standard and it indicates a need for additional requirements for static and dynamic stability.

4.2 ANSI/ROHVA 1-2016

Side–by-side vehicles (SSVs) are covered by the ANSI/ROHVA 1-2016 standard [14]. The standard includes requirements for:

- brakes
- mechanical suspension including minimum wheel travel
- throttle, clutch and gearshift controls
- engine and fuel cut off devices
- lighting

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[13] Submission by Roy Deppa to the ACCC on the Consultation RIS. https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

[14] See American National Standards Institute (ANSI) (2011)

- tyres and parking brake mechanisms
- static stability
- dynamic stability
- occupant retention system (ORS) or seat belts
- vehicle handling
- occupant protective structures (ROPS)
- owners' manual, hang-tags and compliance certification labelling.

A tilt table is used to evaluate the static lateral stability in two configurations; namely with the vehicle loaded to the gross vehicle weight rating (GVWR) or with the operator and passenger. In the case of the operator and passenger configuration, the tilt table is raised until there is a two-wheel lift and the results are presented in a hang tag.

The minimum TTR values for the lateral loading are 0.65 for the vehicle plus passengers, and 0.45 for the GVWR condition.

A tilt table is also used to evaluate the pitch stability both forward and rearward. The minimum TTR value is 0.53.

Dynamic testing uses the J turn tests where the vehicle is accelerated to 51 to 56 km/h and the steering wheel rapidly turned. The test is run 5 times in each direction and in 8 out of the 10 runs there is to be *"no two wheel lift*". A further constant steer test is used to find the ratio of the change in yaw velocity versus speed in a lateral acceleration range of 0.4 to 0.5 g to the change in yaw velocity versus speed in a lateral acceleration range of 0.1 to 0.2 g. These tests have not been considered in the Consultation RIS but are briefly considered later in this report.

The occupant protective structures are tested with a lateral, vertical and longitudinal loading based on the mass of the vehicle. The vehicle also includes a lateral energy calculation based on the force-deflection response at the loading point. The lateral energy requirement does not have to be met at the same time as the force requirement is met. The standard states:

> *"If the force is attained before the energy, the force may decrease but shall attain the required level when the lateral energy requirement is met or exceeded."*

The standard allows for deformation of the system with a maximum deformation specified by a "deflection limiting volume" which is an orthogonal approximation of a large seated male wearing a protective helmet.

This standard for SSVs has requirements for static and dynamic stability and offers a good starting point for SSVs. The limits for static stability are below those described in the Consultation RIS and less than values recorded by Grzebeita et al (2015a and b).

This standard would be an acceptable standard for SSVs in Australia and could be used for the basis for an Australian Standard.

4.3 ANSI/OPEI B71.9-2016

ANSI/OPEI B71.9-2016 standard is for multipurpose off-highway utility vehicles. The standard includes requirements for a similar set of parameters as the ANSI/ROHVA 1-2016 standard. These include:

- brakes
- mechanical suspension including minimum wheel travel
- throttle, clutch and gearshift controls
- engine and fuel cut off devices
- lighting
- tyres and parking brake mechanisms
- static stability
- dynamic stability
- vehicle handling
- occupant protective structures (ROPS)
- owners' manual, hang-tags and compliance certification labelling.

A tilt table is used to evaluate the static lateral stability in two configurations; namely vehicle plus driver and passengers and gross vehicle weight rating (maximum allowable total weight recommended by the manufacturer). The standard calls for the longitudinal pitch to be established using a tilt table with the vehicle loaded to the gross vehicle weight rating (GVWR).

The minimum TTR values are the same as those in the ANSI/ROHVA 1-2016 standard. For the lateral loading is 0.65 for the vehicle plus passengers, and 0.45 for the GVMR condition. The maximum TTR for longitudinal pitch is 0.53.

Dynamic stability is measured with a J-turn test, constant radius test to predict the yaw rate ratio. These tests have not been included in the Consultation RIS and are not discussed further here.

A force of 22.24 kN or 1.5 times the kerb weight of the vehicle (whichever is less) is applied to the front top corner and the rear top corner of the occupant protective structure in an inclined fashion. The test deflection, measured along the line of the applied force, is required to be less than 127 mm.

The standard requires a hang tag that gives the tilt table results and a warning statement. An example hang tag is shown in Figure 2.

This standard for SSV-type vehicles has requirements for static and dynamic stability with the tilt table limits the same as for the ANSI/ROHVA 1-2016 standard.

This standard would be an acceptable standard for SSVs in Australia and could form the basis for an Australian Standard.

4.4 European standard EN 15997:2011

The European standard EN 15997:2011 [15] contains the same stability requirements as in ANSI/SVIA 1-2017 standard, as both standards require a longitudinal stability coefficient (K_p) calculated using the same equation:

$$K_p = \frac{L_1 tan\alpha}{L_1 + R_r\ tan\alpha} \qquad (2)$$

[15] European standard EN15997 All terrain vehicles (ATVs – Quads) - safety requirements and test methods.

where L_1 is the projected distance from the rear axle to the centre of gravity (CoG)

α is the tip angle, and

R_r is the vertical distance from the rear axle to the ground

Figure 1 illustrates the dimensions. The minimum K_p value is again 1.0 and the comments about the ANSI/SVIA 1-2017 standard in Section 4.1 also apply to this standard. Note that this European standard only covers rearward longitudinal stability; forward pitch and lateral roll are not covered.

Quad bikes complying with the stability requirements in this standard will also comply with the stability requirements in ANSI/SVIA 1-2017 standard.

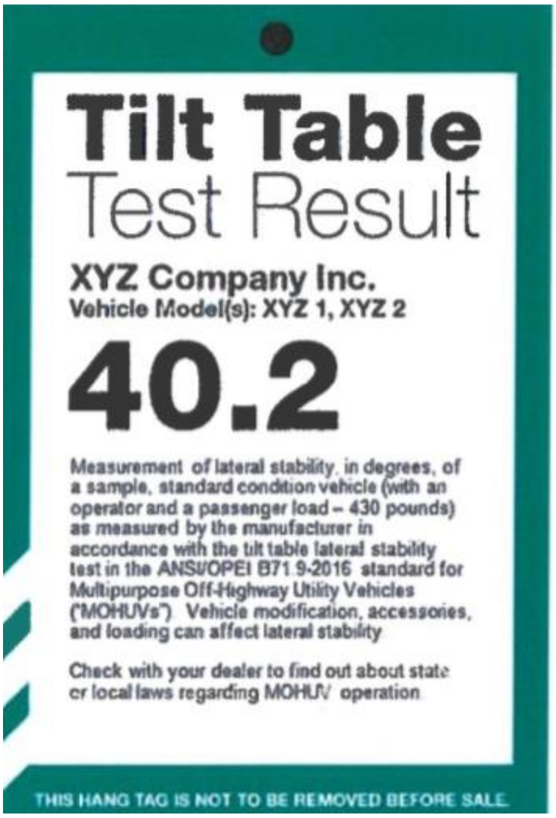

Figure 2. Hang tag recommended in ANSI/OPEI B71.9-2016 to indicate lateral stability.

4.5 Other applicable standards

Additionally, to cover all SSVs sold in Australia, it has been suggested that other standards may also be considered, including SAE 2258 Light Utility Vehicles. This standard has not been reviewed.

4.6 Recommendations

It is useful to adopt an international standard or at least to base an Australian standard on an international standard. Accordingly, it is recommended that quad bikes conform to the US ANSI/SVIA 1-2017 standard for ATVs, or the European standard EN 15997 (subject to it having similar "non-stability" requirements to ANSI/SVIA 1-2017 standard) and that additional tests for static stability, dynamic handling stability and other attributes be incorporated into an Australian standard. The additional requirements for an Australian standard are discussed in Section 17.

The latest version of the ROHVA standard (ANSI/ROHVA 1-2016) or the ANSI/OPEI B71.9-2016 standard would be appropriate to adopt for SSVs as they contain requirements for all the main safety features and measures of static and dynamic stability.

5. Outline of the star rating system

The proposed star rating system is outlined in Attachment A of the Consultation RIS and includes measures of static stability, dynamic handling and rollover crashworthiness.

For static stability, a number of tests are proposed for lateral roll, forward pitch and rearward pitch. In each case a number of different load configurations are proposed; namely:

- unloaded
- with operator
- with operator and front cargo load
- with operator and rear cargo load, and
- with operator, front cargo load and rear cargo load.

This would in effect amount to 15 tilt table tests.

The star rating system proposed in the Consultation RIS evaluates vehicle control and handling characteristics which are *"likely to improve a driver's/rider's vehicles path control and the vehicle's resistance to rollover"*.

Attachment A of the Consultation RIS describes the basis of the dynamic handling tests as follows:

- Steady-state circular driving behaviour dynamic test to determine each vehicle's limit of lateral acceleration and the understeer/oversteer characteristics [16].
- Lateral transient response dynamic test to determine a vehicle's responsiveness to steering manoeuvres.
- Bump obstacle perturbation test to determine a vehicle's responsiveness while riding over asymmetric bumps.

[16] The maximum observed lateral acceleration is when the two vehicles lift off the ground or when the inside rear wheel loses traction and limits the maximum speed.

The same test protocol is used for both quad bikes and SSVs. The precise details of these tests are described in the following sections.

Rollover crashworthiness is proposed to be evaluated using different test protocols for quad bikes and side-by-side vehicles (SSVs). For quad bikes, it is proposed to use ground contact load measures, and rollover tests with and without Operator Protection Devices (OPDs). For SSVs it is proposed to test occupant retention systems, rollover outcome and the load strength assessment of rollover protection systems (ROPS).

Points are given for each measure; namely static stability, dynamic handling, and rollover crashworthiness. Additional points are given for open differentials and for seatbelt interlocks.

The static and dynamic tests that are proposed for a star rating system are similar to those that have been proposed for a standard. The standard specifies minimum values for the different tests and the star rating system combines the results from tests to inform consumers.

The testing for both a star rating system and a standard is discussed in the next sections.

6. Static stability testing

The ANSI/ROHVA 1-2016 standard specifies rearward stability testing. Option 2 of the Consultation RIS requires lateral, forward and rearward testing to be measured and included in the determination of the star rating. Options 4 and 5 require minimum levels of lateral, forward and rearward stability to be specified in a standard.

The following sections discuss the efficacy of measuring lateral static stability and forward and rearward measures.

6.1 Lateral static stability test process

The test procedure used in the TARS study [17] is relatively simple in that an unloaded or loaded quad bike or SSV is tilted slowly on a tilt table. The vehicle is restrained from moving down the tilt table and from overturing as shown in Figure 3.

The maximum tilt angle is recorded when both wheels (on the upper side) of the loaded or unloaded quad bike or SSV have lost contact with the tilt table. Appendix E of the Crashlab Special Report SR2013/003 [18] has photographs of typical ATV forward and rearward pitch test showing the moment when the two upper wheels have lost contact. Also see report by SEA Limited (2016) on 12 adult single rider all terrain vehicles (ATVs) produced in the model year 2014-2015.

The results are presented as tilt table ratios (TTRs), which are the tangent of the angle of the table's incline.

[17] See Grzebieta, Rechnitzer and Simmons (2015a)

[18] See Crashlab (2013a)

Figure 3. Typical quad bike lateral roll test (Source: Crashlab 2013a)

6.2 Evaluation of static lateral stability tests

In evaluating the use of dynamic stability measures through a J-turn, the Yamaha Motor Corporation [19] stated that:

> *"Tilt table angle measurements ("TTA") are superior and preferable to lateral stability measurements (ay) during J-turns as an indicator of lateral stability.*
>
> *...*
>
> *Tilt table measurements are particularly advantageous for vehicles equipped with compliant suspension and tire components because the deflection of those components is automatically and consistently reflected in the tilt table results. Similarly, tilt table measurements inherently reflect weight distribution effects (both side to side, and fore-aft), as well as the effect of track width differences between front and rear. Finally, tilt table measurements do not require complicated and expensive test equipment. For all these reasons, tilt table measurements are superior to the NPR's J-turn requirements."*

While this is justification for the use of the tilt table to measure static stability, its value must be understood in relation to dynamic lateral stability measures. Macmillan (2017) stated:

> *"In terms of lateral instability, the QB [quad bike] will act much more like a rigid body than it does for longitudinal instability. Hence, the two static requirements for instability are as follows:*

[19] Yamaha Motor Corporation comments on the CPSC's recreational Off-highway vehicles NPR 19 June 2015 and presented as appendix F to the FCIA's submission to the ACCC Consultation RIS. https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

(i) The component of the (static) weight down the slope, plus any (effectively quasi-static) forces through the CoG [centre of gravity] (such as the centrifugal 'force' during turning) and any dynamic inertial forces arising from sliding impact on a resisting object, must fall outside the base.

(ii) The lateral force at the wheel/surface contact patch must not exceed the shearing strength (represented by tan γ, the 'lateral coefficient',) at that interface."

The static stability provides an indication of whether the vehicle will be able to be positioned on a slope (defined by the tilt table ratio; TTR). Macmillan (2017) re-plotted the data recorded in Grzebeita et al (2015b), to produce the graph reproduced here as Figure 4. The grey band represents the range of lateral traction coefficients for representative tyres for quad bikes on agricultural soils. From his experience with the operation of tractors, Macmillan then considered that these soil characteristics would equally apply to lateral ground reactive forces. Essentially the resistance to sliding is generated by the tyre-soil interface and, by the soil-soil interface with cohesive properties or structure when the wheel penetrates the ground profile. The test procedure described by Grzebieta et al (2015a) indicated that the vehicles had to be restrained from sliding before the upper wheels left the platform. This illustrates Macmillan's point.

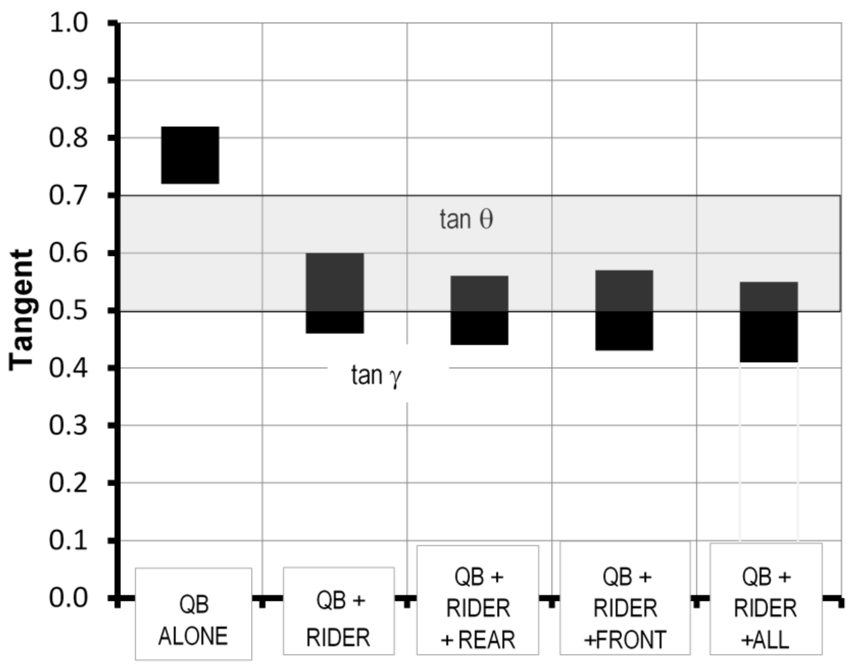

Figure 4. Lateral static stability results for commercially available quad bikes (Source: Macmillan 2017)

Below the grey band would represent very slippery surfaces where the ground offers very little resistance to sliding laterally, or that the ground surface offers little resistance to the tractive effort or braking effort in the longitudinal direction. At the higher end of the grey band, the tyres either establish significant friction with a hard surface, or the soils are strong cohesively, and the tyres penetrate the soil profile and the soil to soil strength creates a strong resistance to sliding laterally or allows the vehicle to have traction with the ground.

Macmillan (2017) provided the following comment on this graph:

> *"The results suggest that among these there is some ±10% variation from the mean angle of slope for static lateral instability. This is also a small variation for prospective purchasers to use to discriminate between more stable and less stable makes. The results also suggest that for all loading arrangements, there is little to choose between QB [quad bike] makes, as all are about as likely to roll over as they are to slide off.*
>
> *Considering (ii) above, if the lateral force that can be generated at the wheel/surface interface (also represented by tan θ) is exceeded on a slope before the roll-over angle (tan γ) is reached, the vehicle will slip sideways and will not roll over as a result of the static forces alone. This of course may bring its own issues of control, and a resultant dynamic instability."*

Figure 4 needs a little more explanation. Considering the case of a quad bike and rider, the tilt table values are listed in Table 1 and ranged from 0.46 to 0.60 for quad bikes with a rider (95th Percentile Adult Male (PAM) Hybrid III (H3) Anthropomorphic Test Dummy (ATD), i.e. 95th PAM ATD) but without any additional load or an operator protection device. Sport and youth quad bikes have been excluded from the analysis. If the ground conditions have a limiting lateral force represented by a tan θ equal to 0.5, then one quad bike (TTR less than 0.5) would rollover, and the remaining 7 quad bikes would slide [20]. On improved ground conditions with a tan θ equal to 0.55, then 4 quad bikes would slide and 4 would rollover. A further improvement in ground conditions to a tan θ equal to 0.61, then all quad bikes would roll over.

Table 1. Static lateral stability for production general use quad bikes tested by TARS with a 95th PAM ATD (Source: Grzebeita et al 2015b)

Make	Model	Maximum angle	Tan theta (TTR)
Kymco	MXU300	24.5	0.46
Honda	TRX250	27.2	0.51
Yamaha	YFM450FAP Grizzly	27.4	0.52
Kawasaki	KVF300	28.2	0.54
Suzuki	Kingquad 400ASI	29.6	0.57
Honda	TRX500FM	29.9	0.58
CF Moto	CF500	30.9	0.60
Polaris	Sportsman 450HO	30.8	0.60

[20] TARS data recorded in Grzebeita, Rechnitzer and Simmons (2015b) *and in Crashlab (2013)*

Macmillan's point is that the ground conditions usually found on rural properties provide for the lateral forces on wheels to be in the range specified by tan θ being between 0.5 and 0.7 and the outcome of a quad bike traversing a slope is significantly affected by the lateral force that can be generated by the ground as explained by Macmillan (2017).

Quantifying the potential ground conditions is difficult. Macmillan [21] used results from Payne and Fountaine (1952) who assessed English agricultural soils and his experience to consider that in general soil characteristics encountered on agricultural and rural land have tan θ values at the lower end of the 0.5 to 0.7 range

For comparison, in crash reconstruction, the friction between passenger car tyres and the ground is assumed to be around 0.70, for grassed surfaces it is between 0.2 and 0.4. The friction on a gravel road is also approximately 0.4 [22]. It is noted that the tyres on a quad bike operate differently to car tyres and involve a different mechanism for sliding. However, these values indicate the consequences when the vehicle is driven on hard surfaces.

As a consequence, Macmillan's work indicates that the quad bikes with higher stability ratings (higher tan γ or TTR values) are more likely to slide than rollover on slopes. A sliding quad bike provides more opportunities for a rider to jump from the machine and reduces the number of rollovers. This will increase the safety of some operators.

Macmillan (2017) also indicates that the quad bikes travelling on a slope may still rollover, even though the ground condition would indicate they would slide. Macmillan states that the conditions for this rollover to occur include:

- *"an impulse (perpendicular to the surface) on the upper wheels;*
- *the inertial effect if the rotation of the QB is stopped when the lower wheels fall into a hole;*
- *the inertial effect if the QB is stopped while sliding sideways due to the quasi-static failure noted above."*

In this case a moment is applied to the quad bike about the interface between the ground and the two lower wheels. Macmillan concludes that these dynamic effects may overwhelm the quasi-static stability results. He states:

> *"If the dynamic effects are added to the static and quasi-static effects as they may be in actual operation, the differences between makes are likely to be at best confusing, and at worst unreliable as a basis for ranking QBs in lateral operational instability."*

SEA Limited (2016) tested 12 ATVs for static stability on a tilt table. Their results for the Tilt Table Ratio (TTR) are listed in Table 2 and are comparable to those recorded by Grzebeita et al (2015b) in Table 1 for a 95th PAM ATD (104kg) . The Hybrid 2 ATD was used and ballasted to a mass of 97 kg (213 lb).

[21] Personal communication with Mr Macmillan July 2018.

[22] Canek, Jamieson and McLarin (2006)

These dynamic effects will be discussed later in this report. It is concluded here that for a given quad bike mass, the static stability can assist in predicting the general lateral stability of a quad bike.

Table 2. Static lateral stability for ATV and rider tested by SEA Limited (2016)

Vehicle	Average Lateral TTR	Vehicle	Average Lateral TTR
F	0.474	E	0.624
A	0.501	I	0.624
G	0.542	D	0.632
J	0.585	H	0.650
C	0.604	L	0.650
B	0.613	K	0.670

6.3 *Additional forward static stability testing*

In the Consultation RIS, Options 2-5 recommend that a forward static stability test be used as part of the star rating system. Options 4-5 also recommend it for minimum performance requirements. As with lateral stability, the forward and rearward tilt tests illustrate the ability of the vehicle to climb or descend slopes. The forward tilt test completes the tested orientations.

Using the concepts in Macmillan, vehicles with high tilt table ratios are more likely to slide rather than tip over on surface conditions generally found on rural properties. The selection of the limits will be discussed later in this report.

6.4 *Application of these static stability tests in the options proposed in the Consultation RIS*

The application of these tilt tests in the standard requires a minimum value for the tangent of the tilt angle, which is the Tilt Table Ratio (TTR). For Options 4 and 5, the Consultation RIS recommends minimum stability test requirements expressed by the tilt table ratio (TTR) of 0.8 for lateral roll. These limits appear to be arbitrarily chosen, however, the TARS group had indicated that the prototype vehicle had achieved these values or close to these values with a 95th PAM ATD and met these requirements without an ATD [23].

Further the Consultation RIS recommends testing with a *"50th Percentile Adult Male (PAM) Hybrid III (H3) Anthropomorphic Test Dummy (ATD) as a simulated rider"* [24].

A heavier rider can adjust the position of the centre of gravity of the rider and quad bike to a greater extent than a lighter rider and consequently make active riding more effective. When testing for lateral stability a rider is positioned upright and a heavy ATD is then

[23] See Table 11 of Grzebeita et al (2015b)

[24] ACCC Quad bike safety, Consultation RIS

less representative of real-world applications. A 95th PAM ATD would represent an extreme condition, whereas a 50th PAM ATD would represent "average" conditions. As the static stability tests are to provide an indicator over a range of conditions, the 50th PAM ATD is more appropriate.

The ATD cannot be positioned to represent all conditions. An upright position provides a consistent ATD seating position which increases the repeatability of the static stability tests.

Testing with a 50th PAM ATD [25] produces values between those obtained with a 95th PAM ATD and those obtained with no ATD and closer to values for the a 50th PAM ATD. Simmons (2018) has provided further evidence of the effect of using a 50th PAM. He calculated the lateral stability factor (K_{st}) for the quad bikes tested by TARS using the equation:

$$K_{st} = [L\ t_2 + L_{cg}\ (t_1 - t_2)]\ /\ 2\ L\ H_{cg} \qquad (3)$$

where L is the wheelbase (mm)

t_1 and t_2 are the front and rear track width respectively (mm)

L_{cg} is the location of the CG forward of the rear axle (mm) and

H_{cg} is the height of the CG above ground.

Simmons found that these K_{st} values did not correlate with the measured tilt table results and revised the calculations to include tyre deformation. Although this improved the estimates, they still did not strongly correlate with the measured results. However, his work does indicate that the TTR values for lateral stability are likely to be improved by 4 to 5 per cent by using a 50th PAM ATD instead of a 95th PAM ATD.

Simmons (2018) also found that the calculated forward and rearward stability factors would be improved by approximately 7.5 per cent on average in the rearward direction and by approximately 2 per cent in the forward direction. An improvement in the TTR values could also be expected, but not necessarily by the same amount (this is discussed further in Section 6.8).

Simmons concluded:

> *"The proposed values for stability, namely TTR_{st} = 0.8, TTR_{pr} = 1.0 and TTR_{pf} = 1.10 are all readily achievable within tested vehicle design parameters when using a 50 PAM H3 ATD surrogate rider."*

It appears that these limits were based on this evaluation or a similar one and using the results of a prototype vehicle, which indicated possible stability values. The prototype vehicle was not in commercial production.

Although these values are arbitrary, it is noted that higher TTR values indicated a higher degree of stability in a static condition and when a vehicle is travelling over relatively smooth ground conditions on slopes where there are limited dynamic impulses on the vehicle.

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25 50th PAM ATD weight is 78 kg and a 95th PAM weighs 104 kg

6.5 Limitations with the application of static stability tests

There are two major limitations of the static stability tests using a tilt table. First is whether these static tests provide a good indication of the dynamic stability of a quad bike or SSV. Macmillan (2017) indicates that, while they provide an indication, dynamic impulses to the vehicle can significantly affect its dynamic performance. It is recognised that the loadings and the orientation of the ATD will affect the results; it is not possible to account for the application of "active riding". Nevertheless, it is noted that these tests are routinely undertaken [26] and because of their simplicity, they give repeatable and reproducible results.

The second limitation is the arbitrariness of the minimum TTR values in the Consultation RIS Options 4-5 and the weighting coefficients incorporated into the star rating system proposed in the Consultation RIS Options 2-5. These values do not have a fundamental basis, except to say that more stable vehicles are preferred and that the prototype vehicle was able to achieve these limits.

Figure 4 from Macmillan (2017) indicated that with a rider, the effect of different loading states makes little difference to the range of TTR values recorded in lateral roll. Figure 5 is a similar plot of the forward and rearward pitch results for the quad bike alone, the quad bike and rider and the quad bike with a load in both the front and rear positions. A load in the front only makes the vehicle less stable going down slopes and similarly a rear load affects stability on upward slopes [27].

Figure 5 indicates that the range of stability values for the quad bike alone is similar in the forward and rearward direction and that the rider or the rider plus load reduced the stability. In general, the rearward pitch TTR values are lower than those for the forward pitch particularly if the tractive effort is included when going uphill.

Macmillan (2017) points out that the practical range of soil conditions on rural properties has a traction coefficient in the range of 0.5 to 0.7 and consequently, the quad bike is more likely to slide rather than tip over (in the forward and rearward direction).

The research by Macmillan demonstrates the links between static stability, dynamic stability and ground shear conditions. The static stability TTR values are then an indicator and not a predictor of rollover propensity in the field. However, the results are repeatable, within limits, and do indicate stability. The hang tag shown in Figure 2 illustrates its acceptance as an indicator.

[26] See SEA Limited (2015; 2016)

[27] It is considered that vehicles are equally likely to travel up slopes as they would travel down slopes.

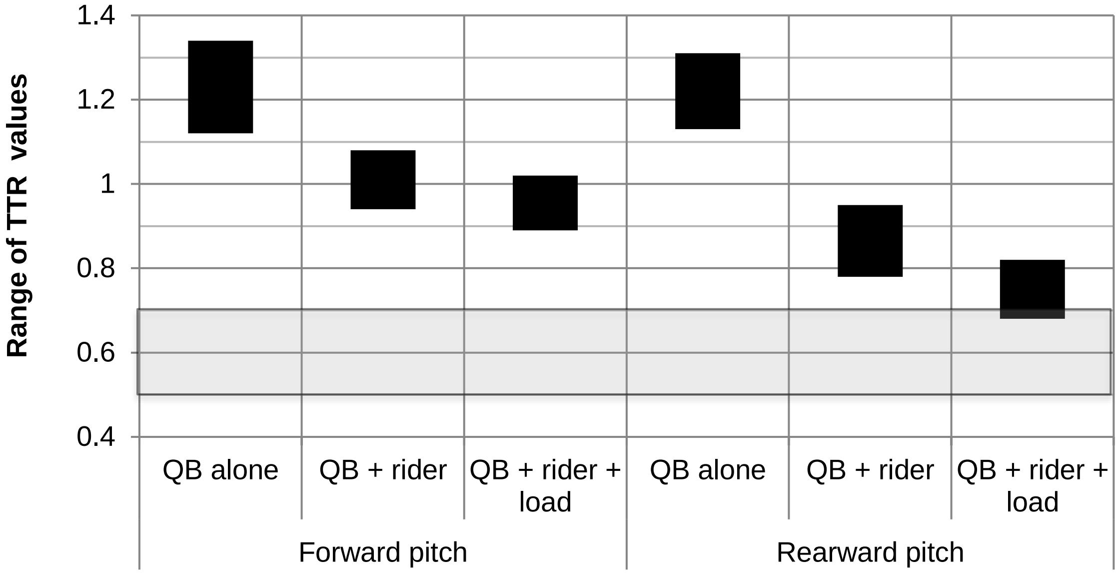

Figure 5. Range of TTR values for different load characteristics and pitch direction. Typical soil ranges are shown by the greyed area

6.6 Effect of lateral stability on vehicle safety

The demonstration that lateral stability will reduce injury rates is not clear.

Deppa [28], in a memorandum to Robert Frye, stated:

> *"In October, 1990, CPSC staff from EP and EC reported to the commission that their analyses of injury data could show no relationship between lateral stability and risk of injury [29]. Engineering judgement and experience run counter to these findings, because the results of engineering work indicate that higher stability should result in fewer rollovers. Specifically, the physics underlying the dynamic conditions indicate that even within the range of variables studies, increasing values of K_{st} can result in vehicles with less propensity to roll over during certain operations."*

Later in the memorandum Deppa stated:

> *"In particular, considerable attention has been devoted to the issue of lateral stability, or the vehicle's resistance to rollover. Several of the studies conducted by ES staff and the contractors have quantified the effects lateral stability has on the handling characteristics of ATVs and thus to some extent the influence that this parameter has on operational safety [30]."*

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28 Memorandum from Roy Deppa to Robert Frye at the US Consumer Product Safety Commission, Washington DC, and dated February 28 1991. Exhibit F15 to the Queensland Coronial Inquest into nine deaths caused by quad bikes, August 2015

29 See Scheers, Fulcher and Polen (1989) and Rodgers (1989)

30 See Deppa and Hauser (1989)

Rodgers (1989) reported on the all terrain vehicle injuries treated in an emergency room for the full 1989 calendar year. He stated that

> *"These results therefore indicate no statistically significant relationship between the injury risk and K_{st} values within either the class of three-wheeled ATVs (with K_{st} values ranging from 0.54 to 0.67) or the class of four-wheeled ATVs (with K_{st} values ranging from 0.87 to 1.0)."*

Rodgers concluded:

> *"Finally, the analysis did not find any significant statistical relationship between the static measure of lateral stability, K_{st}, and the injury risk. This does not mean that there is no theoretical relationship between K_{st} and sideways rollover; rather, it means that changes in K_{st} within the ranges examined have no measurable impact on the accident risk. Consequently, the study provides no statistical support for raising the minimum acceptable K_{st} level for four-wheeled ATVs above the current levels specified in the CPSC-industry supplemental agreement to the voluntary standard."*

Scheers et al (1991) [31] reported data from telephone surveys with injured persons from the National Electronic Injury Surveillance System (NEISS) sample. They collected data on the number of injury incidents and the likely exposure from household interviews.

They stated that:

> *"ATV-related injuries treated in U.S. hospital emergency rooms were estimated to have increased from about 8,000 in 1982 to over 85,000 in 1985."*

This rapid increase in the number of injuries signifies a serious safety issue with quad bikes in the US. In the years following, the estimated injury rate reduced from 3.2 injuries per 100 quad bikes in use in 1985 to 2.3 injuries per 100 quad bikes in use in 1989 [32].

Scheers et al segregated the data by the weight of the quad bike; namely under 181 kg (400 lbs) or between 181 and 226 kg (400 to 499 lbs). All vehicles tested by TARS were over the 181 kg limit but 7 out of 8 had an unladen mass of more than 226 kg. Scheers et al data for quad bikes in this range are shown in Table 3, based on 25 incidents and 106 exposure measures. With these small sample sizes, the results are not statistically significant. However, the data does show a trend of reducing crash rates as the lateral stability increased. Scheers et al (1991) indicated that the risk to riders under 16 years old is higher than for all riders but has also shown a decline in the risk between 1985 and 1989 for this younger age group.

[31] Also see memorandum from Dr N J Scheers to Robert Frye at the US Consumer Product Safety Commission, Washington DC, and dated February 1991, Exhibit F15 to the Queensland Coronial Inquest into nine deaths caused by quad bikes, August 2015

[32] Refer to Table 1 of Scheers et al (1989)

Table 3 Sample sized for exposure (E) and injury (I) observations for quad bikes weighing less than 181 kg and 181 to 226 kg (Source: Scheers et al 1991)

Vehicle weight		K_{st} range			
		0.87 to 0.90	0.91 to 0.94	0.95 to 0.99	1.00 to 1.08
< 181 kg	Injuries (I)	23	59	7	0
	Exposure (E)	77	156	5	15
181 to 226 kg	Injuries (I)	17	8		0
	Exposure (E)	52	28		26

Scheers et al (1991) stated:

> *"Because of this lack of a consistent relationship between increasing Kst values and decreasing risk of injury, it would be difficult to use these data to support regulations requiring new ATVs to have Kst equal to 1.0 or greater."*

However, it needs to be appreciated that, for injury data to produce statistically significant results for a change in vehicle stability, it would require large data sets because of the number of potential variables in a crash.

The engineering and physics demonstrate that making the vehicles more stable will reduce the vehicle's propensity to rollover. The general crash statistics, in Section 2, show that lateral rollover has a significant risk of fatalities. The potential for lateral rollover is reduced with more stable vehicles. Consequently, it is argued, that actions to improve lateral stability should be supported even if the data do not show statistically significant trends at this time.

The FCAI in its submission to the Consultation RIS raised concerns about requiring increased stability and the implications for mobility and safety. It stated:

> *"Requiring minimum levels of static stability that are higher than those of current ATVs will result in vehicles that have less mobility. This is because achieving higher static stability will require vehicles to have less ground clearance or larger wheelbase/track width. Having a larger wheelbase / trackwidth results in smaller breakover angles, which are common measures of mobility for off-road vehicles."*

And further in its submission:

> *"There would be more undercarriage "ground strikes", which are annoying, potentially damaging to crucial safety-related components, expensive to repair and also hazardous."*

In essence, a change in a quad bike's dimensions to improve static stability may prevent the vehicle being used in some tight locations. However, the argument is weak as no matter how narrow a vehicle is or how much ground clearance is available, there will always be some locations that cannot be reached by the vehicle. There is no established relationship between a quad bike's dimensions and the loss of accessibility, mobility or safety. However, it is acknowledged that there can be situations where a loss of mobility may increase risk.

The notion of ground strikes being more prevalent and being hazardous implies that riders would not judge the ground clearance and proceed without regard to the terrain. This argument is not supported. It is expected that riders would appreciate the danger in ground strikes and would alter their driving style and routes taken. A significant ground strike could cause the vehicle to decelerate sharply and for the rider to be dislodged.

6.7 Using static stability tests in a star rating system

For Options 2-5, the TARS system for the star rating uses the five loading conditions for each orientation of the vehicle on the tilt table. Grzebeita et al (2015a) described the process of developing a static stability overall rating as follows:

> *"The stability indices are firstly based on the TTR values for each of three tilt test directions, by summing and then averaging the TTR values for each loading combination within those test directions:*
>
> 1. *Lateral Roll*
> 2. *Forward Pitch*
> 3. *Rear Pitch*
>
> *The final Static Stability Overall Rating Index for each vehicle is then derived from weighted average TTR values for each of the three test directions"*

The TTR values are normalised by dividing the average TTR by a benchmark value of 1.0, 2.0 and 1.75 for lateral roll, forward pitch and rearward pitch respectively. While these benchmarks were chosen arbitrarily, Grzebeita et al (2015a) state that these *"benchmark values were achieved (or nearly achieved) by those vehicles displaying the highest TTR stability measures, in some loading conditions."* They continued and stated that these values *"provide a reasonable starting point"*.

The static stability overall index is the sum of the normalised rearward pitch index, the forward pitch index and twice the normalised roll index. This was because the *"lateral roll can occur in two directions (left and right) compared with one each for forward and rearward pitch"* [33].

This is a complicated formulation and hides a lot of detailed knowledge and it would be more transparent to the consumer if the process was simplified.

For vehicles travelling across slopes, the stability for the vehicle going in each direction needs to be considered. Note that the lateral static stability TTR values need not be the same for vehicles orientated in the two directions across a slope. Accordingly, it is reasonable to consider the minimum tilt table ratio (TTR values) for tests with the vehicle facing to the left or right across the tilt table.

It is recommended that a simpler testing program using the minimum longitudinal and the minimum lateral TTR values be used to define static stability.

[33] See Grzebeita et al (2015a)

The reason for taking the minimum longitudinal and the minimum lateral measures is that vehicles need to both climb and descend slopes and they need to drive across slopes in both directions. There would be no point in having a vehicle being able to descend a slope without being able to ascend it again.

An evaluation of the test results by Macmillan (2017) above indicates the difference in the loadings is a second order effect for the lateral roll (see Figure 4). For the forward and rearward tilt, the position of the load has a greater effect particularly in the rearward pitch direction. A load on the rear of the quad bike reduces its static rearward pitch stability.

The worst-case loading could be used to evaluate pitch stability. It is argued that it would be better to test with the rider only, and set the minimum value higher. The definition of the worst-case is not well defined as the type of load and its dimensions, even if it has the same mass, will affect the stability in the field. A higher load will reduce stability. The movement of water in a spraying system can also reduce stability. It is therefore impossible to design a representative or worst-case load and it is argued that it not informative to use TTR values from a loaded quad bike. As stated above the TTR values are an indicator for general conditions and general stability and not a predictor of all field conditions.

The notion is that the tests should be easily able to be explained to consumers and they do not have to be an exact representation of the particular conditions in the field.

The construct of a recommended star rating system is discussed further below in Section 15.

6.8 Using static stability tests in an expanded standard

An important part of the testing requirements is that the tests be repeatable at one test site and reproducible at other test sites. Accordingly, simplifying the tests, where appropriate, is important. A reduced number of loading configurations would simplify the subsequent analysis, particularly as it is difficult to demonstrate that the loading configurations are realistic across the board.

The same testing procedure should be used for the star rating and requirements in an extended standard. In the previous section, the work of Macmillan (2017) indicates that quad bikes should be tested without any additional loads.

As for the star rating system, the quad bikes, tested for static stability on a tilt table, should use a 50^{th} PAM ATD positioned in the driving seat or on the saddle. The minimum lateral and longitudinal tilt table ratios (TTRs) will then be used in the standard. Figure 6 illustrates these values for general use quad bikes evaluated by the TARS team using a 95^{th} PAM ATD. As a 50^{th} PAM ATD is proposed, the TTR values for a lighter rider would be slightly higher than those for the 95^{th} PAM ATD.

Simmons (2018) calculated the static stability factors for using the dimension of the vehicle. For the forward pitch, the K_{pf} values are increased by average of 2 per cent when a 50^{th} PAM ATD was used instead of the 95^{th} PAM ATD. The rearward values (K_{pr}) were increased by approximately 7.5 per cent with a lighter ATD. This is also described in Section 6.4 of this report.

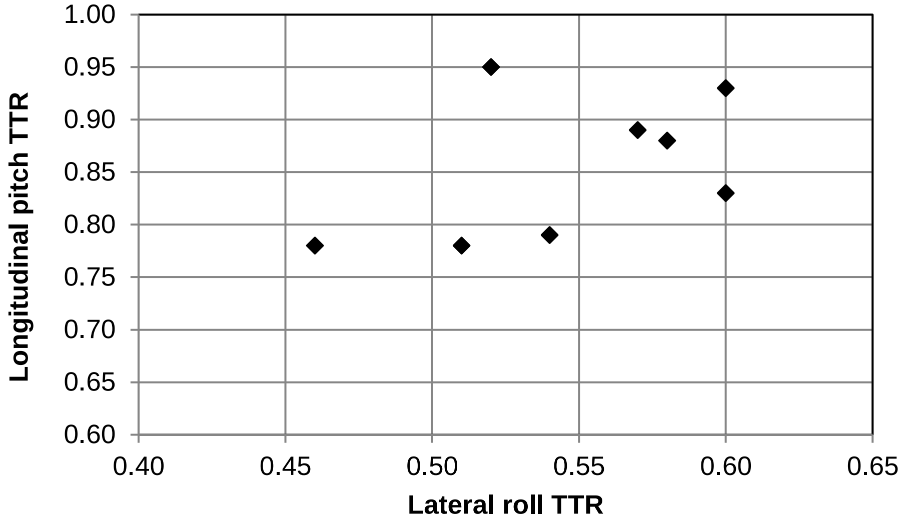

Figure 6. Lateral roll TTR and Longitudinal pitch TTR measured using a 95th PAM ATD

The evaluation of the pitch TTR values could be further refined and it does not need to involve as many arbitrary values. This will be discussed further in Section 17.4.

Similarly, the lateral stability factor (K_{st}) for the quad bikes tested by TARS was increased by approximately 4 per cent if the lighter ATD was used. Applying the change in the K_{pf} and K_{pr} values for the different ATDs to the TARS recorded TTR values give estimates of the TTR values with the 50th PAM ATD. These expected values are plotted in Figure 7.

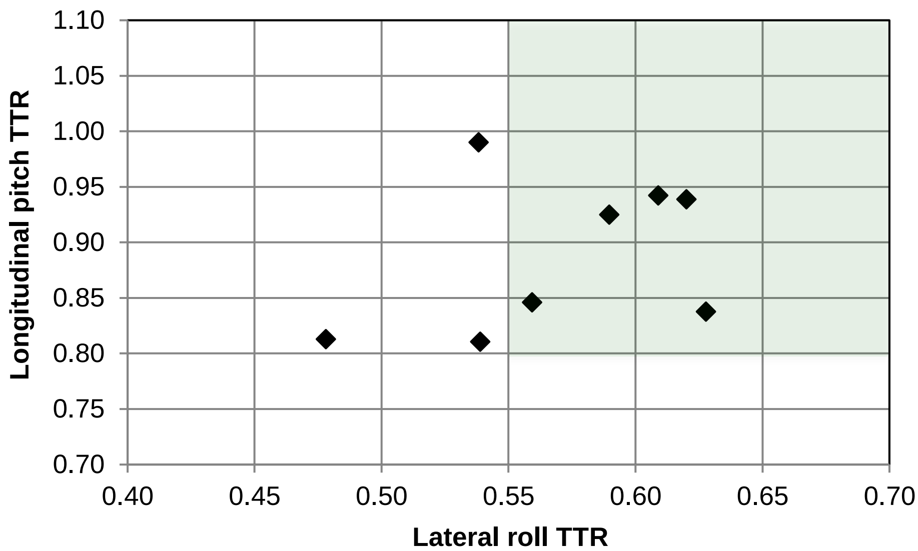

Figure 7. Expected Lateral roll TTR and Longitudinal pitch TTR values using a 50th PAM ATD

If the minimum requirements were for the lateral roll TTR was chosen to be 0.55 and the longitudinal pitch values to be 0.80, then the shaded area in Figure 7 shows the acceptable characteristics. This would exclude three of the eight vehicles tested by the TARS team.

The Consultation RIS suggested minimum limits of TTR of 0.8 for the lateral stability, a minimum TTR of 1.0 for rearward pitch and a minimum TTR of 1.1 for rearward pitch. While these values are achievable as demonstrated by the prototype vehicle, it is not known how it's handling and safety performance would compare with other quad bikes in real-world applications.

Roy Deppa, an experienced engineer formerly with the Consumer Product Safety Commission concurs with this statement. In his submission to the Consultation RIS, he stated:

> *"There does not appear to be any rationale underlying the choice of TTR > 0.80 for lateral roll, for instance, other than the fact that the TARS group built a prototype that exhibited a result of 0.8."*

Applying the same limit static pitch stability for quad bikes in the forward and rearward direction, leads to a TTR value of 1.0 for the minimum longitudinal TTR. If these limits were applied immediately, then no commercial quad bike tested by TARS would meet the standard. The lateral stability limit for SSVs in ANSI/ROHVA 1-2016 for Operator and Passenger Configuration is 0.65. Applying this limit would also eliminate all general-use quad bikes tested by TARS (Grzebeita et al 2015a).

In Section 6.2, the research by Macmillan (2017) was discussed. He indicated that the soil or ground conditions on most rural properties could only establish longitudinal and lateral wheel forces given by tan θ being in the range 0.5 to 0.7. This range is indicative and there may well be soils with values outside this range. Vehicles with a TTR value of 0.7 may still rollover. However as a general statement, vehicles with higher TTR values (than 0.7) would slide rather than rollover when in the static condition.

Recommended additional requirements for static stability in an expanded standard are discussed in Section 18.

6.9 Anecdotal evidence

Kuranda Rainforest Journeys, in its submission to the ACCC on the Consultation RIS wrote about changing the models in its quad bike fleet and stated *"[that] almost immediately we began experiencing rollovers with the 250's including an incident with myself driving*". They also stated that they *were using the exact same trails with the exact same kind of customers* as before. Further in their submission, they indicated that *"rollovers continued (5 in 5 months)".*

Kuranda Rainforest Journeys then found that their local agent "did in fact stock after-market hub spacers (an interesting fact in itself) which fit in behind the wheel, effectively increasing the wheel width of the bike by 100mm (50mm per spacer)".

Finally, they stated:

> *"We fitted the spacers immediately to all four wheels on all of our 250's and* ***have not had a single rollover*** *in the 6 months the spacers have been fitted. [Emphasis included in the submission]"*

It is appreciated that this is only one example, but it does highlight that lateral stability can be easily improved and it is speculated that the agents were expecting similar situations as they had appropriate spacers in stock.

7. Constant radius dynamic testing

7.1 Constant radius testing procedure

The testing procedure requires a quad bike or SSV to be ridden around a circular path and gradually accelerated until the two inside wheels lifted from the pavement and tipped up, the vehicle could not continue on its path and was driven wide out of the circle, or the vehicle could not go any faster.

The vehicle was ridden (and not autonomously controlled) and outriggers were used to prevent the vehicle toppling over. Figures 8 and 9 from Grzebeita et al (2015a) illustrate the tests and the quad bike with outriggers.

Figure 8. Typical quad bike circular driving test (Source: Grzebeita et al 2015a)

Figure 9. Outriggers on an SSV (Source: Grzebeita et al 2015a)

The performance of a quad bike on asphalt or softer surfaces is dependent on the tyre-surface interaction. The tyres on quad bikes are very different. Deppa (1991) stated:

> *"It is important in this context to note that ATV tires are unusual and the ways in which they generate frictional forces with the ground are unlike those of other tyres. Thus it is not possible to obtain usable tyre data simply by conjecture or extrapolation from auto tire data."*

Deppa in his submission to the Consultation RIS stated:

> *"Our tests showed that ATV tires could generate 1 g in side force on typical flat terrains."*

These statements illustrate the effect on the dynamic performance of these vehicles.

Grzebeita et al (2015c) indicated that the tests used for the quad bike and SSV handling assessments were developed based on SAE J266 (ISO 4138:2012) tests. They used a circular path with a 7.6 m radius, as was used in the ANSI/ROHVA 1-2011 standard for Recreational Off-highway vehicle testing. This radius gave lateral vehicle accelerations of 0.5 g at speed less than approximately 25 km/h. Grzebeita et al (2015c) stated that "*a crash at these speeds though considered highly unlikely, would have a low injury risk for the test rider should one occur"*. A robotic system of control would reduce this risk. This is discussed below.

The instrumentation in the tests conducted by Grzebeita et al (2015c) collected yaw rate, steering angle, vehicle velocity and the vertical distance above the ground on each side of the vehicle. The data were collected at 100 Hz and filtered through a 10-step moving average filter. A Crashlab (2013b) report contains the details of the process.

The total weight of the rider and outriggers and data acquisition system was ballasted to 103 kg ± 0.5 kg, which is the same mass of the 95^{th} PAM ATD. Efforts were made by the TARS team to make the results as repeatable as possible.

The testing was conducted on a number of surfaces. Grzebeita et al (2015c) respected the fact that other ground surfaces would be encountered in the field. They stated:

> *"Alternate testing was conducted on various surfaces including asphalt, loose bluemetal over compacted roadbase, and on grass. It was acknowledged by the Authors and the test team that there will be a variation in handling response if operating the vehicle on a plastic (i.e., yielding) surface, such as course sand or thick mud, where the surface grip at the tread face is relatively low causing increased slip and early saturation, but sideways movement is opposed by material that will build up against the outside of the tyres, both reducing the amount of slip and increasing rolling resistance. This was not considered to be a critical issue, since on those surfaces a rider will normally adapt their riding style and limit their top speeds to suit the riding circumstances. Firmer and smoother surfaces however, encourage higher speeds, since the rider experiences smooth running and has no expectation of needing to undertake an emergency manoeuvre or critical steering response."*

The output was a plot of the steering angle against the lateral acceleration to identify understeer and oversteer characteristics. A sample output is shown in Figure 10 (with details of the vehicle removed). Other data collected are the lateral acceleration at the tipping point (when two wheels leave the ground surface).

SEA Limited testing [34] used constant radius tests and followed a similar process of gradually accelerating the ATV (quad bike) on asphalt and groomed dirt surfaces. Their circle radius was larger at 15.2 m and used a robotic control and counter mass to simulate a rider. See below. In other tests the radius of the circle had been extended to 21.3 m. This testing process is a common one when evaluating dynamic handling characteristics and it is rational to use this test protocol in Australia. The choice of circle radius affects the speed to achieve the required lateral acceleration of 0.5 g.

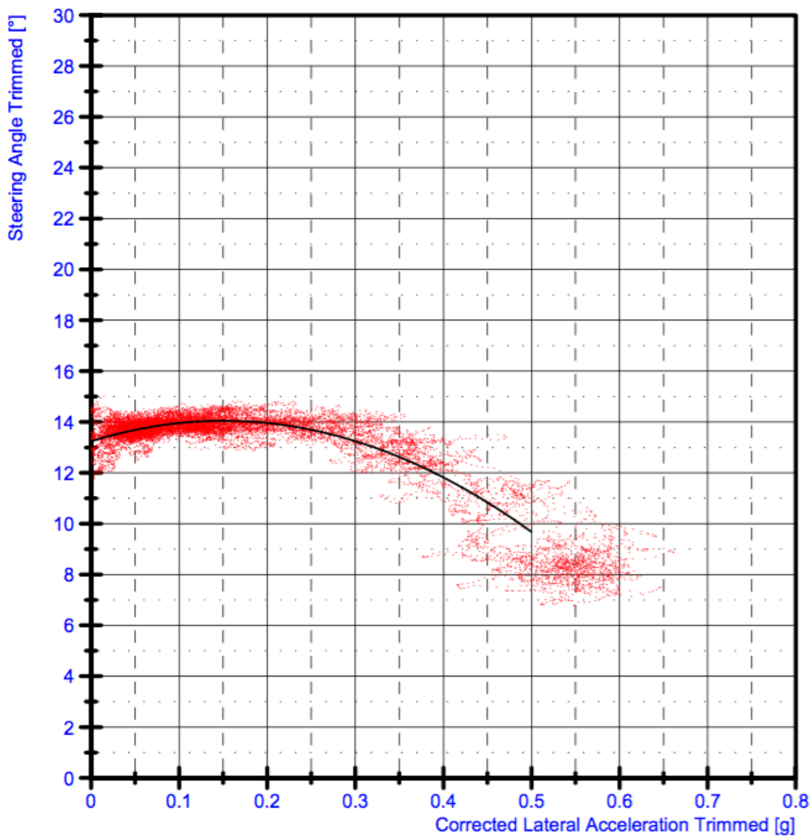

Figure 10. Sample output from the constant radius test showing both understeer and oversteer (Source: Crashlab 2013b)

7.2 Are understeer and oversteer important qualities?

The tyre-ground surface interaction needs to generate lateral forces for a vehicle to negotiate a curve. As tyres generate the greater lateral forces, they slip and their slip angle increases. Understeer occurs when the front wheels slip more than the rear wheels and oversteer occurs when the rear wheels slip more than the front wheels.

[34] See SEA Limited (2017a and 2017b)

The definition of understeer and oversteer is related to the change in steering angle as the lateral acceleration is increased. Figure 10 is a plot of the steering angle against lateral acceleration (in the road plane). A quadratic function is fitted to the data up to a lateral acceleration of 0.5 g. The maximum steering angle from the fitted curve is at 0.15 g.

For conditions with a lateral acceleration below 0.15 g, the quad bike would understeer, as there was a positive gradient of the fitted curve. Similarly, for conditions with a lateral acceleration above 0.15 g the fitted curve gradient was negative indicating that the vehicle was oversteering. The transition point between understeering and oversteering is 0.15 g. SEA Limited (2016) used the same process when determining the point of transition between understeering and oversteering.

While the measurement of understeer, oversteer and the point of transition is a standard procedure, there is no indication how these terms relate to the optimum or acceptable performance of a quad bike. Grzebeita et al (2015a) indicated that rollover propensity was a function of dynamic handling. They quoted a US Consumer Product Safety Commission (CPSC) report [35], which proposed a Safety Standard for Recreational Off-Highway Vehicles (ROVs), Notice of Proposed Rulemaking, 16 CFR Part 1422 states that:

> *"The Commission believes that improving lateral stability (by increasing rollover resistance) and improving vehicle handling (by correcting oversteer to understeer) are the most effective approaches to reducing the occurrence of ROV rollover incidents".*

Grzebeita et al (2015a) considered this comment to apply to both vehicle types.

Deppa [36], in the evidence provided by FCAI to the Queensland Coroner, stated:

> *"The engineering studies have shown direct relationships between measured lateral stability values and cornering capability of the vehicle as measured by speed around a circular path."*

The cornering capability is important, but lateral stability while cornering is more important.

In the extreme, an understeering vehicle will tend to continue straight ahead and is consequently less manoeuvrable. Similarly, a vehicle with extreme oversteer will broadside and slide. The quad bike will be both uncontrollable and have the potential to rollover if the ground conditions provide significant resistance to sliding. These extreme conditions should be avoided.

In the submission to the Consultation RIS, there were comments relating to whether oversteer is a hazard in itself. The FCAI submission on the Consultation RIS states:

> *"Requiring dynamic handling changes that eliminates oversteer will make ATVs less agile, less maneuverable, and less able to negotiate tight turns without going wide. Previous research [37] indicates that under real off-road*

[35] See Consumer Product Safety Commission (2014).

[36] Memorandum from Roy Deppa to Robert Frye at the US Consumer Product Safety Commission , Washington DC, and dated February 28 1991. Exhibit F15 to the Queensland Coronial Inquest into nine deaths caused by quad bikes, August 2015

[37] See Fowler (2015)

conditions (in contrast to the sealed surfaces used in the UNSW TARS tests) riders prefer ATVs that have an "understeer-oversteer" characteristic over ATVs that have understeer throughout the range of lateral accelerations."

Roy Deppa in his submission to the Consultation RIS stated:

"The testing that I directed led me to conclude that "all oversteer" or "all understeer" was much less a problem than the reality that ATVs shifted their steering responses unpredictably from understeer to oversteer and back, depending upon the terrain conditions and rider balance while cornering. A rider can adapt to oversteer or understeer. Either steering response is predictable, but the loss of control in understeer is more benign than the loss of control in oversteer, hence the preference in general for understeer. But having the vehicle shift from one response to another, often suddenly, means that the rider does not know what to expect, and thus cannot compensate in time to maintain vehicle stability."

It is the unpredictability of a sudden shift from understeer to oversteer that creates more issues. Deppa continues and states:

"Because all of the vehicles transitioned from understeer at lower lateral acceleration to neutral and then oversteer response with increasing lateral acceleration, the reasonable goal seemed to be to keep the vehicle in understeer, or even understeer to neutral steer. ... I do not disagree with that objective because the rider is presented with a predictable and less difficult steering response."

The key issue is that quad bikes or SSVs need to have predictable dynamic handling characteristics. Grzebeita et al (2015c) were positive about this point and stated:

"The focus of the Quad Bike Performance Project is to encourage those dynamic characteristics that provide predictable and forgiving handling characteristics while remaining responsive and highly mobile in a farming and workplace environment. Moreover, in order to provide predictable and forgiving handling characteristics while remaining responsive and highly mobile, a vehicle should be designed to provide a light understeer response of between 1 to 2 degrees per g lateral acceleration. In light off-road vehicles, this understeer characteristic should continue to at least 0.5 g lateral acceleration."

Honda's submission to the Consultation RIS [38] further reiterates the need for handling predictability and stated:

"The claim that oversteer is unsafe is an opinion. There is no consensus in discussions with the CPSC about this claim.

From the opposite perspective, on occasion, excessive understeer may lead to dangerous incidents in scenes such as obstacle avoidance. Therefore, we believe that the relationship between understeer/oversteer and safety cannot be uniquely determined.

[38] See https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

If such a relationship is to be evaluated, Honda stresses the predictable characteristic is important, and recommend checking the transient steering characteristics."

In the Polaris submission to the Consultation RIS [39], it is stated:

"Polaris also rejects the proposition that there should be a requirement for off-road vehicles to exhibit an understeer characteristic when ridden on off-road tyres, but on a hard, smooth, sealed surface. The handling characteristics of off-road vehicles (including understeer, neutral-steer and oversteer) may change substantially, even on a single ride, depending on rider position, ground surface, tyre compatibility and compliance with the current ground surface, accelerator input, brake input, vehicle loading and many other factors. Polaris engineers conduct substantial off-road testing on each and every model to ensure that the transitions from one handling characteristic to another (such as from oversteer to neutral-steer, to understeer or vice versa) are smooth and predictable for the rider."

It is clear that some vehicle manufacturing industry and research teams recommend predictable dynamic handling and that the understeer or neutral steering characteristics are important qualities. It is also clear that oversteering or understeering, if not excessive, are both acceptable steering attributes.

While undertaking these tests, Grzebeita et al (2015c) stated:

"The test team observed that as the rear wheel lifts and breaks traction on the dry bitumen and dry grass surfaces used, the plow effect on such surfaces is suddenly relieved, which demands a steering correction requirement to remain on path. This then causes the lateral acceleration to reduce and the inside wheel to re-engage the ground and repeated oscillation occurs until at higher lateral accelerations, the inside rear wheel is suspended permanently in the air and the Quad settles down to more stable path following."

The oscillations in the required handlebar steering angle reduces the controllability of the quad bike.

Given that steering oscillations are undesirable, then this quote implies that a test on one surface cannot be used to indicate the likely impact on another surface.

Figure 11 from Deppa and Hauser (1989) illustrates this handlebar steering action at higher speeds and lateral acceleration for a quad bike with excessive oversteering properties. Deppa [40] indicated that the handlebar oscillations can cause the rider to need to turn the handlebars from full lock in one direction to full lock in the other direction. This rapid action quickly exceeds the physical capability of the rider and leads to an uncontrollable condition that may lead to rollovers.

[39] See https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

[40] Personal communication from Roy Deppa

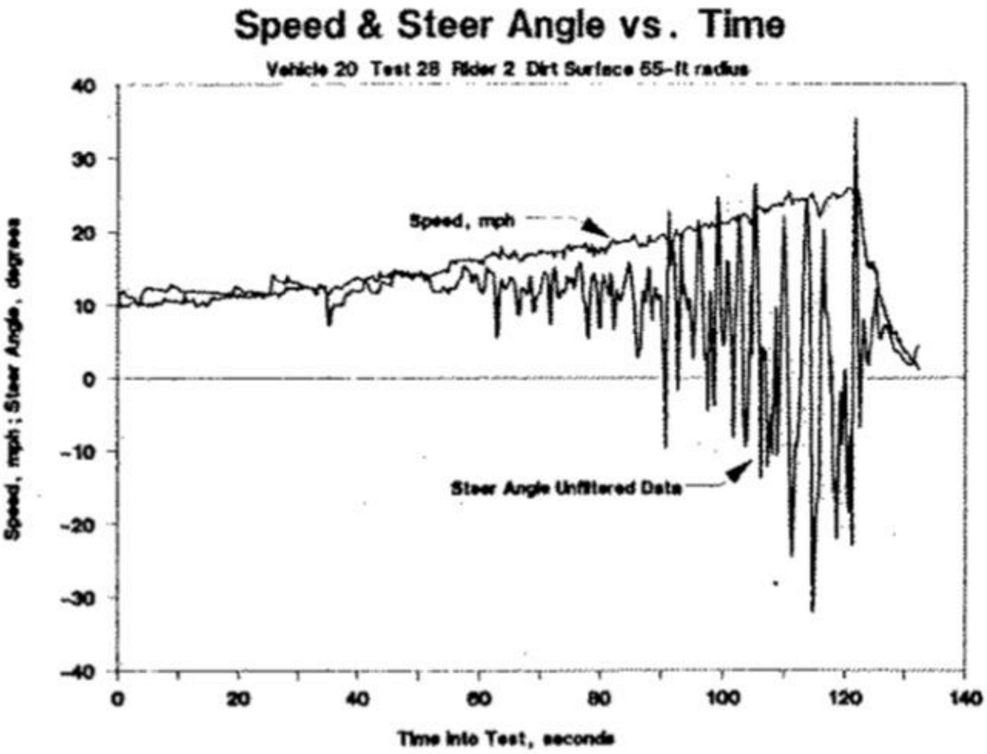

Figure 11. Speed and steer angle versus time for constant 16.7 m radius tests on a hard packed clay soil surface (Source: Deppa and Hauser 1989)

7.3 Limitations with the proposed constant radius dynamic handling tests and evaluation

The tests as proposed are common acceptable tests. However, there are some concerns about the repeatability of the results and the consequences of testing on a paved area. Figures 12 and 13 were obtained by scaling the quadratic equations describing the steer angle versus the lateral acceleration data contained in Appendix D of the Crashlab Special Report SR2013/004 for the same vehicles (Yamaha Grizzly YFM450FAP, specimen TS57201 and Honda Fourtrax TRX250, specimen TS57199).

The results for the Yamaha Grizzly YFM450FAP are shown in Figure 12. This vehicle understeers and then oversteers. For the conditions presented here the transition points are between 0.13 and 0.18 g.

Figure 13 shows that the effect of direction and ground conditions for the Honda Fourtrax TRX250. This vehicle largely oversteers through the range of lateral accelerations studied. Crashlab test G130452 has a transition point at a lateral acceleration of 0.05 and in the other tests the vehicle was constantly oversteering.

The understeer – oversteer characteristics of both vehicles were similar whether on grass or asphalt.

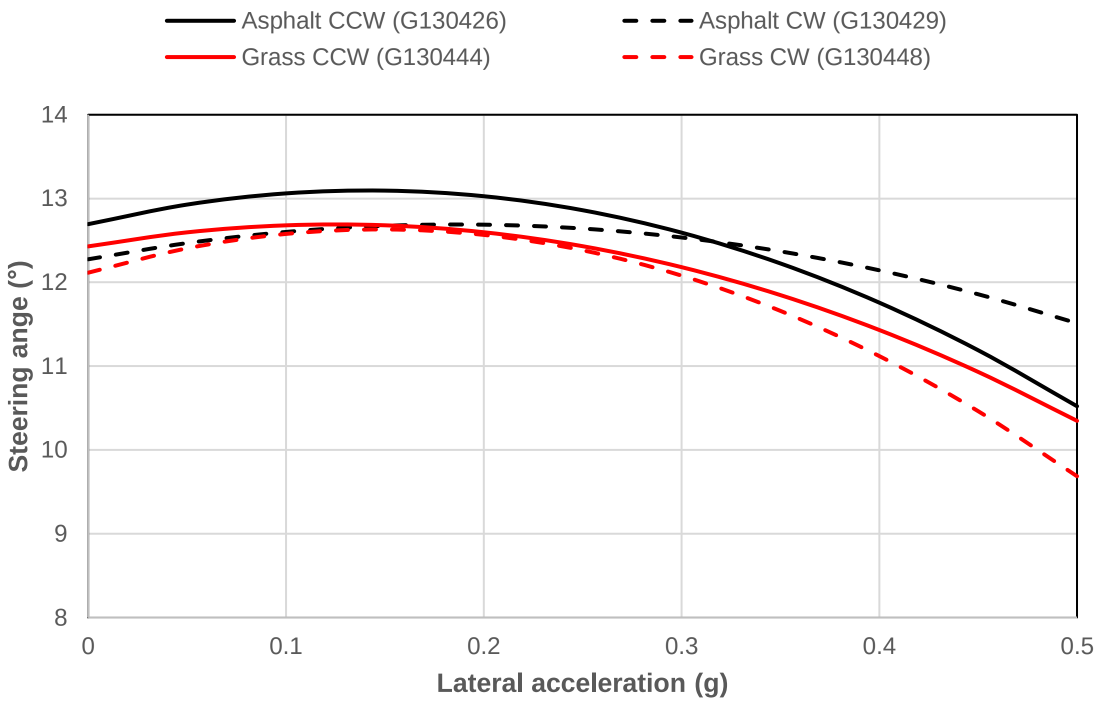

Figure 12. **Steering angle against lateral acceleration for both clockwise and counter clockwise directions for the Yamaha Grizzly YFM450FAP. Crashlab test numbers are shown in brackets**

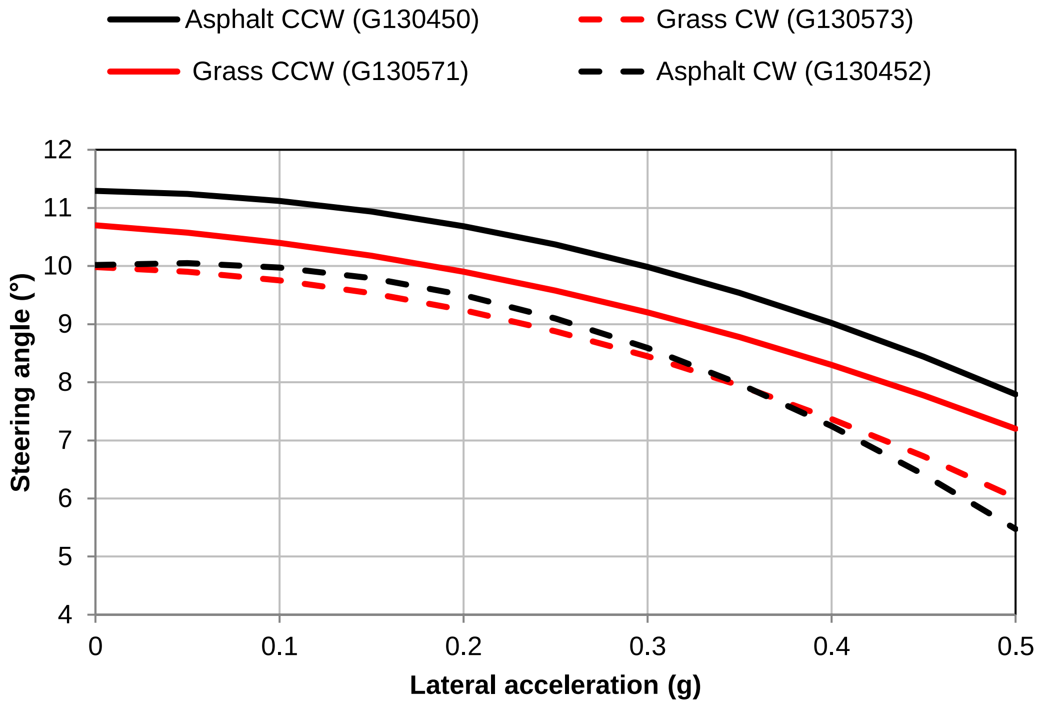

Figure 13. **Steering angle against lateral acceleration for both clockwise and counter clockwise directions for the Honda Fourtrax TRX250. Crashlab test numbers are shown in brackets**

The transition points for the Yamaha vehicle were similar whether on grass or asphalt; for the counter clockwise direction, the transition point was 0.14 on asphalt and 0.13 on grass and for the clockwise direction the transition points were 0.18 for asphalt and 0.15 for grass. The Ackerman steering angle, the predicted steering angle at zero lateral acceleration, was lower for the grassed surfaces.

Grzebeita et al (2015a) stated:

> *"The three Quad bikes that were tested on asphalt and grass displayed very similar handling characteristics and tipped up at similar lateral acceleration values on both surfaces. Testing of Quad bikes on an asphalt surface did provide relevant, performance characteristics."*

The similar lateral acceleration at tip up on grass or asphalt simply reflects the fact that the tyre surface interface can generate greater side forces than those required to tip up the quad bike.

SEA Limited (2017a) studied the performance of 12 quad bikes on an asphalt and on groomed dirt surfaces. The tests included:

- Constant radius turns to evaluate understeer – oversteer characteristics.
- J-turn tests or step steer tests which provide a measure of the minimum peak lateral acceleration to cause two wheels to lift form the ground.
- Constant steer tests, or Yaw rate ratio test, to again evaluate understeer – oversteer characteristics.

SEA Limited (2017a) stated:

> *"As stated before, this is a preliminary comparison of autonomous testing of the 12 test vehicles on an asphalt surface (with 0° rider lean and tests constrained in the counterclockwise, left turn direction) with autonomous testing on a groomed dirt surface. There is mixed bag of correlation between the results from tests conducted on groomed dirt and on asphalt. During Circle tests on both surfaces, the same four vehicles (Vehicles C, D, E and L) remained understeering up to the tests' limits of 0.4 g. For the remaining vehicles, five of them transitioned to oversteer at higher lateral accelerations on groomed dirt tests and three of them transitioned to oversteer at higher lateral accelerations on asphalt."*

Based on the testing and the analysis of these vehicles, and the comment by Grzebeita et al, the data collected on a paved surface should still provide some comment on a vehicles' dynamic handling qualities. It is also noted that it is not possible to check the performance of the quad bike on all surface types and an asphalt surface is expected to be more consistent than unpaved surfaces.

Figure 12 and 13 also shows the difference in outcome when travelling in a different direction as the quad bikes are not symmetrical. Counter clockwise travel has been recorded by the direction "left" in the graphical data.

SEA Limited (2016) reported on the performance of 12 quad bikes using similar plots to those in the Crashlab report but subtracted the measured Ackermann steering angle (the predicted steering angle at zero lateral acceleration). This allows the gradient to be more easily discerned. Figures 14 and 15 present the Crashlab test results in the same manner for a Honda Fourtrax TRX250 quad bike.

These figures demonstrate that higher tyre pressures will reduce the oversteering gradient to a small extent. The position of the rider on the seat has minimal effect. The effect of active riding is discussed in the next sub-section.

7.4 Effect of active riding on constant radius dynamic testing

Figures 14 and 15 demonstrate that active riding, and to a lesser extent higher tyre pressures will reduce the oversteering gradient. However, it is questioned whether there was a consistent level of active riding.

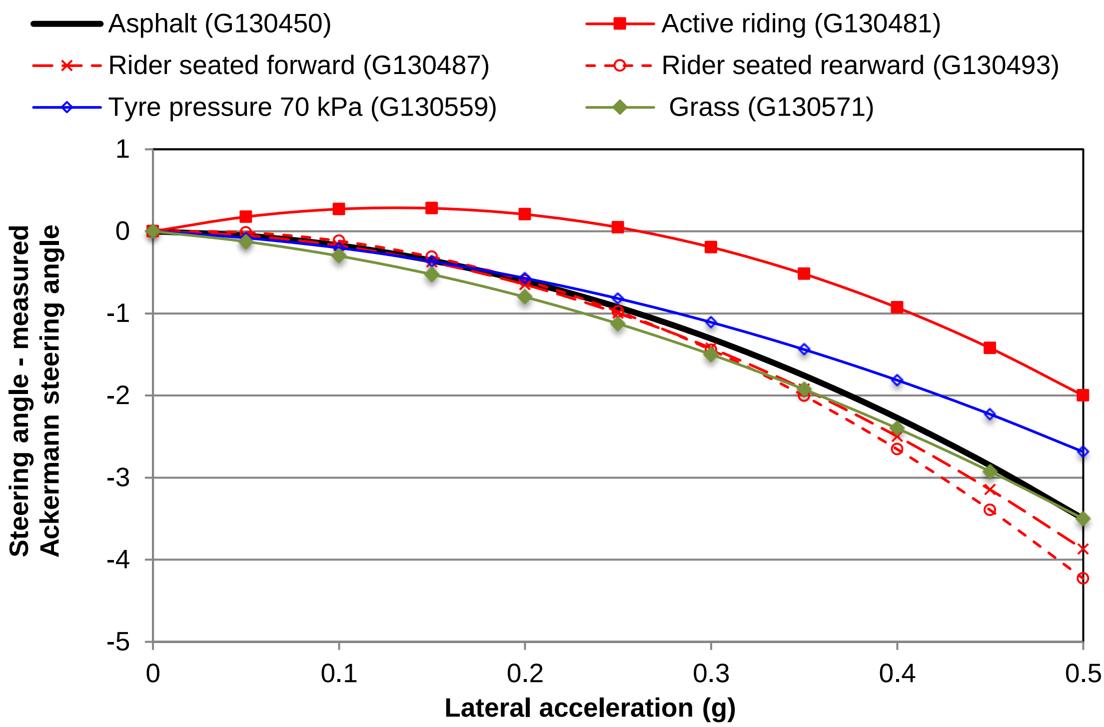

Figure 14. Steering gradients for quad bike data travelling in a counter clockwise direction. Crashlab test numbers are shown in brackets

For the counter clockwise direction, the effect of active riding was substantial with understeering extending to up to 0.17 g.

Figures 14 and 15 indicate that the results are dependent on the rider and every attempt should be made to reduce these effects by using robot riders to improve the repeatability of test results.

It is concluded that the constant radius test on asphaltic surfaces are appropriate to a point. However, the results will always need to be interpreted and considered in light of the testing methodology. This aspect will be discussed later in this report.

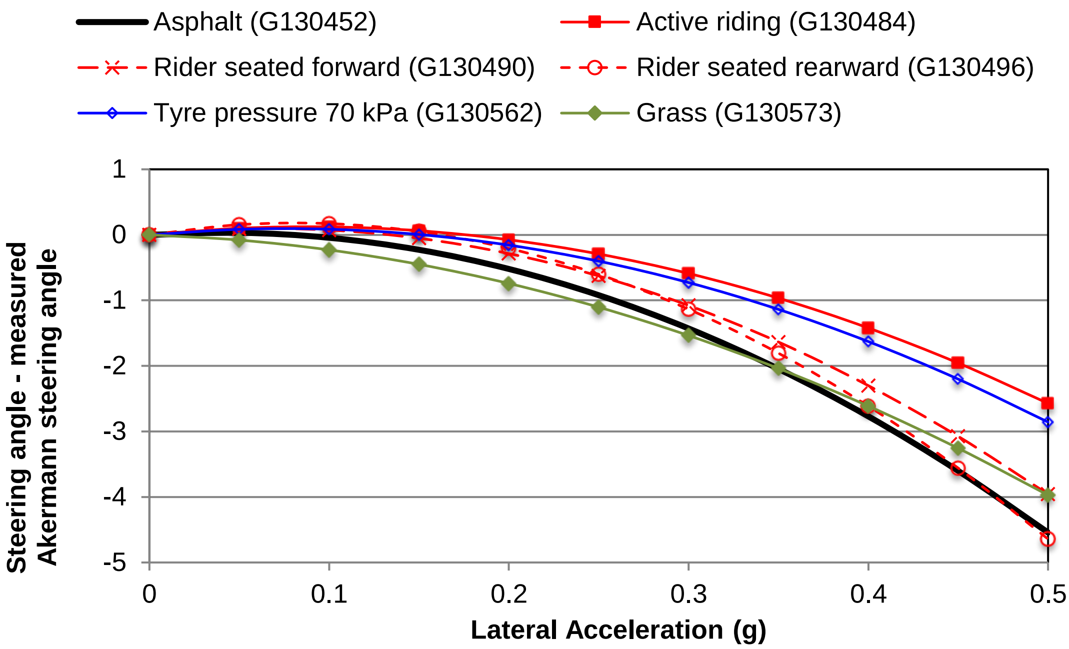

Figure 15. Steering gradients for quad bike data travelling in a clockwise direction. Crashlab test numbers are shown in brackets

SEA Limited (2017b) investigated the effect of active riding in which the rider shifts his or her weight to assist in cornering. Figure 16 shows a rider leaning while negotiating a circular path. Figure 17 shows a remote-controlled quad bike with a supporting structure and a moveable counterbalancing weight to simulate the effect of a rider leaning to an angle of 20°. By moving the counterbalance further outboard, SEA Limited was able to simulate a rider leaning at an angle of 40°.

Figure 16. Constant radius test with "active riding" (Source: SEA Limited 2017b)

Figure 17. Autonomous quad bike with counter weights to simulate a rider with a 20° lean. (Source: SEA Limited 2017b)

The results of the SEA Limited testing, shown in Table 4, indicate that the transition point between understeer and oversteer was at a higher lateral acceleration as the angle of driver lean increased. This table shows values for quad bikes which had a transition between understeer and oversteer. These results also indicate that the rider's actions will affect the outcome of the tests and that autonomous quad bikes would provide more consistent results.

Table 4 Lateral Acceleration of the transition from understeer to oversteer (Source: SEA Limited (2017b)

Vehicle	Autonomous 0° Driver Lean (g)	Autonomous 20° Driver Lean (g)	Autonomous 40° Driver Lean (g)
A	0.17	0.21	0.24
B	0.18	0.21	0.25
F	0.13	0.16	0.25
G	0.17	0.19	0.22
H	0.15	0.18	0.24
I	0.18	0.21	0.24
J	0.17	0.21	0.24
K	0.25	0.27	0.29

SEA Limited (2017) indicates that the autonomous testing produces similar results to those with a rider and state:

> *"The autonomous tests using the fixed weight frame for driver ballast removed the influence of driver motion from the tests. ... For the most part, both series of tests – despite the differences in loading and test conditions – produced test results that ranked the 12 vehicles similarly and they are both useful for comparing the performance of the vehicles to one another."*

7.5 Implications of the constant radius dynamic handling tests on injuries

There are no safety or injury statistics that can demonstrate the safety implications of changes in dynamic handling established through the constant radius tests.

There is an engineering consensus that lateral stability has an impact on the propensity to rollover. Consequently, it is likely to affect the safety of the rider although the injury data does not demonstrate statistically significant relationships.

Oversteering vehicles have been considered to be more hazardous to ride. Section 7.2 discusses this point and indicates that oversteering or understeering, if not excessive, are both acceptable steering attributes. There is no reason why one characteristic should be favoured over the other, except to say that loss of control though understeering is more benign as pointed out by Roy Deppa in his submission to the Consultation RIS:

> *"There is not a direct link between injury rates and oversteer characteristics or the lateral acceleration at the transition point."*

Conversely, it is argued that a vehicle with unpredictable steering characteristics is more likely to be more hazardous. This cannot be demonstrated from the crash statistics, but it would be preferable to have vehicles with predictable dynamic handling performance.

7.6 The concept of predictable steering control

Section 7.2 discussed whether the overseer was an acceptable attribute. A number of submissions indicated that it was more important to have predictable steering qualities in a quad bike. A number of submissions also indicated that it does not matter whether the vehicle understeers or oversteers, so long as the vehicle is predictable and the extent of the understeering or oversteering is not excessive.

Grzebeita et al (2015c) stated:

> *"The focus of the Quad Bike Performance Project is to encourage those dynamic characteristics that provide predictable and forgiving handling characteristics while remaining responsive and highly mobile in a farming and workplace environment."*

The Consultation RIS stated:

> *"A vehicle that is slow to respond or that responds differently in similar circumstances, or that has responses that change over time independent of operator actions, is an unpredictable and difficult to control vehicle."*

A number of quotes in Section 7.2 have indicated the need for predictable steering qualities. Honda in its submission to the Consultation RIS stated:

> *"… Honda stresses the predictable characteristic is important, and recommend checking the transient steering characteristics."*

Polaris submitted the following comment on the Consultation RIS:

> *"Polaris engineers conduct substantial off-road testing on each and every model to ensure that the transitions from one handling characteristic to another (such as from oversteer to neutral-steer, to understeer or vice versa) are smooth and predictable for the rider."*

Finally, Roy Deppa in his submission to the ACCC about the Consultation RIS stated:

> *"The testing that I directed led me to conclude that "all oversteer" or "all understeer" was much less a problem than the reality that ATVs shifted their steering responses unpredictably from understeer to oversteer and back, depending upon the terrain conditions and rider balance while cornering."*

The notion of predictability expressed by Roy Deppa is one that is caused by an impulse at the quad bike's wheels when it is travelling over uneven terrain and hits a log or similar object and causes the front wheels to change their steering direction. The impulse causes the quad bike to oversteer, requires the rider to counter steer as a result of this increased lateral acceleration. In effect, the bump becomes an external steering input, requiring the rider to react to regain control. This can be demonstrated from the steering angle – lateral acceleration graphs. A vehicle may be cornering with a lateral acceleration of 0.3 g, the bump causes operating conditions to move to a lateral acceleration of 0.4 g. In doing so the vehicle's steering characteristics might rapidly change from understeer to oversteer [41].

The question is can we judge the predictability of the steering characteristics using the constant radius tests? If we can't, then is there a rational test for predictable dynamic handling? Comments from Gary Heydinger [42], have indicated that predictable dynamic handling could be established using the Yaw Rate Ratio test which has been included in the ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 standards and based on SAE J266. The test involves steering vehicles at a constant steer angle: one that would allow the vehicle to negotiate a circular path at slow speeds. With the steer angle set, vehicles are accelerated until the lateral acceleration reaches 0.4 g, or two wheels lift off the pavement. The analysis calculates the change in the yaw velocity (radians/s) divided by the change in speed (m/s) when the vehicle's lateral acceleration changes from 0.1 to 0.2 g. A similar quantity is calculated for conditions where the vehicle's lateral acceleration changes from 0.3 to 0.4 g. The Yaw Rate Ratio is then the ratio of these two quantities. Given the comments by Heydinger, it is considered that this test may be a suitable measure to demonstrate predictable dynamic handling. At this stage, the author recommends that the vehicle manufacturers and distributors be asked to assist in establishing whether the yaw ratio test is suitable or finding an alternative measure if the yaw rate measure is not suitable.

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41 Personal communication from Roy Deppa

42 Personal communication and a review of a draft of this report by Gary Heydinger (from SEA Limited)

7.7 Use of the constant radius test in a star rating

Oversteer and understeer

The proposed star rating system in Grzebeita (2015a) allocated points for different attributes and performance characteristics of quad bike. Table 5 lists the points toward a star rating for steady state turning on a constant radius path. This table is taken from Table 7 of Grzebeita et al (2015a).

The concept of understeering vehicles being preferred over oversteering vehicles would seem to be inherent in the criteria in this table. Even modest levels of oversteering would produce a points rating of 3.

Table 5. Oversteer and understeer characteristics (Source: Grzebeita et al 2015a)

Criteria	Points rating				
	1	2	3	4	5
2. Steady State turning - Transition to oversteer (g)	0.1	0.2	0.3	0.4	0.5
3. Steady State turning - Understeer Gradient (degree/g)	≥8.0	8.0 to 6.0	5.9 to 4.0	3.9 to 3.0	0.49 to 3.0
4. Steady State turning - Oversteer Gradient (degree/g)	≥ -8.0 Oversteer	-7.9 to -4.0 Oversteer	-3.8 to -1.0 Oversteer	-0.99 to 0.5 Neutral	0.49 to 3.0 Understeer

Section 7.2 indicates that oversteering and understeering characteristics are acceptable so long as they are not excessive. Section 7.6 indicates that it is more important for the steering characteristics to be predictable, although an appropriate test has not been identified in the literature.

There is no rational basis for the grading of the points to give stars, although the number of points has an approximate linear relationship to the measure. It would be better if a change in one star rating would represent a recognised change in the performance of the quad bike. There is no data that can assist in defining a relationship and the use of a linear relationship is a reasonable assumption.

Lateral acceleration at tip up

The constant radius tests also determine the maximum lateral acceleration when two wheels are no longer in contact with the ground. Figure 18 is a plot of the maximum lateral acceleration recorded when two wheels lifted up against the lateral TTR value from the tilt table. The correlation coefficient is 0.95 which is significant at the 1 per cent level. Consequently, the static stability TTR values are a good predictor of the dynamic stability on flat, smooth and relatively hard terrain.

Figure 18 includes two data points that refer to a quad bike on grass. The results are consistent for those on bitumen. If this test is to be used then testing on an asphalt surface would provide consistent results and be an indicator of dynamic lateral stability.

The dynamic stability measure does not predict the outcome when the vehicle is approaching instability on a slope or when cornering and an impulse is made to the wheels on the vehicle. This is developed in the work of Macmillan and described in Section 6.2.

For a star rating process, Grzebeita et al (2015a) allocated points in proportion to the maximum lateral acceleration as listed in Table 6. It is not clear why this linear relationship should be applied. Using the research by Macmillan's (2017), increasing TTR values over 0.7 is unlikely to have a significant effect on preventing lateral rollovers and the subsequent safety. Figure 18, shows that the TTR values are generally larger than the lateral accelerations when two wheels lift of the pavement. Conservatively, if the lateral accelerations when two wheels lift of the pavement was required to be over 0.7 g, it is also unlikely to have a significant effect on the number of lateral rollovers.

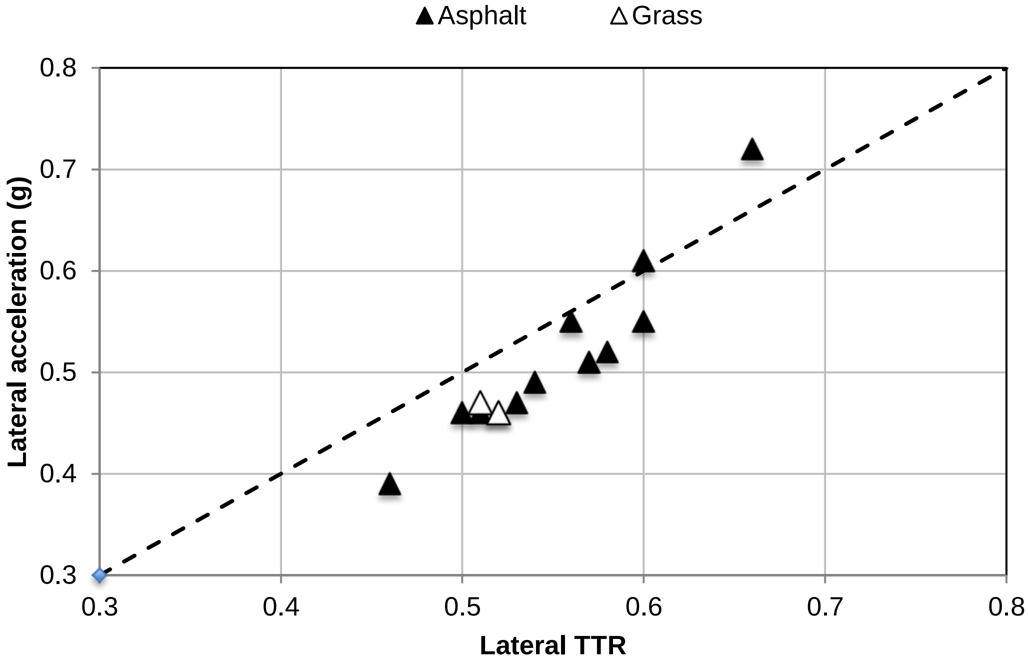

Figure 18. Maximum lateral acceleration when two wheels lifted up against lateral static stability TTR values. The dotted line is a line of equality. (Data from Grzebeita et al 2015b and Grzebeita et al 2015c)

Table 6. Dynamic lateral stability (Source: Grzebeita et al 2015a)

Criteria	**Points rating**				
	1	**2**	**3**	**4**	**5**
Lateral Stability Ay (g) at tip up (no tip up = 3 pts)	<0.4	0.4 to 0.59	0.6 to 0.79	0.8 to 0.99	>1.0

It is recommended that the dynamic handling assessment need not include a dynamic limit on lateral acceleration, as dynamic performance can be predicted with some confidence from the static stability tests.

It is however recommended, as noted in Section 7.6, that a means of evaluating the predictability of the steering characteristics be developed and used in a star rating.

7.8 Use of the constant radius test in an extended standard

Oversteer and understeer

The Consultation RIS proposed an Australian standard which incorporated a constant radius test. The performance requirements are that:

> *"The understeer gradient obtained from the testing shall be positive for values of ground plane lateral acceleration from 0.10 g to 0.50 g. Negative understeer gradients (oversteer) shall not be exhibited by the vehicle in the lateral acceleration range specified."*

As discussed in Section 7.2, the requirement to have the quad bike operating with understeering characteristics for lateral accelerations less than 0.50 g cannot be substantiated. Oversteering and understeering characteristics are both acceptable so long as they are not excessive. Section 7.6 indicates that it is more important for the steering characteristics to be predictable, although an appropriate test has not been developed. The important aspects of the steering characteristics, based on the steering angle versus lateral acceleration, are considered to be gradients and the deviation of the steer angle from the measured Ackermann steer angle.

It is therefore considered that this test is inappropriate and is not recommended that it be included in the extended standard.

Lateral acceleration at tip up

The constant radius tests for the maximum lateral acceleration, when two wheels are no longer in contact with the ground, was not proposed in the Consultation RIS. In any case, the static stability TTR values are correlated with the maximum lateral accelerations, if two wheels are able to lift of the ground before the vehicles reaches it maximum speed or runs wide on the circular path.

Again, this test is not recommended to be included in the extended standard for the same reasons that it is not included in the star rating system. (see Section 7.7)

Selection of limiting values

The dynamic handling performance measures proposed for the Standard and as part of the star rating system have limiting minimum requirements in the standard and values for the different star ratings. At present these values are arbitrary and are open to criticism. The basis seems to be that a prototype vehicle was able to achieve these limits. The chosen limiting values can have a significant effect on the market and need to be selected in collaboration with the manufacturers and distributors.

This report has questioned whether the parameters assessed are correct and appropriate. For instance, whether oversteering characteristics are always inappropriate for lateral accelerations between 0.1g & 0.5g.

8. Lateral Transient response dynamic tests

8.1 Testing procedure

Grzebeita et al (2015c) described the lateral transient response test where a vehicle was driven in a straight line to a speed of 20 km/h and then had a rapid steering input to generate a lateral acceleration of 0.4 g response. The yaw rate and steering response time was subsequently recorded. They stated:

> *"A standard test for this response time is the Lateral Transient Response Test (ISO 7401). This test is more often referred to as the step steer or J turn test. The intent is to have a near instantaneous steering change to produce a given steer angle and hold that angle and measure the yaw rate of the vehicle while maintaining its speed."*

As a vehicle's response to a steering input takes a finite amount of time, "response time is measured from when the steer angle is at 50% of the desired step steer angle to the time when the yaw rate reaches 90% of the steady state yaw rate."

The testing by Grzebeita et al was undertaken on an asphalt surface and a dry grass surface.

8.2 Testing results

The lateral transient response times for the quad bikes ranged from 0.09 to 0.23 s for both left and right directions. The range of values for the sports and youth quad bikes was from 0.1 to 0.2 s. This range is similar to the range for general-use quad bikes. SSVs, had values that ranged from 0.17 to 0.29 s and were slightly less responsive than quad bikes.

Table 7 lists the results for the individual runs for the quad bike and rider on an asphalt surface. For these conditions, the combined standard deviation, about the individual means, is 0.014, which is considered to be relatively large at approximately 10 per cent of the mean. Entries are shaded for vehicles with a range greater than 0.03.

The response times for the alternate rider were close to those of the first rider. Figure 19 shows the response times on grass against those on an asphalt surface. The values for the grass surface were 0.15 to 0.2 s slower on average than those on an asphalt surface.

It is concluded that collecting transient response times on an asphalt surface gives a broad indication of the response times on grass and perhaps on other surfaces, but it does not provide an accurate value or a useful indication for all surface types. The response times would be largely affected by the tyre-ground interaction, which is likely to vary considerably on rural properties.

Table 7 Transient response times (Source: Crashlab 2013b)

Specimen number	Direction	Transient response times (s)				
		Run 1	Run 2	Run 3	Average	Range
TS57199	Left	0.12	0.13	0.12	0.12	0.01
	Right	0.15	0.14	0.12	0.14	0.03
TS57200	Left	0.16	0.17	0.15	0.18	0.02
	Right	0.16	0.17	0.18	0.17	0.02
TS57201	Left	0.14	0.14	0.14	0.14	0.00
	Right	0.13	0.12	0.14	0.13	0.02
TS57202	Left	0.13	0.11	0.16	0.13	0.05
	Right	0.13	0.14	0.12	0.13	0.02
TS57203	Left	0.16	0.17	0.17	0.17	0.01
	Right	0.14	0.14	0.17	0.15	0.03
TS57204	Left	0.12	0.13	0.13	0.13	0.01
	Right	0.14	0.13	0.13	0.13	0.01
TS57205	Left	0.11	0.12	0.11	0.11	0.01
	Right	0.08	0.09	0.09	0.09	0.01
TS57206	Left	0.25	0.24	0.19	0.23	0.06
	Right	0.18	0.17	0.17	0.17	0.01
TS57211	Left	0.15	0.17	0.13	0.15	0.04
	Right	0.14	0.15	0.15	0.15	0.01
TS57212	Left	0.15	0.15	0.14	0.15	0.01
	Right	0.19	0.19	0.22	0.2	0.03
TS57213	Left	0.1	0.1	0.1	0.1	0.00
	Right	0.17	0.13	0.12	0.14	0.05

The single point, in Figure 19, where the response time was better on grass than on an asphalt surface is when the front rack was loaded.

Grzebeita et al (2015c) indicated that the TARS team "adopted a response time of 0.25 to 0.5 seconds as an appropriate response time for both the Quad bikes and SSV assessments".

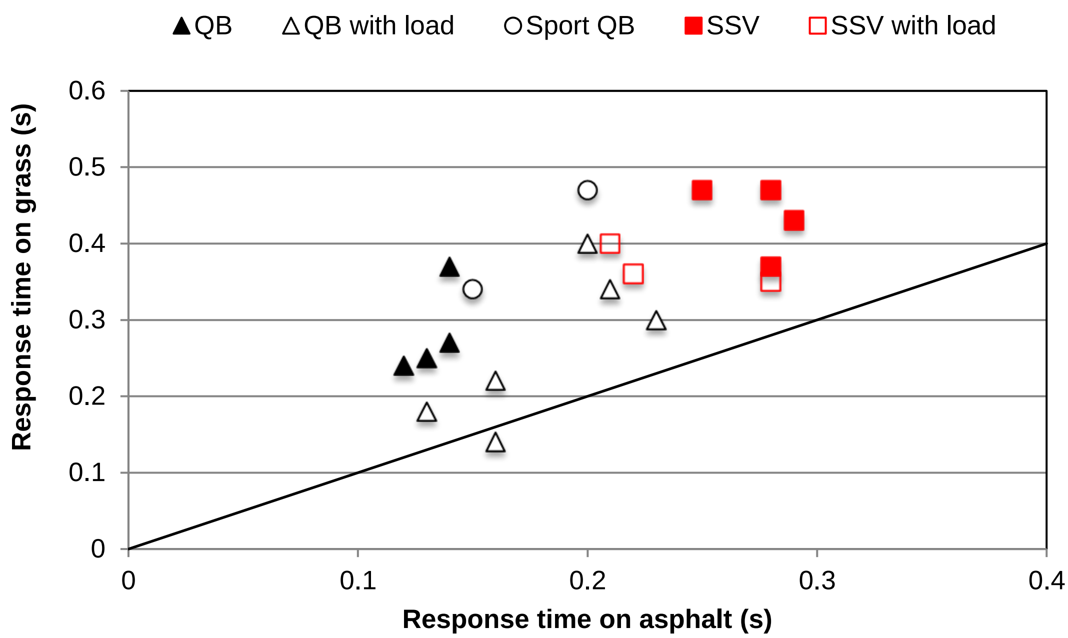

Figure 19. Response times for vehicles on asphalt surface against the values on a grass surface

8.3 Limitations of the transient response times

The values of the response times when on an asphalt surface are a measure of the responsiveness of vehicles on that surface alone. There is not a simple relationship between the recorded values and those experienced in the field as the ground-tyre interaction characteristics are variable and unpredictable. Because of ground condition variability, it would be difficult to construct a responsiveness test that represents a range of field conditions. It must be said that the research results recorded in the TARS research with Crashlab provide an increased understanding of the performance of quad bikes and SSVs on hard groomed grass surfaces

Good (1977) discussed transient response measures and stated:

> *"It seems apparent that setting a broad envelope for acceptable transient responses does not provide a very sensitive specification of handling quality. It is clear that response time is a parameter of paramount importance. ... The relative damping of the response seems somewhat less important than the response time. However, given adequate response times, well damped responses are preferred. It may be that a composite parameter similar to the* t_R/ζ_{eff} *suggested in Ref* ***[49]*** [43] *will take care of both aspects of the transient response characteristics."*

It is concluded that there may well be a revised testing program that would provide a better description of desirable response times for quad bikes and SSVs.

[43] Repa, B. S. and Wierwille, W. (1976). Driver performance in controlling a driving simulator with varying vehicle response characteristics. SAE Paper No. 760779.

8.4 Issues with the use of the transient response times

There is some discussion in the responses to the Consultation RIS about the arbitrariness of the limiting values. For instance, Honda submitted the comment to the Consultation RIS in which they stated:

> ***"Lateral transient response*** *It is not enough to evaluate safety only by response time. Honda believes other factors such as steering load should also be evaluated. Furthermore, regarding the evaluation criteria, the judgement of a fast response time is insufficient."*

It is understood that the values are arbitrary. However, they do provide a starting point for discussion.

Appendix A of the Federal Chamber of Automotive Industries submission stated:

> *"The J-Turn test has been applied to ATVs (for research purposes) and to SSVs (for measuring resistance to 2-wheel lift). However the "yaw time delay" limits for passenger cars (which ATVAP uses the J-Turn test to measure and to rate) are not applicable to ATVs and SSVs because of large differences in speed, vehicle type and tires, on which yaw time delay is highly dependent.*
>
> *…*
>
> *The variability range of the J-Turn test results was as high as 67%. This variation range for lateral transient response time is unacceptable for discrimination and rating purposes, and would result in unfair, non-repeatable and non-reproducible results."*

The variability range quoted by the FCAI was based on an individual result. As stated in Section 7.2, the combined standard deviation about the individual means, is 0.014 or approximately 10 per cent of the means, indicates that the variability of the results were reasonably large. It is acknowledged that the results were subject to the influence of the rider.

8.5 Use of the transient response times in a star rating

Grzebeita et al (2015a) proposed that the transient response times be incorporated into a star rating system. The points are linearly related to the steering response times as shown in Table 8. However, there is no clear and identified connection between response time and safety although it could be postulated that a vehicle that is particularly slow to respond may impact on rider safety in some circumstances.

Table 8. Steering response time (Source: Grzebeita et al 2015a)

Criteria	Points rating				
	1	2	3	4	5
Steering response time (s)	>0.5	0.4 to 0.5	0.3 to 0.4	0.2 to 0.3	<0.2

The Consultation RIS proposed that the steering response time be included in the star rating. But given the lack of a an established relationship between the steering response times and safety, and because the response times on an asphalt surface are not representative of ground condition in the field, its use in the star rating system cannot be recommended.

8.6 Use of the transient response times in an extended standard

The Consultation RIS did not propose that the steering response time be included in the extended standard and it is not recommended that it should be.

9. Bump response test

9.1 Description of the test

Grzebeita et al (2015c) described the bump test as one where a quad bike or SSV was towed over a 150 mm semicircular half pipe. The vehicle free-wheeled over the bump and the acceleration of the pelvis of an ATD was recorded. McIntosh and Patton (2014) analysed data from the National Coroner’s Information System and identified that a number of crashes occurred when quad bikes struck an object and are destabilised. Figure 20 illustrates a vehicle passing over a bump.

Figure 20. Bump test (Source: Grzebeita et al 2015c)

Three runs were conducted with the left track of the vehicle passing over the bump and three runs were made with the right track vehicle passing the bump. The average acceleration in the ATD’s pelvis for each side was calculated and the maximum value recorded.

9.2 Description of the results

Grzebeita et al (2015c) provided results for eight general-use quad bikes, two sport quad bikes and one youth quad bike. Grzebeita et al noted:

> *"The visible outcomes of the bump obstacle test ranged from the Quad bike with its dummy rider passing straight over the bump, without significant perturbation to either, to a large vertical and lateral displacement of the Quad bike and dummy with associated steering input leading to near rollover of the test vehicle."*

The maximum resultant pelvic accelerations of the ATD from the perturbation are plotted in Figure 21.

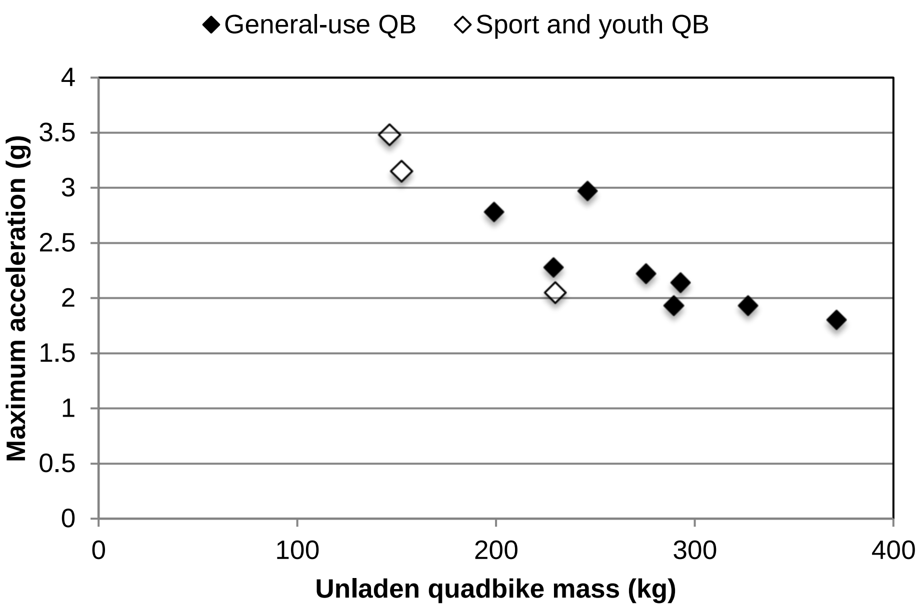

Figure 21. Maximum acceleration during the bump test against unladen quad bike mass

Quad bikes are less effected by the bump if the mass moment of inertia, about the front wheels, is increased. Heavier quad bikes have larger mass moment of inertia and a lower maximum average acceleration. Similarly, the quad bikes with lower acceleration values also have longer wheelbases, and subsequently were more likely to have the CoG further from the front wheels, again increasing the mass moment of inertia. The height of the CoG also affected the vertical acceleration, to a lesser extent. This is expected as the mass moment about the wheels will be increased slightly if other parameters remain the same. These attributes increase the mass moment of inertia about the front wheels and reduce the instability of the quad bike by reducing the impulse into the rear wheels traversing a 150 mm bump. This impulse affects the vertical acceleration of the rear of the quad bike and the possibility of riders being dislodged from the saddle of the quad bike.

Some quad bikes had independent rear suspension and this attribute is also likely to influence the maximum vertical acceleration.

9.3 Limitations with the application of bump response tests

There is a limitation that this testing involves only one bump type and height. The Consultation RIS states:

> *"While a wide variety of input speeds and obstacle configurations are possible, this sample is generally representative of the circumstances for at least a proportion of fatal and serious injury quad bike crashes that have occurred in the agricultural workplace in Australia."*

It is this association of a bump and observed fatal crashes that indicates the importance of the test. It is acknowledged that a test matrix would be better, in that a number of different bump heights and speeds could be used. No matter how extensive the matrix is, it cannot represent all conditions in the field. This single test is an indicator of the effect of impulse from one specified bump and speed on the vehicle's stability and rider safety.

The TARS team selected the use of a 150 mm high bump test as being representative of field conditions knowing that it was somewhat arbitrary. Grzebeita et al (2015c) stated:

> *"During a visit at the early stages of test development by the FCAI representatives on the Project Reference Group, Dr. John Zellner suggested the team try using asymmetric obstacles that were semi-circular, with radii of 100, 150 and 200mm. Suitable obstacles were developed and tested at these same speeds (10-25 km/h). The perturbation experienced by the rider indicated that while the largest obstacle produced the most perturbation, there was sufficient disturbance created by the 150mm obstacle to warrant its use as the test obstacle.*
>
> *Further justification was found in narratives of Coroner's reports, where 150mm obstacles were occasionally described (McIntosh and Patton, 2014). The team also considered that 150mm obstacles such as logs, rocks, ruts and grass tussocks were more likely to be concealed by long grass or might not appear to be a threat to the rider, whereas the larger 200mm obstacle would more likely be seen by a rider and because of its size, an appropriate riding style was more likely to be adopted to negotiate it correctly."*

The TARS team did note that by using one test there is a possibility that manufacturers will "tune" their vehicles to respond to a single test. The vehicle manufacturing and distribution industry through the FCAI recommended that a matrix of speeds and bump heights be used [44]. Grzebeita et al (2015c) tested for a range of conditions, but chose to use a single 150 mm bump. They stated:

> *"Based on the results obtained and the knowledge that there was information contained in Coroner's reports suggesting a large percentage of the fatal crashes on farms had occurred at low speeds, i.e. less than 25 km/h, it was*

[44] See https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

> *decided to use only a single test speed of 25 km/h for the bump obstacle perturbation test (McIntosh and Patton, 2014).”*

The testing program had the vehicle towed over the bump to decrease the effect of the rider’s actions if he or she was dislodged from the saddle.

A 150 mm bump at 25 km/h gives a reasonably high impulse into the rear wheels for evaluating the steering attributes when traversing bumps. It could always be argued that different dimension bumps exist or that the speed of 25 km/h does not represent all conditions. This is true. However, if a test matrix was used then the same argument could be levelled at the matrix. There is no way of deciding how the matrix of speeds and bump heights should be selected. The approach taken by the TARS team is sound.

Grzebeita et al (2015c) also identified a further potential issue if a rider pulls on the handle bars or if the rider were to “*inadvertently press the thumb accelerator and accelerate the vehicle during this mechanism”*.

As with other measures, the question of repeatability of results is a common concern. It would be better if the testing were to be done in the simplest way possible. This is discussed below.

Zellner et al (2015) commented on the TARS final summary report [45] and on the differences in the results from run to run. Using the data published in the Crashlab Special Report SR2013/004 published the data for individual runs. A summary of this data is presented in Table 9. Conditions when the range is greater than 10 per cent of the three-run average are shaded. The combined standard deviation of all results (assuming the variation is constant across all vehicles) is 0.10 g. This demonstrates a significant variance between runs.

The FCAI [46] has raised concerns that the ATD *“does not have human-like response for vertical (bump) impacts; that dummy is far more rigid than it is human [sic] in the vertical (bump) direction and reacts as a dead weight. This is also the case for its deadweight effect on steering inputs, in response to the bump.”* Further in its submission on the Consultation RIS, the FCAI [47] stated that *“the dummy used in this test is not biofidelic in the vertical direction which will distort the test results”.* These concerns have often been raised when an ATD is used to predict responses and injuries. For this test, the ATD choice is influenced by the availability of particular ATDs. In any case the results provide an indication of the likely outcome from riding over a bump.

A revised procedure that can reduce this variation in the results would be useful, perhaps by looking at the acceleration of body of the quad bike above the rear wheel.

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45 See Gzebeita et al (2015a)

46 See Zellner et al (2015) which is included as Appendix A of the Submission by the Federal Chamber of Automotive Industries submission to the ACCC Consultation RIS: https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent. Also see Zellner et al (2015)

47 Submission by the Federal Chamber of Automotive Industries submission to the ACCC Consultation RIS: https://consultation.accc.gov.au/product-safety/quad-bike-safety-draft-regulation-impact-statement/consultation/published_select_respondent

Table 9. Bump test results (Source: Crashlab 2013b)

Specimen	Side	Resultant average acceleration (g)				
		Run 1	Run 2	Run 3	Average	Range
TS57199	Left	2.59	2.27	2.48	2.45	0.32
	Right	2.84	2.85	2.66	2.78	0.19
TS57200	Left	2.17	2.05	2.20	2.14	0.15
	Right	2.10	2.04	2.27	2.14	0.23
TS57201	Left	1.76	1.84	1.68	1.76	0.16
	Right	1.80	2.06	1.93	1.93	0.26
TS57202	Left	1.81	1.99	2.00	1.93	0.19
	Right	1.82	1.59	1.76	1.72	0.23
TS57203	Left	1.88	2.33	2.23	2.15	0.45
	Right	2.23	2.2	2.23	2.22	0.03
TS57204	Left	2.55	2.56	2.55	2.55	0.01
	Right	3.04	2.91	2.96	2.97	0.13
TS57205	Left	2.30	2.21	2.32	2.28	0.11
	Right	2.12	2.21	2.07	2.13	0.14
TS57206	Left	1.66	1.58	1.47	1.57	0.19
	Right	1.77	1.84	1.78	1.80	0.07
TS57211	Left	2.58	2.61	2.68	2.62	0.10
	Right	3.36	3.66	3.41	3.48	0.30
TS57212	Left	3.21	3.19	3.04	3.15	0.17
	Right	3.11	3.02	3.19	3.11	0.17
TS57213	Left	1.93	1.74	1.99	1.89	0.25
	Right	2.05	2.03	2.08	2.05	0.05

9.4 Potential reduction in injuries if the bump test was used

The stability of the vehicles in the field is affected by its dynamic stability. The constant radius test and the static stability tests demonstrate the stability of the quad bike in either a quasi-static or a steady state dynamic condition. The steady state stability reflects the condition of a vehicle travelling relatively slowly across a slope with a smooth surface. The constant radius curves demonstrate lateral stability on a flat smooth ground surface. Neither of these two conditions are similar to a quad bike being ridden across a moderate slope on which wheels runs over a log on the ground or some other raised obstruction. Under these conditions, the impulse into the vehicle could cause the vehicle to overturn.

Section 6.2 discusses the work of Macmillan who indicated that the dynamic impulses are also important. For pitch stability, Macmillan (2017) states:

> *"Given these inertial effects, the instability of a QB may be influenced not only by the static and quasi-static effects discussed above, but also by its mass and mass moment-of-inertia about the rear axle."*

He makes a similar statement about the influence of the dynamic impulses and lateral stability. Macmillan concludes:

> *"In addition to static instability parameters, there may be an additional dynamic component that arises from the inertial properties of the chassis and the wheels. Most QB operational instability will occur under these dynamic conditions and hence any realistic and practical discrimination between safer and less safe vehicles would need to consider both contributions to the instability."*

While there are no statistics to establish whether this test will improve rider safety, it is reasonable to expect that a reduction in the effects from riding over a bump will affect dynamic stability and reduce the rollover rate. It is on this basis that the bump test be considered in a star rating system and in an extended standard.

9.5 Issues associated with the bump test

As with other measures, the manufacturers and distributors of quad bikes are concerned with the arbitrariness of values chosen for the limits in the star rating and for the requirements in any proposed standard. For instance, Honda in its submission to the Consultation RIS stated:

> *"Honda believes that it is inappropriate to make a judgment based only on the proposed test condition (vehicle speed / bump height). It should also evaluate the transient state in vehicle behaviour when the vehicle speed is increased. The basis for the criterion (generated acceleration is less than 2g) is unclear. The correlation between actual situation and the test condition of the proposal is unclear."*

Further, in its submission Honda also stated:

> *"There are risks in setting targets for one specific bump:*
>
> - *If the suspension is tuned to achieve the target for this one bump, it may be set artificially soft to absorb the 150mm bump.*
> - *A larger bump could result in a much worse reaction than a system designed for a wide range of performance.*
> - *With this requirement, the high inertia of the suspension system crashing into the frame could cause an unstable condition or much higher g than 2.0.*
> - *Regulating specific items that have a big effect to the tuning of the system can greatly compromise the intended character of the vehicle."*

These concerns are acknowledged, particularly the use of one bump height and impact speed. However, the lessening of the propensity of quadbikes to overturn must be the objective.

Having one bump height rather than a matrix of tests does potentially create a position where the manufacturers will tune the suspension set ups to have the best outcome for this test. It is recommended that manufacturers and distributors be asked to assist in refining this test to avoid this issue. In the absence of an acceptable matrix of bump height and impact speed configurations, it is recommended that a single test be used (150 mm high bump impacted at 25 km/h). The preference would be to use a limited matrix of tests, that provides information for a range of conditions and reduces the propensity for manufacturers to simply tune the quad bike's suspension to the meet the testing requirement.

Heydinger [48] questioned the TARS calculation procedure and suggested that some aspects of the procedure need clarification if the bump test is used in a standard or a star rating system. He also indicated that different speeds might be useful as a test speed of 10 km/h might *"cause higher peak accelerations, as it might further excite the bounce, pitch and roll natural frequencies of the test vehicles."*

From Figure 21, heavier quad bikes have lower vertical accelerations. This test may lead to manufacturers and distributors favouring the sale of heavier quad bikes in the market.

9.6 Use of the bump test in a star rating system

For the bump response, the basic testing procedure is reasonable. It is an indication of the outcome if a vehicle traverses a 150 mm high log in the grass. Any test, especially on an asphalt surface, does not replicate the conditions in the field and it can be criticised on these grounds. Testing is better if it is simplified so that the testing is more repeatable and targets the issue at hand. In this case the reduction of the vehicle's response to a vertical impulse to the vehicle's wheels is the objective, as it is noted that rollover incidents have been shown to have a higher potential to end in a fatality.

The Consultation RIS proposed that the results from the bump test be used as a measure in the star rating in Options 2-5. Grzebeita et al (2015a) proposed the points allocation as shown in Table 10.

Table 10. Bump response test – point rating (Source: Grzebeita et al 2015a

Criteria	Points rating				
	1	2	3	4	5
Bump Obstacle Response - Pelvis acceleration (g)	>3.0	2.0 to 3.0	1.5 to 2.0	1.0 to 1.5	<1.0

The bump test is an indicator of the vehicles response to an impulse to the rear wheels and this is an important aspect to dynamic stability.

It is recommended that the response of the vehicle to a 150 mm bump be used as part of the star rating system. This recommendation is made even though there is only one bump height and speed as there is no basis for designing a matrix of tests at present. Appreciating that one bump height and impact speed allows the quad bike to be tuned for

[48] Personal communication and review of a draft of this report by Gary Heydinger (from SEA Limited)

this test, the use of a matrix of tests should be discussed with input from the manufacturers and distributors. The preference would be to have a simple limited matrix of tests, however without an acceptable matrix, the simple test should be adopted in the first instance.

In an effort to simplify the testing protocol, it is questioned whether the accelerometers could be attached to the vehicle and not the rider or indeed should weights be used to simulate the mass of a rider as in the robotic vehicle test shown in Figure 16. It is questioned whether the use of robotic vehicle control is likely to provide more repeatable results.

9.7 Use of the bump test in an extended standard

Following on from the discussion in the previous sub-section, the Consultation RIS proposed that results from the bump test be used in the minimum suspension test requirements in Options 4 and 5. The proposed requirements in the Consultation RIS are:

> *"General-use model quad bikes shall achieve a bump response of less than 2.0g when tested in accordance with the Bump Response Test Procedure in Attachment D [of the Consultation RIS]"*

It is noted that the dynamic stability of a quad bike is related to its stability in steady conditions, on smooth ground conditions and the effects of dynamic vertical impulses into the vehicle's wheels. The static stability gives an indication of the stability and the bump test an indication of the response to a vertical impulse.

Figure 22 shows the maximum acceleration for a general-use quad bike traversing a 150 mm high half round obstacle.

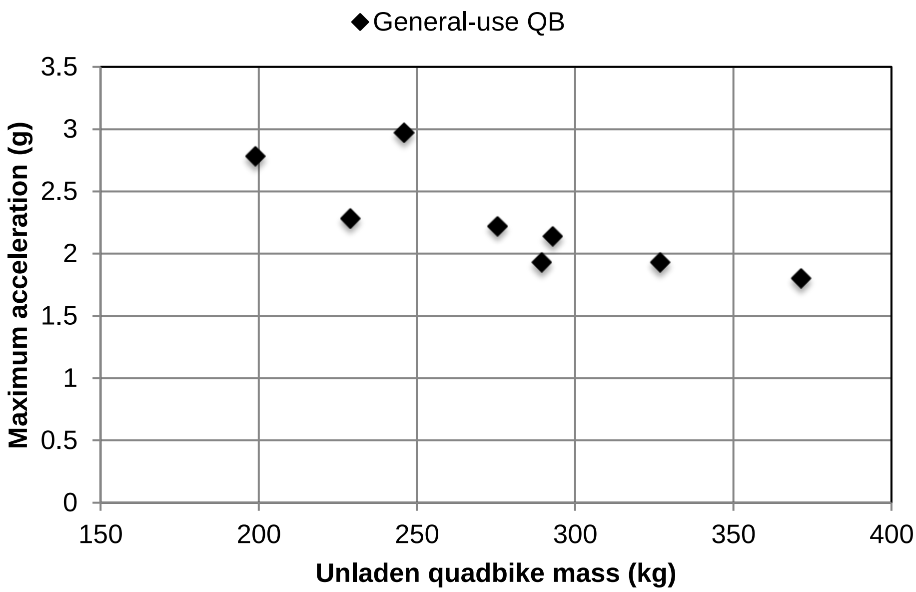

Figure 22. Maximum vertical acceleration for a vehicle traversing a 150 mm high bump

The Consultation RIS indicated that minimum acceptable vertical acceleration should be 2.0 g. This would cause five quad bikes tested by TARS to fail this requirement. A standard which significantly affects the market, will have difficulty in gaining acceptance by manufacturers and distributors. Consequently, in the short term, the recommended minimum limit for the maximum vertical limit is 2.5 g. Two general quad bikes tested by TARS would be unable to meet this requirement.

It is recommended that the response of the vehicle to a 150 mm bump be used as part of extended standard. This recommendation is made even though the there is only one bump height and speed as there is no basis for designing a matrix of tests at present. Appreciating that one bump height and impact speed allows the quad bike to be tuned for this test, the use of a matrix of tests should be discussed with input from the vehicle manufacturers and distributors. Again, the preference would be to have a simple limited matrix of tests, but without an acceptable matrix, the simple test should be adopted in the first instance.

10. Minimum wheel articulation

10.1 The test

A minimum wheel articulation has been specified in Options 4 and 5 of the Consultation RIS. The Consultation RIS states:

> *"The minimum wheel articulation shall be 150 mm for all wheels. This articulation is to be centred about (approximately half available for compression and half for rebound) the suspension position when the articulation is measured with a 50th PAM H3 ATD seated on the saddle in a normal riding position."*

This requirement for increased wheel articulation when combined with the bump response test is aimed at reducing the risk of a rider being displaced from the saddle when unexpectedly impacting a log or similar obstacle.

Simmons (2018) reported that the "*TARS Research Team measured suspension travel and spring stiffness (not reported in the TARS reports). ... Six of the eleven tested quad bikes already meet the required minimum suspension travel articulation [f 150mm]. A further two quad bikes do not meet the minimum requirement by less than 10 mm."*

10.2 Limitation of the wheel articulation requirement

Simmons (2018) has based the 150 mm minimum wheel articulation on some earlier work by Renfroe and Fleniken (1994) on SSVs and by accounting for differences in the wheelbase of SSVs and quad bikes. Using the results provided by Simmons, there is a very low correlation coefficient (0.094) between the wheel articulation and the maximum acceleration recorded in the bump test. The results are shown in Figure 23. Some low bump test accelerations were obtained with shorter suspension articulation.

Honda, in its submission to the Consultation RIS, stated that the 150 mm wheel articulation was arbitrary. They listed additional concerns as:

- *"This criteria has a significant impact on how ATV suspension is tuned.*

- *It will limit the suspension setting on vehicles (initial travel must be soft enough to meet the test and the stabilizer bar must be at least as soft).*
- *It will also limit the ability to tune roll moment distribution and roll stiffness.*
- *It would likely eliminate swingarm vehicles, which offer high roll stiffness that provides lateral stability in a loaded condition."*

In addition, when discussing the requirement for the articulation to be centred, Honda stated:

> *"This requirement would also put the ATV at a disadvantage for absorbing larger bumps.*
>
> - *Typically, a higher bump to rebound ratio is required to absorb large bumps at speed and keep the vehicle stable.*
> - *With less bump stroke, these obstacles are more likely to upset the machine."*

The comment that this requirement will reduce a manufacturer's ability to optimise the performance of the quad bike is acknowledged.

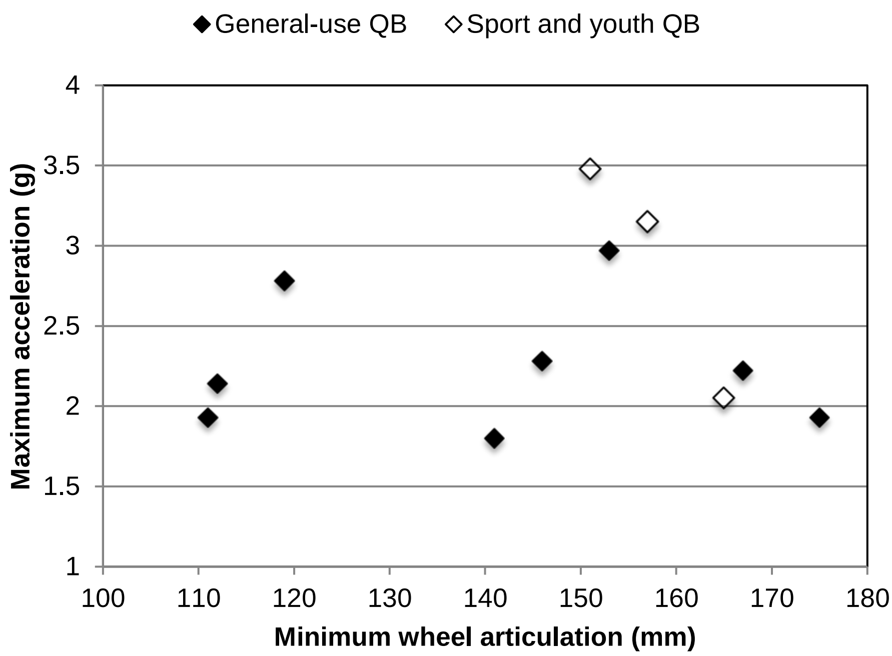

Figure 23. Maximum acceleration from the bump test against average wheel articulation

10.3 Safety benefits in using a minimum wheel articulation

There is no information to illustrate that the wheel articulation requirement (of 150mm) will improve safety. Figure 21 demonstrates that lower bump responses can be achieved on quad bikes with shorter wheel articulation measures.

10.4 Use of the minimum wheel articulation in a star rating system or in an extended standard

The minimum wheel articulation is a design specification and not a performance specification.

Section 4.3 of the ANSI/SVIA 1-2017 specifies a minimum wheel travel of 50 mm, in order for the quad bikes to have a minimum workable suspension. Figure 23 indicates that all quad bikes tested by TARS had a minimum wheel articulation of more than 110 mm.

In general a design Standard should not use a design dimension but should rather use a performance specification. Consequently, it is not recommended that either the star rating or the extended standard incorporate a minimum wheel articulation measurement.

11. Operator protection devices

Operator protection devices (OPDs) include both crush protection devices (CPDs), which minimise the risk of the rider being crushed if the vehicle rolls over, and rollover protective structures (ROPS), which enclose the rider and also minimise the risk of the rider being crushed if the vehicle rolls over. Examples of current OPD designs for quad bikes are shown in Figure 24. TARS have evaluated these two OPD systems.

11.1 Concerns with the use of CPDs

The general concern with the use of CPDs is whether or not they improve riders' safety, or, in certain situations, may have a detrimental effect on operator safety.

The FCAI in its submission to the Consultation RIS stated:

> *"There also can be other rollover circumstances where the OPD can prevent the ATV from rolling away from the rider and can be the cause of the asphyxiation."*

And further on its submission states:

> *"A study of real-world rollover events[49] also found that 63% of riders attempted to actively dismount their ATV during a rollover event, of whom 72% did so successfully. That study also found that an OPD like the Quadbar could impact the rider and prevent this active dismount."*

[49] see Van Ee et al (2014)

Figure 24. Two versions of CPDs currently available. On the left is the Quadbar ™ and on the right is the ATV Lifeguard ® (Source: Consultation RIS)

Polaris in its submission to the Consultation RIS stated:

> *"Polaris is unaware of any detailed and reputable evaluation of so called OPDs or CPDs which indicates a net benefit over a range of vehicle models and usage scenarios."*

Quad bikes require riders to use different skills. This is generally termed "active riding" where the rider uses his or her weight to assist when riding on slopes and around corners. Roy Deppa, in his submission to the Consultation RIS, commented on the use of an open rear differential provided an insight on the riders' practice when cornering. He stated:

> *"Because of the solid-axle directional stability, the operator must allow the inside rear tire to unload normal force enough to allow some tire/soil slip for the vehicle to turn. The process of doing this has been described as "rider active" steering. This is very different from automobile steering. In order to steer a Quad Bike, the operator must do two quite different things simultaneously: turn the handlebars in the direction of the turn (say Left) and shift weight enough to the outside of the turn (the Right side) to take some of the weight off the inside (Left) rear tire."*

He continues:

> *"But, of course, the Left rear tire generally still has some contact with the ground, so not all of the weight has been lifted. The result is that, for most turns, the tip axis shifts to the right, but not all the way. If speed is high enough, and if the terrain is rough, that weight shift can be complete so that the vehicle suddenly steers sharply to the left. At the point where the Right rear tire loses traction and side-slips, the vehicle spirals sharply into the turn to the point where it may roll over."*

Quad bikes are quite different to other vehicles, as the rider's control through the movement of his or her body on the quad bike (active riding) significantly affects the performance of the vehicle. It is therefore important for riders to be able to freely move around. Seat belts are therefore not a rational option for quad bike riders. It is important that the CPD does not reduce the ability of quad bike users to actively ride.

SSVs do not require the same "active riding" ability and occupants are constrained within a ROPS by seat belts.

11.2 Injury statistics for quad bikes with and without CPDs

It has previously been demonstrated in Section 2, that a major cause of injuries and fatalities involves quad bike rollovers and for the riders to be crushed or asphyxiated. Vallmuur et al (2015) reported that fractures were the predominate injury being 51 per cent of hospitalisations due to work or farm related incidents between 2009 and 2013 in Queensland. For incidents involving other activities in the same period, 54 per cent of hospitalisations were due to fractures.

Injury data from Queensland

When evaluating the likely injuries from CPDs, Vallmuur et al (2015) stated:

> *"The 'possible' presence of a crush protection device on the quad bike was recorded for 9 ED cases and 22 ambulance attendances. In reviewing cases to identify the presence of crush protection devices in the fatality and injury data, it is possible to gain some insight regarding whether the vehicle was a quad bike or SSV. If the description mentions a roll cage, seat belts/safety harness, buggy or that the patient was 'in' the quad bike it would indicate that the vehicle is possibly a SSV (even if the clinical notes document a quad bike). Five of the ED cases and 17 of the ambulance cases are possibly SSV's based on the description provided.*
>
> *In general, suspected fractures of the upper and lower extremity were the most common result of the collision with crush protection devices in quad bikes (Note: ambulance data only describes the suspected nature and body region of injury prior to thorough investigations in the hospital and can only be considered an approximation of the likely injuries sustained)."*

In the conclusion to this report it is stated:

> *"Up to two-thirds of ambulance attended cases across contexts indicated that there was no helmet worn at the time of injury. There were a small number of cases where the possible presence of a crush protection device on the vehicle could be identified in the documentation, with the majority of injuries related to these mentioning fractured upper extremities from contact with the CPD."*

From this analysis, between 2009 and 2013 in Queensland, there were 4 Emergency Department presentations and 5 ambulance attendances as a result of injuries associated with the presence of a CPD. The injuries associated with rollovers resulted in 41 work related Emergency Department presentations and 107 work or farm related incidents at which an ambulance attended. As the proportion of riders requiring medical attention that were riding a quad bike with a CPD is unknown, it is not possible to determine the impact of a CPD on injuries to a statistically acceptable level.

The TARS (2017) report on the safety of using quad bikes in the workplace used three studies to evaluate the safety provided by CPDs. Each of these studies will be discussed in turn.

Quad bike Tour Company case study

The tour company provided event history for the period 1990 to 2016 with more detailed data for the last three years. The company currently operates approximately 100 recreational quad bikes within a workplace environment. The company provides tours along beaches and nearby areas on the Queensland coast. They have up to 25,000 individual participants each year.

The TARS (2017) report states:

> *"This company has operated Quad bike tours in their current location since the mid-1990s. By the early 2000s, the Quad bike fleet had grown to more than 20 adult and 10 youth Quad bikes. Safety related incidents occasionally occurred in which guests were injured, some very seriously. In the absence of detailed records, experienced staff have estimated 70% of these incidents involved a rollover crash and 65% of these rollovers resulted in the Quad bike rolling on top of the rider."*

The company progressively reviewed their practices and formalised the tracks and trails, provided pre-ride instruction and testing, imposed speed limits and required all riders to wear AS 1698 compliant helmets. Despite these changes in their practices, the crashes and injuries continued.

In around 2005, all quad bikes were fitted with CPDs (the Quadbar^{TM}). Since that time the number of participants per year has considerably increased (at least by a factor of 3) and injuries have been reduced. It acknowledged that this is not a formal study to determine the effect of using CPDs but rather a company responding to the number of injuries recorded in their practices. As such the data are not perfect and are reliant on the memories of staff. Nevertheless, the TARS (2017) report stated:

> *"The tour company managing operator stated that the incidents still remain at around 120 annually. Of these incidents, no guests have required helicopter evacuation (compared to 2-3 annually previously), 2 guests each year (on average) have required first aid treatment (compared to 30 annually previously) and 3 required the assistance of an Ambulance (compared to 20-30 annually previously). The company operators also stated that Quad bike rollovers still occur in around 70% of the incidents (average 85 per year) whilst none of the injuries result from the Quad bike rolling onto, or the OPD impacting, the rider."*

Looking at the more recent and comprehensive data, the TARS report stated:

> *"Analysis of the 188 incident reports completed between January 2014 and June 2016 (with Quadbar^{TM} OPDs fitted to the fleet) provided to the research team revealed for this company (20 months of data) that around 73% (n=137) identified the OPD did prevent more serious injury and 27% (n=51) were not*

> *applicable events. In no reported circumstance did the OPD contribute to crash or injury causation."*

The TARS report concluded:

> *"Moreover, the harm reduction effect is unlikely to be the result of administrative controls alone as discussed above but more likely the result of fitting an OPD to their Quad bikes."*

The TARS (2017) report notes that a randomized study to more formally predict the safety consequences of using or not using an CPD cannot be ethically undertaken.

Fleet managers survey

TARS (2017) reported that 16 fleet managers from Australia and New Zealand agreed to participate in a survey consisting of "*multiple choice and short answer questions, designed to collect self-reported information"*. The survey collected information about:

- *"The numbers and locations of Quad bikes used in their workplace;*
- *Commodity or type of work undertaken;*
- *Terrain types operated on;*
- *Type, brand and age of Quad bikes in use;*
- *Specific tasks Quad bikes are used for in their workplace;*
- *Typical usage patterns by season, month, day and hours ridden (i.e. exposure data);*
- *Speed limits imposed in the workplace and how they are enforced;*
- *Quad bike rider training provided to employees;*
- *Loads carried on Quad bikes;*
- *Type of OPD fitted;*
- *Effect of the OPD on performance of work tasks;*
- *Number of crashes (and specifically rollovers) in workplace with and without OPD fitted;*
- *Injury severity associated with crashes with and without OPD fitted;*
- *Efficacy of OPD in protecting rider in (rollover) crashes (including injuries caused by the OPD); and*
- *Helmet wearing requirements for employees."*

A summary of the data for rollover crashes is shown in Table 11. This table indicates that the quadbikes without OPDs had 57 rollover incidents from 115 quad bikes in the survey, while the quad bikes with and OPD has 12 rollovers from 321 quad bikes. This difference in the rollover rates with and without a OPD cannot be attributed to the OPD alone and there must be other factors, like quad bike type, rider skill, terrain, use and the amount of use, that are influencing this result. The sample sizes are too small to warrant a statistical analysis. It is noted that there were almost 3 times as many quad bikes with an OPD than without one.

Table 11. Injury statistics for rollover crashes from fleet managers survey (Source: TARS 2017)

Injury from rollover crashes	No OPDs fitted	OPDs fitted
No Injury	40	6
Minor injury	5	0
Attended hospital	11	4
Admitted to hospital	1	2
Total number of rollover crashes	57	12
Number of quad bikes in survey	115	321

Of the 12 reported incidents with quad bikes with an OPD, in 8 cases it was considered by the fleet managers that the OPD prevented the quad bike rolling onto the rider, in 2 cases the OPD held the vehicle above the rider, in one case the OPD made no difference to the outcome and in the remaining case the OPD caused injury to the rider (though the rider stated that the OPD prevented him receiving more serious injuries).

As with the results reported here, the TARS (2017) report stated:

> *"These results need to be viewed with caution as this survey was relying on the recall of fleet managers and was limited in scope. The number of events recorded are very small. Moreover, the data collected did not account for exposure rates of the vehicles fitted with and without an OPD. The survey was only meant to be a preliminary survey with respect to the much broader Individual Workplace Riders (main) Survey in order to get a brief 'first glimpse' overview of the in-field data."*

Individual Workplace Riders Survey

An online survey of quad bike users was used to evaluate safety in field conditions. There were 1,553 completed responses from 2037 people who began the survey. Fifty-one per cent of riders had had a crash, with some having multiple crashes.

Sixty-seven per cent of the crashes (963/1430) involved rollover crashes with the following injury breakdown listed in Table 12.

When examining torso injuries from quad bike rollovers, TARS (2017) reported that the rate of injuries and serious injuries per crash. Riders were injured in 19.1 per cent of crashes involving quad bikes without an OPD. This is higher rate than crashes with quad bikes with an OPD in which 9.1 per cent of crashes resulted in the injuries. However, these results are not statistically significant.

Table 12. Evaluation of injuries from rollover crashes (Source: Individual Workplace Riders Survey, TARS 2017)

Injury	Total number of injuries	Quad bikes without an OPD	Quad bikes with an OPD
No injury	767	682	85
Minor injuries	135	127	8
Serious injuries	61	59	2
All injuries	196	186	10
All rollover crashes	963	868	95

The rate of injuries and serious injuries per crash was also lower for Quadbar™ and ATV Lifeguard ® OPDs (both proprietary products) than for other less common or home-made OPDs. The injury crash rate for these proprietary products is 5.3 percent of all crashes. Again, the results are not conclusive as they are not statistically significant.

The TARS report continues:

> *"In regard to safety benefits of fitting Quad bikes with OPDs, and in particular Quad bikes retrofitted with Quadbar and Lifeguard OPDs, Table 8 [see Table 3] indicates that for cases where the Quad bike 'rolled over the rider' and a chest injury occurs and/or the rider is pinned, a trend analysis identified that with increasing severity of chest injury, the proportion of OPD fitted vehicles decreases (p=0.02). That is, the infield data is suggestive that OPDs reduce to some extent serious chest injuries in rollovers.*
>
> *…*
>
> *The question that arises is whether an OPD is effective in reducing injuries, but also importantly, whether OPDs are harmful to the rider in the workplace environment, i.e. cause serious injuries or death. There have been rollover events in which OPDs have had a protective benefit, but there have also been rollover cases where the presence of the OPD has been reported by riders that it has contributed to their injury.*
>
> *In regard to deaths, there have not been any fatalities identified in this study or elsewhere where the OPD fitted to the Quad bike was causal to a fatal injury."*

There have been anecdotal examples of where riders have suffered injuries from the OPDs and there are examples of riders being uninjured when the quad bike rolls over them.

The TARS (2017) report reviewed a number of factors that contribute to a greater chance of a serious injury. These include hard surfaces, speed and whether the vehicle rolled over the rider. Other broad conclusions were that 77.5 per cent of respondents indicated that the OPD made no difference and 94 per cent of the respondents stated that an OPD made their tasks easier or about the same.

Mustering (gathering stock) and other stock work had the highest number of crashes and subsequent injuries. Approximately 22 per cent of the riders in the survey were wearing a helmet when they crashed. Wearing a quad helmet significantly reduced minor and serious injuries.

The TARS report concludes:

> *"In summary, while it is possible that a rider may receive an injury from an OPD, from the in-field data collected and presented in this report. However, on balance from Sub-studies (i), (ii) and (iii) the data is suggestive that OPDs reduce to some extent serious chest injuries in rollovers. More importantly though, the data is indicating that neither the Quadbar or Lifeguard OPDs were causing serious chest or head injuries in rollover crashes."*

The TARS team recognised the limitation of their studies from a statistical perspective. They state:

> *"In particular, the number of OPD users responding to the surveys were less than expected, and consequently the number of OPD no-injury cases and related injury and serious injury cases are relatively low resulting in a lack of statistical power to be able to fully assess the effectiveness of such devices."*

The number of riders with a CPD was less than expected and so the number of serious injury, injury and no injury cases was also small. This reduces the ability to predict statistically significant results.

11.3 Simulation studies

There are a number of simulation studies relating to the safety benefits or costs associated with using a CPD on a quad bike [50]. Equally there has been significant comment on these simulation studies [51].

In the Queensland Coroner's report, there is a description of his assessment of the simulation studies in which Justice Lock concluded:

> *"I have formed a view that the research from all sources has sufficient inherent difficulties and statistical inconsistencies for me to be able to reach a conclusion about the efficacy of CPDs in particular."*

This report is not going to add to the comments that are in the literature but will outline the issues associated with computer simulations in general.

Computer based simulation studies are used to extend knowledge based on known events or outcomes. Computer simulation programs have been developed for a range of event types including collisions between vehicles, collisions between vehicles and objects, the outcome of vehicles traversing different terrains and so on.

[50] See Munoz, Van Auken and Zellner (1996), Van Auken and Zellner (1998), Zellner, et al (2004), Van Auken and Zellner (2007), Zellner, et al (2008) and Zellner, et al (2016)

[51] See McDonald (2011), Anderson (2014), Grzebeita et al (2015a) Kahler and Martin (2017), Lower (2017), Federal Chamber of Automotive Industries (2018) and TARS (2017)

Simulation programs are more effective when the attributes of the events simulated are close to the attributes of known real world events. In these cases, the outcomes from the real-world events can be used to inform the simulation model.

When examining the effectiveness of CPDs when a quad bike rolls over, a simulation program needs to be able to match the outcomes of a range of controlled physical full-scale rollover tests. The process should start with the program being able to replicate the detailed kinematics shown in the full-scale tests, firstly for a single quad bike and then with a range of quad bikes. The kinematics would include the orientation of the vehicle (pitch, yaw and roll) and the accelerations in the three directions at the centre of gravity. This will ensure that the simulation is capable of being reasonably accurate in predicting the outcome for vehicles rolling over in the real world. The accuracy needs to be such that comparisons of the kinematics from the full-scale tests and the simulations are close at each time period and in accordance with recognised standards for simulations of this kind [52]. It is appreciated that the simulation and the full-scale crash tests results would not be exactly the same and the comparison methods need to quantify these differences.

In most cases, the vehicle's components will need to be modelled in detail in order to obtain a comprehensive model of the vehicle. This involves the disassembly of the vehicle and the properties of components measured [53].

As these full-scale tests would normally involve ATDs, it is important that the simulation of each full-scale test can reasonably predict the kinematics of the ATD and the forces on the ATD. If this can be done then the model could be said to reflect the basic outcomes of the full-scale tests and the model is therefore, considered to be validated.

Different ATDs are used to measure the different range of forces that are expected to be applicable to the event being simulated. Grzebeita et al (2015c) stated:

> *"Moreover, crash test dummies such as the MATD, are tuned to provide measures of acceleration and displacement that are associated with serious injuries that commonly occur in road crashes, and injury risk measures determined from laboratory tests with cadavers and other human surrogates and correlated. Measurements on ATDs, such as chest deformation or femur loads, are typically calibrated for specific load patterns and directions, e.g. axial load of the femur and anterior-posterior compression of the thorax. These loads are more predictable in a contained occupant ATD within a vehicle in comparison to an ejected or separating occupant in a Quad bike rollover test. Therefore, it is possible that an ATD, such as the MATD, may not register some loads during tests because of its design and intended purpose."*

Given that the simulation model predicts the same loads as were recorded by the ATD, then we can be satisfied that the model and the full-scale tests are aligned. The final step is the prediction of the injury outcomes from the loads on different parts of the ATD's body. This is perhaps the more difficult process, but one that needs to be done in order that trauma can be reasonably able to be predicted. There is not a one to one relationship

[52] See Ray et al (2010)

[53] Ibid

between loads on a body and the expected Maximum Abbreviated Injury Scale (MAIS) outcomes [54]. A particular load on a body can produce a range of MAIS outcomes.

The researchers both at TARS and DRI are aware of this general approach and have documented many parts of their process in line with these comments. Nevertheless, there is an absence of the detailed comparisons to give a reader confidence that the simulation models can reasonably provide accurate predictions of the kinematics or predict the potential for harm.

In conclusion, the absence of the detailed comparisons between the simulations and crash tests and field tests does not give confidence in the simulation models and their output at this time and therefore the results from the simulations do not provide a clear statement of the effectiveness of CPDs.

From the simulation studies, it is therefore not possible to quantify how CPDs in general or Quadbar™ and ATV Lifeguard ® in particular would perform under different crash scenarios.

11.4 Are CPDs effective in reducing injuries?

The surveys show the use of CPDs on quad bikes to be beneficial. However due to small sample sizes, the results are not statistically significant. Whilst these surveys have limitations, taken together the benefits outweigh the harm from the fitting of CPDs. This is not to say that injuries will be eliminated with the use of effective CPDs.

One of the reviewers of the research by TARS stated [55]:

> *"The consistency of results across the three different sub-studies (and various samples), adds to the validity of the overall findings and assists in minimising any potential bias from respondents. Furthermore, the consistency of findings in addition to other data that is already in the public domain regarding fatal incidents, reinforces the broader generalisability of the results within Australia and internationally for typical work-place environments.*
>
> *In conclusion, the studies main key findings that OPDs on balance appear to be effective in reducing serious chest injuries as well as rollover related serious injuries, plus that helmets are effective in reducing injuries, are supported by the study data."*

The author of this report considers that this statement is accurate and reasonable.

The use of simulations to further explore the safety outcomes of CPDs has been extensive. But, in the opinion of the author, the simulation studies have failed to fully document the necessary validation process that would give a reader confidence that there is a simulation model that can reflect the potential for harm and provide reasonably accurate predictions of the outcomes.

[54] See Schmitt et al (2014)

[55] See TARS (2017)

While it is acknowledged that the CPDs will not eliminate injuries, it is recommended that, in accordance with Option 3, tested and effective CPDs would be provide a net benefit if installed on general-use quad bikes, as demonstrated in the Section 11.2.

11.5 Concerns with the survey data

The anecdotal evidence in the Quad Bike Tour Company case study has been criticised for being just that, even though the number of users is high and the outcomes are positive. The Fleet Managers survey has also been criticised, as it was not a controlled study. The major survey has been criticised, as the respondents were self-selected and therefore could not be randomised. The TARS team acknowledged these aspects and the analyses were undertaken carefully. In fact, it would be difficult to see how the data could be collected without the effect of being “self-selecting”. Even if users were selected at random, it would be difficult to see how they could be encouraged to participate to maintain a random distribution.

Manufacturers and distributors have been critical of the requirement to fit CPDs as they consider that they do not significantly reduce harm and consequently, they have strongly contested the findings in any studies of the effectiveness of CPDs.

11.6 Predicting the outcome from a rollover

It is difficult, if not impossible, to predict the outcome from an individual rollover. The number of quarter turns a quad bike will roll depends on a number of factors including the energy of quad bike, the geometry and hardness of the ground surface, the geometry of the quad bike and its trajectory.

The research by the TARS team and others documented in Section 11.2 show the use of CPDs on quad bikes to be beneficial. It will always be possible to refer to situations where the presence of a CPD has caused an injury.

The TARS team (Grzebeita et al, 2015d) used a quad bike with a motorcyclist ATD to study lateral, forward and backward rollovers without a CPD, with a ATV Lifeguard ® CPD or with a Quadbar™ CPD. The vehicle was positioned 1 m from the lower edge of the tilt table as shown in Figure 25. The TARS team had positioned the quad bike further from the lower edge in preliminary tests. The tilt table was raised to the point where the quad bike would tip over and then the quad bike was released.

The TARS team stated:

> *“Without an OPD fitted the Quad bike rolled onto the MATD and came to rest on the MATD with the MATD located between the Quad bike and the ground (2nd row frames in Figure 8 to Figure 10 [not presented here]). When reviewing the videos it appeared that a large portion of the vehicle’s weight is being transferred to the MATD. The vehicle came to rest on top of the MATD in the lateral roll and forward pitch scenarios and rolled off in the rearward pitch scenario.”*

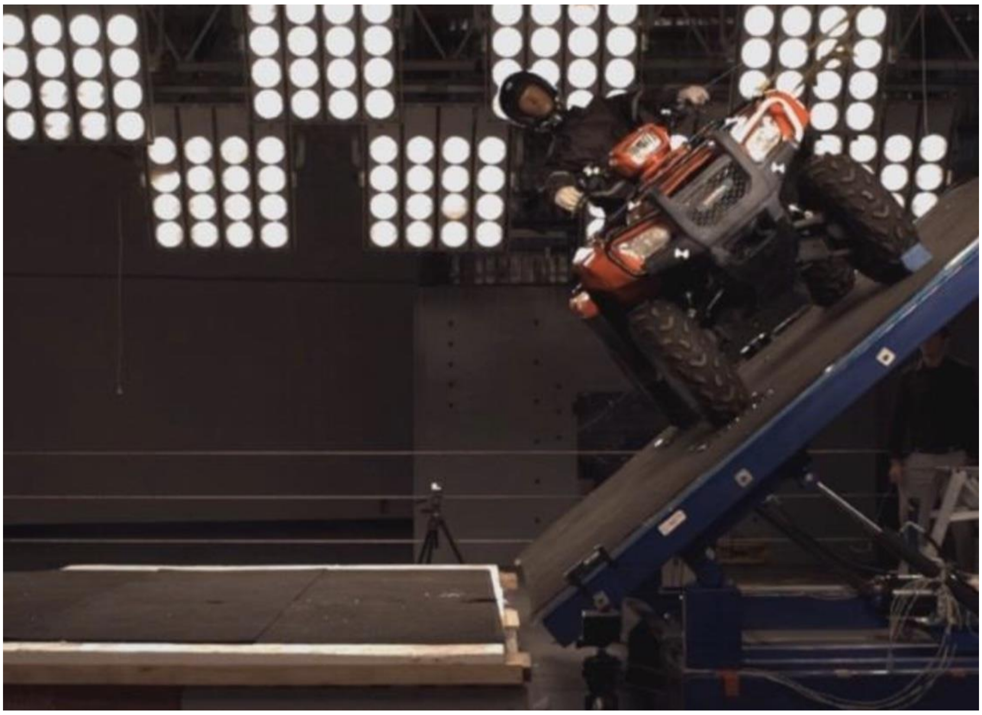

Figure 25. Positioning the quad bike on a tilt table for rollover tests (Source:Grzebeita et al 2015d)

Testing with the ATV Lifeguard ® did raise a concern about the MATD being entangled in the device's flexible segments. The TARS team considered that the device should be redesigned to account for this action as it was potentially hazardous. Otherwise Grzebeita et al (2015d) stated:

> *"With a Lifeguard OPD fitted the Quad bike rolled over and on top of the MATD such that the rear of the Quad bike was being supported by the Lifeguard during this rollover/pitch process. The Quad bike did not load the MATD as can be ascertained in the 3rd row frames in Figure 8 to Figure 10 [not provided here]. The Quad bike came to rest over the MATD in the lateral roll and forward pitch scenarios. In the rearward pitch scenario, the vehicle rolled off to one side after having been over the MATD. The Lifeguard OPD increased the clearance (survival space) under the Quad bike relative to no OPD."*

When the Quadbar™ was used the TARS team stated:

> *"With a Quadbar OPD fitted the Quad bike did not fully roll onto the MATD (4th row of frames in Figure 8 to Figure 10). In the rearward pitch the vehicle remained vertical as shown in the 4th row of frames in Figure 10 [presented as Figure 26 here]. However, it was observed that when the fall height was larger, as in the case of the exploratory tests where the vehicle was placed 1,500 mm from the 'lowered' edge of the tilt table, the Quadbar deforms as a result of the impact force but still maintains the rear of the vehicle above the MATD as shown in Figure 12 [presented as Figure 27 here]. In regards to lateral roll and forward pitch the Quadbar kept the rear of the vehicle above*

> *the MATD without allowing the Quad bike to apply load to the MATD. The Quadbar OPD increased the clearance (survival space) under the Quad bike relative to no OPD in the inverted position."*

Grzebeita et al (2015d) concluded and stated:

> *"In summary, in these limited (low speed) test series, typically, without an OPD fitted, the vehicle came to rest on the MATD, imparting a load. Typically, with an OPD fitted, the vehicle came to rest separated from the MATD, or supported the mass of the vehicle above the MATD. In one case, contact between the (Lifeguard) OPD and the dummy appeared to apply spinal loads, which could have been injurious to a rider."*

Grzebeita et al (2015d) considered that testing the CPDs with the chosen vehicle was representative of the performance of OPDs with other quad bikes in the sample and argued that that tests with other quad bikes is not warranted.

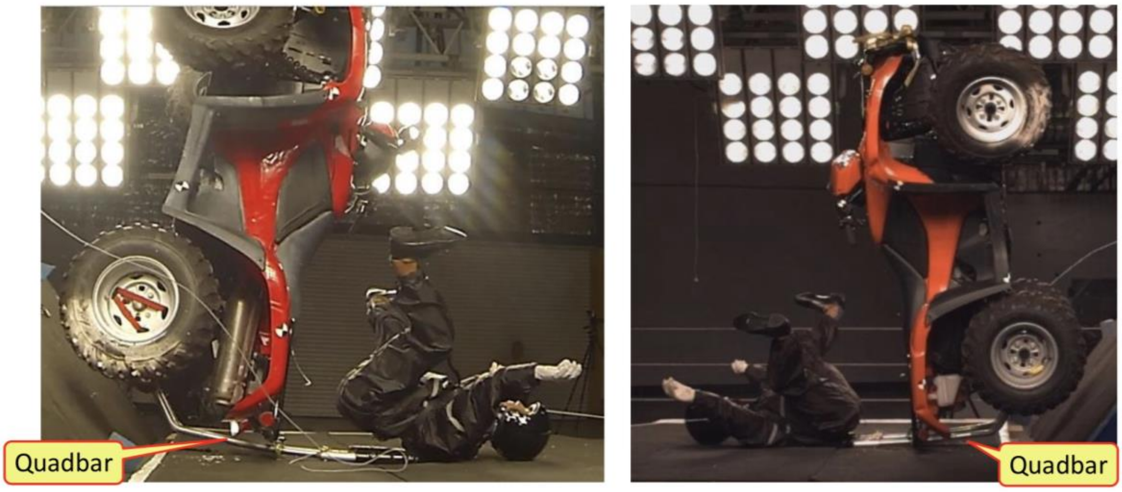

Figure 26. Quad bike with a Quadbar™ in a rearward rollover test, 1 m from the edge (Source: Grzebeita et al 2015d)

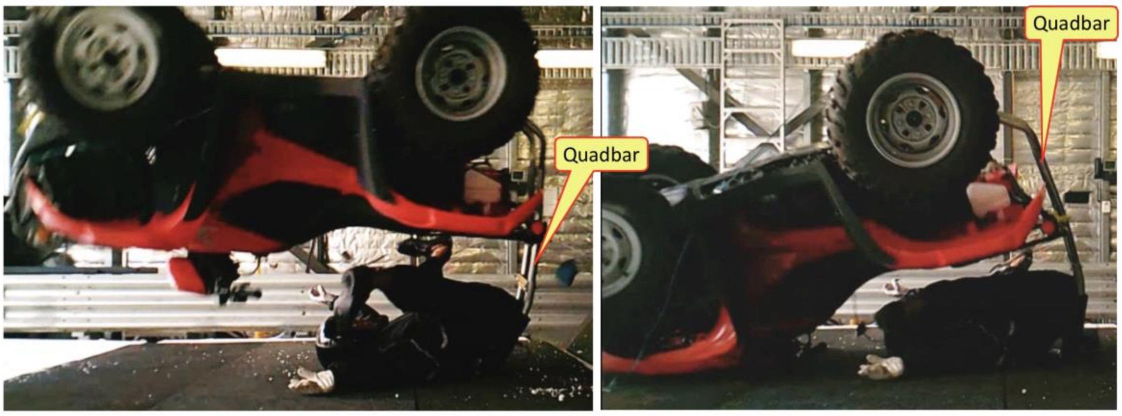

Figure 27. Quad bike with a Quadbar™ in a rearward rollover test, 1.5 m from the edge (Source: Grzebeita et al 2015d)

These tests are insufficient to predict the outcome in all incident configurations, but they do indicate that the MATD was provided with a survival space which would assist in limiting injuries. Grzebeita et al (2015d) describe the survival space as *"the space left between the upturned Quad bike and the ground from which a rider can crawl"*. These tests do not provide guidance on the effect of speeds both longitudinal and laterally. This should not diminish the value of these tests even though submissions to the Consultation RIS have suggested otherwise.

Neglecting the issues with the simulation studies outlined in Section 11.3, the FCAI in its submission to the Consultation RIS stated;

> *"For each of the rollover crash types, the simulations were run with and without the Quadbar OPD. In some cases, the Quadbar was found to increase injuries, in some cases the Quadbar was found to reduce injuries, and in some cases the Quadbar had no effect"*
>
> …
>
> *"With respect to asphyxiation, the Quadbar caused as many asphyxiations as it prevented. The reason for this may be that the Quadbar greatly increases the tendency of the ATV to come to rest on its side, rather than upside down."*

and

> *"A system that protects and does not harm in one particular test condition at one particular speed may be harmful in other test conditions or at other speeds. "*

It has been acknowledged above that these tests cannot cover all contingencies and that these tests do not reflect all field incidents as there are multiple factors affecting the outcome.

There has been discussion in the submissions to the Consultation RIS that a CPD would restrict a rider from separating from the quad bike in the event of a rollover. Grzebeita (2015d) provides illustrations from Van Ee and others in which a rider is observed having the quadbike roll over him without injury. It is expected that if a rollover is anticipated, then the rider might be more prepared and be able to separate from the quad bike before it eventually rolls over. This is a different situation to one in which the rider was not prepared, or competent to separate from the quad bike.

The FCAI has referred to the research by Van Ee et al (2014) in its submission to the Consultation RIS. Van Ee (2014) reviewed 129 Quad bike rollover incidents from YouTube. A summary of their results in the abstract of the paper is:

> *"One hundred twenty-nine ATV rollover events were coded, with side rolls representing 47%, rear 44%, and forward rolls 9%. The speed at onset of roll was relatively low, with 86% of the rolls occurring at speeds of 10 mph or less and 53% occurring at less than 3 mph. No injury was identified for 79% of the events; 16% resulted in injury due to ATV contact and 5% resulted in injury unrelated to ATV contact. Active dismount of the ATV was a commonly employed strategy, with 63% of the riders attempting active dismount, resulting in successful separation from the ATV in 72% of the attempts. The overall injury rate for riders attempting active dismount was 15% and the injury rate for riders not attempting active dismount was 32%. This*

> *investigation confirmed the importance of active rider movements, including active dismount and subsequent separation in determining the outcome of ATV roll events."*

The authors describe a few cases *"identified in the video database that did not result in rider injury but may result in unintended consequences if a CPD is implemented"*

The use of YouTube video cannot be considered to be representative. The rollover may have been anticipated for the video to be recorded and the riders may be more likely to be involved in recreational activities.

11.7 Strength and deformation tests for CPDs

The Consultation RIS provides energy absorption measures for CPDs and ROPS based on the mass of the vehicle. It stated:

> *"All general-use model quad bikes sold in Australia shall have a device that ensures, in the event of a rollover, the impact on the operator is minimised and the device is able to absorb the energy of 1.75 times the mass of the vehicle (CPD Absorbed Energy = 1.75 x vehicle mass)."*

The Silsoe Research Institute (2006) in a report the UK Health and Safety Executive stated:

> *"Whilst application of the currently-accepted lateral roll-over ROPS performance test criteria (ROPS-Absorbed Energy = 1.75 x vehicle mass) may result in a 15 – 17% energy over- estimate for the lowest mass vehicles considered (~ 300 kg), this criteria appears to become progressively more appropriate as vehicle mass increases towards 600 kg. In conclusion, there is insufficient evidence to recommend the application of an alternative energy – mass relationship, even at the lower end of the vehicle mass range considered by this investigation and, on balance, significantly more evidence exists to support the application of the currently- accepted relationship for larger vehicles to off-road vehicles in the 300 – 600 kg mass range. Appropriately-engineered 'conventional' ROPS solutions would therefore appear to be suitable for application to these smaller vehicles, where a roll-over risk is deemed to exist."*

The wording in the Consultation RIS does not specify direction although it can be assumed to be a lateral loading energy absorption requirement. The vertical and longitudinal load requirements should also be specified.

The vehicle manufacturing and distribution industry believe that CPDs are not warranted and have not provided comment on a strength requirement. This is not to say that the strength requirements will not be raised by manufacturers and others in the future.

CPDs need to be tested for a range of conditions including vertical load, longitudinal energy absorption and lateral energy absorption. The Consultation RIS considers lateral energy. Corresponding longitudinal energy absorption requirement would be the energy in Joules is equal 1.4 times the vehicle mass in kg [56]. This is consistent with the

[56] The Consultation RIS reports in a footnote that this formulation has been adopted from ISO3471, AS1636.2 2294, SAE J1040.

statements made by Mr Robertson from Quadbar™, in his submission to the Consultation RIS.

The energy absorption requirement is important as the energy removed from the system decreases the movement and roll of the quad bike. However, the energy has to be absorbed without unduly large displacements. If the CPD remains elastic, any energy consumed in deforming the device will be returned as the device is unloaded. Thus the CPD needs to deform to absorb a significant amount of energy

Given that the CPD is designed to deform, then it is important that the deformation is limited and it may be the case that the deformation in one test does not allow the device to be used in another test. A minimum survival space or volume needs to be specified [57]. The proposal in the Consultation RIS is silent on the acceptable deformation and appears to treat the CPDs as rigid structures.

The New Zealand guidelines [58] for ROPS include lateral force and energy absorption, vertical force and longitudinal force and energy absorption. The value of energy absorption cannot be unstated, although it does require the ROPS to deflect. The specified deflection limiting volume (DLV) essentially specifies the maximum deflection. This DLV must not be violated. For quad bikes the DLV translates to providing a survival space.

Along with these loading and deformation requirements, CPDs should also have minimum dimensions to prevent the operator becoming entangled.

An important aspect of the OPD is to provide a survival space for the quad bike rider to crawl out from under a quad bike on its side or up-side-down. Honda in its submission to ACCC about the Consultation RIS stated:

> *Whilst OPDs increase survival space and it is expected to provide a benefit by decreasing suffocation of riders, new risk cases such as being pinned between OPD and the ground surface are also assumed.*
>
> *In the evaluation from DRI based upon ISO 13232 which comprehensively evaluated the Quadbar, it was reported that the benefits and risks are likely to be equivalent to each other.*

Honda's view is based on the simulations by DRI (Zellner et al, 2016) and ISO 13232 [59].

The proposed details of a standard have not clearly specified the minimum dimensions or the survival space.

There needs to be more testing and development of a standard for it to be suitable for design. It should be based on the requirements presented in the ANSI/ROHVA 1-2016, the ANSI/OPEI B71.9-2016 standards and the New Zealand guidelines.

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57 A personal communication from Mr Macmillan about a paper he has in preparation which discusses this point.

58 New Zealand Guidelines for the Design, Construction and Installation of Rollover Protective Structures (ROPS) for All Terrain Vehicles

59 ISO 2005, Motorcycles – Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles, ISO 13232:2005, ISO (International Organization for Standardization), Geneva Switzerland. The standard is presented in 8 parts

Mr Robertson's submission indicated that the ISO 5700:2013 [60] was used in the design of Quadbar™ and provides another useful starting point.

11.8 A standard for OPDs

The Consultation RIS provides a description of the minimum OPD design considerations. It states that an OPD should be:

- *"consistent with the specifications and intended use of the vehicle and have a minimal impact on the vehicle's stability (low weight and low centre of gravity)*
- *rigorously tested by manufacturers*
- *effective in protecting the rider in rear and side overturns, as well as front and rear overturns*
- *a safe distance away from the rider to minimise impact with the rider in the event of an overturn, or alternatively not protrude from the vehicle during normal operation.*

Additionally, OPDs should not:

- *affect driver visibility*
- *catch overhead branches*
- *restrict access and egress from quad bikes*
- *be able to be crushed during incidents and must therefore be able to withstand the weight of the vehicle.*

A minimum OPD design standard could require:

- *the device to provide a high enough clearance to enable a survival space in the upside- down position*
- *the device to provide a high enough clearance to provide a 'crawl out' space in the upside-down position*
- *that any forces on the operator from the mass of the upturned vehicle are minimised*
- *the chance of the operator being pinned or speared by the vehicle to be minimised."*

While these statements provide the intention for the design, a device cannot guarantee these requirements and the sensible interpretation of the ACCC statements is required.

The details of an appropriate standard for testing CPDs require further development. The basis of a standard discussed in Section 12.4 conforms with similar requirements for small vehicles developed by Silsoe Research Institute (2006), ISO 7500:2013.

[60] ISO 5700:2013(en) Tractors for agriculture and forestry- Rollover protective structures – Static test methods and acceptance

It is recommended that the proposed energy absorption requirements for lateral loadings as outlined in the Consultation RIS be used in the first instance. Although there is a need for clearer definitions of the minimum vertical and longitudinal loads.

It is recommended that the requirements of the survival space need to be developed through vehicle manufacturers and distributors' participation. It should be based on the requirements presented in the ANSI/ROHVA 1-2016, the ANSI/OPEI B71.9-2016 standards and the New Zealand guidelines [61] when describing the performance of ROPS.

12. Fitting of open differentials

12.1 Description of the requirement

Options 4 and 5 of the Consultation RIS require that the quad bike be fitted with an open differential, which allows the rear wheels to rotate independently of each other. The requirement states:

> *"General-use model quad bikes shall be constructed such that each of the wheels can rotate at different speeds at all times, in order to allow safe cornering on hard-surfaces. If a vehicle is equipped with a lockable differential, it must be designed to be normally unlocked.*
>
> *The differential lock selection device shall be "self-explaining", in that the rider shall be able to readily determine if the switch is in the "locked" or "open" position.*
>
> *Sport and Youth quad bikes are not subject to this requirement."*

12.2 Issues with the open differential requirement

The TARS team also installed a lockable differential to a prototype quad bike which had a higher static stability factor, and a higher lateral acceleration in a constant radius test on an asphalt surface. Grzebeita et al (2015a) described the performance of the prototype quad bike and stated:

> *"…the prototype has a widened track width to make the vehicle considerably more stable, an open (lockable) rear differential to allow more responsive and simpler steering on firm terrain, and an understeer characteristic to allow a more intuitive rider response to steering demand in most circumstances."*

They did not however supply details of the effect of locking the differential on the prototype quad bike.

Grzebeita et al (2015c) recorded differences in the understeer and oversteer characteristics of an SSV when tested with a constant radius test on an asphalt surface. They found that the particular SSV understeered when the differential was unlocked and showed a slight oversteer characteristic when the differential was locked. Figure 28 shows plots of the steering angle against lateral acceleration for this case. The SSV with

[61] New Zealand Guidelines for the Design, Construction and Installation of Rollover Protective Structures (ROPS) for All Terrain Vehicles

the locked differential had a larger steering angle at low lateral accelerations than when it was unlocked. A user would find that the vehicle was not as "responsive" when the differential was locked, as the rider will have to turn sharper to negotiate the corner than on a quad bike with an open differential. SEA limited (2018) had also found a similar result for quad bikes when tested on asphalt and groomed dirt surfaces.

Polaris, CF Moto and Linhai have a switchable differential on one or more of their models. Polaris in its submission to the Consultation RIS stated:

> *"Polaris understands how potentially dangerous operating in this unlocked differential configuration is and specifically warns about using it on anything except smooth level surfaces in its ATV manuals.*
>
> *Polaris calls this "open differential" configuration "TURF" mode" because it is designed to allow the wheels turn independently on smooth turf surfaces without damaging the turf. It is there to protect the surface from tyre damage."*

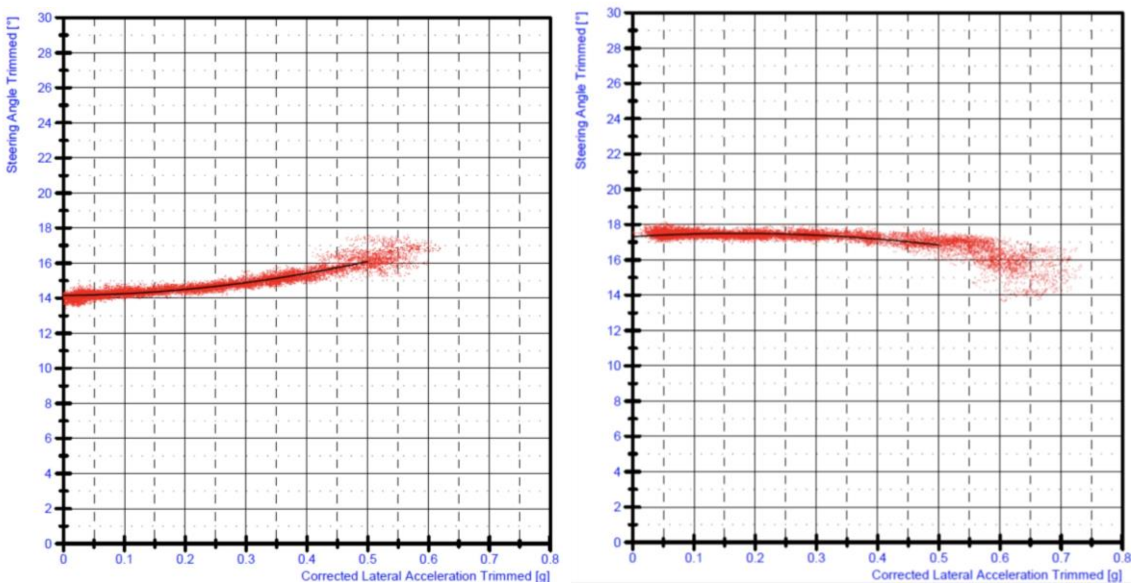

Figure 28. Effect of a locked differential on an SSV. The plot on the left is for a vehicle with a unlocked differential (Source: Grzebeita et al 2015c)

Manufacturers and distributors comments to the Consultation RIS were that users may be unaware of the differential status, particularly after they had stopped and started the vehicle a short time later. It is acknowledged that there is a consensus that a locked differential is essential when the vehicle is running over slippery or rough terrain.

The Consultation RIS indicated that the differential would be *"normally unlocked"* and that it would be needed to be locked for the slippery or rough terrain.

12.3 Safety considerations with the use of an open differential

Some vehicle manufacturers and distributors are against this requirement for an open (unlocked) differential on the basis that it also allows one wheel to slip and for the traction to be lost if the terrain is slippery or rough. When one wheel loses traction, the vehicle will slow. If it suddenly regains traction the vehicle will jerk forward. This action may dislodge the rider.

It is essential that the handling characteristics of quad bikes and SSVs be as predictable as possible. Polaris in its submission to the Consultation RIS stated:

> *"Polaris engineers conduct substantial off-road testing on each and every model to ensure that the transitions from one handling characteristic to another (such as from oversteer to neutral-steer, to understeer or vice versa) are smooth and predictable for the rider. This testing, for example, demonstrates to Polaris engineers that open (unlocked) differentials produce different steering characteristics as the rider's aggressiveness increases and moves toward the limit of grip."*

Polaris indicates that the issue of a locked differential is more problematic when a "*rider's aggressiveness increases and moves toward the limit of grip"*. At this point, any significant impulse into the vehicle will be destabilising. This is a potential safety issue.

The FCAI in its submission to the Consultation RIS provided a similar response and stated:

> *"ATVs with an open differential, or a lockable differential that is inadvertently left open, will have greatly reduced traction, and therefore mobility, on loose surfaces or bumpy terrain. This can be a safety issue when an ATV climbing a hill loses traction on one side due to loose soil or a ground depression. This can result in yawing of the ATV and loss of control."*

For slippery and rough terrain, the consensus is that a locked differential is the preferred option and the safer option if it minimises the effect of one wheel losing traction.

Predictability is enhanced if the quad bike behaves in a similar way each time it is used. Quad bikes that are more predictable should generally be safer. The point raised by Polaris is that the quad bike becomes more unpredictable if the differential operates in the open configuration on start up.

It could be claimed that a safety benefit of an open differential is that the Quad bike is more likely to understeer. As has been pointed out in Section 7.2, understeering or oversteering characteristics are not an issue so long as the extent of the oversteering and understeering is limited. It is therefore not substantiated that an open differential is required on these grounds.

A second point could be that riders who do not use "active riding" would be better suited to a quad bike with an open differential. TARS (2017) demonstrates that the crash rate reduces with increased with experience. It states:

> *"The results show that the least experienced riders (those with less than one year experience) have the highest crash rate (almost four and a half crashes every ten years of Quad bike riding or nearly one crash every two years riding). The more experience the riders have, the less frequently crashes*

> *occur, with riders that have more than 20 years' experience only crashing 0.22 times for every 10 years of Quad bike riding or once every five years."*

TARS continue and state that:

> *"The importance of this finding is that it clearly shows that a large number of riders will eventually have a crash (and within 2 years as a novice). Less experienced riders should be closely supervised in their first few years of Quad bike riding, as they are far more likely to experience a crash event."*

There is no indication whether the open differential would significantly reduce the crash rate as the open differential would only assist on smooth hard ground which is not typical of rural properties. A portion of Table G2 of TARS (2017) is reproduced here in Table 13.

Table 13. Crash characteristics by surface type (Source: Individual Workplace Riders Survey, TARS 2017)

Surface condition	Total all Crashes (no injury + injury)		All Injury Crashes		Serious Injury Crashes (hospital)	
	Number	Per cent	Number	Per cent	Number	Per cent
Loose Material	79	5.5	16	5.6	3	4.0
Mud	138	9.7	20	7.0	5	6.7
Paddock (grass)	1,023	71.5	194	67.8	48	64.0
Sand	19	1.3	4	1.4	1	1.3
Sealed Road	31	2.2	12	4.2	5	6.7
Unsealed Road	134	9.4	38	13.3	12	16.0
Unknown	6	0.4	2	0.7	1	1.3
Total	1430	100.0	286	100.0	75	100.0

This Table indicates that only 2.2 per cent of crashes occurred on sealed roads and 9.4 per cent on an unsealed road. However, these road surfaces are over represented in injury crashes with 17.5 per cent of all injury crashes and 22.7 per cent of all serious injuries occurring on these roads. Consequently, these TARS data indicated that riders are more likely to sustain serious injuries on hard surfaces. The TARS (2017) report uses the adjusted odds ratio to indicate the possibility of injury in different situations. The adjusted odds ratio are 1.56 for hard unsealed roads and 4.25 for sealed roads with the 95 percentile confidence limit for hard surfaces being 1.45 to 12.49 (that is above 1.0).

The safety benefits accrued on hard firm surfaces would be a maximum of 6.7 per cent if all sealed road crashes and injuries were eliminated from the use of an open differential. The potential risk of harm associated with using an open differential on unsuitable surfaces is not known, but at least 75 per cent of serious injuries occurred on surfaces where an open differential is unlikely to be useful.

In conclusion, there is no clear evidence that the requirement to install a lockable differential would reduce the crash rate significantly.

12.4 Recommendations for installing a switchable open differential

An open (or unlocked) differential does allow for the vehicle to ridden over hard surfaces without the need for "active riding". As stated above, the consensus is that a locked differential is better for slippery or rough terrain. A differential that can be locked or unlocked provides this option.

The Consultation RIS proposes a differential that is unlocked when the vehicle is started and then can be locked.

Submissions to the Consultation RIS have argued that this would be confusing to riders who may not be aware of the differential status if they had stopped for a short time. It was considered that this confusion could be eliminated if the differential remained in the same condition as it was when last used.

If a lockable differential is provided on a quad bike, it would be beneficial for riders who were able to choose the correct differential setting for the terrain. Drivers are able to select the appropriate time to engage four wheel drive on other vehicle types to suit different terrains. It is assumed that a switchable differential will not appreciably change the position of the quad bike's centre of gravity and have an effect on stability.

In section 12.3, it was noted that riders, who cannot actively ride, may benefit if the quad bike had an open differential, although there is no information available that it would improve safety.

Based on the assumption that some riders may use the unlocked differential on unsuitable surfaces, the potential risk of harm is likely to outweigh the benefits of using an unlocked differential on hard surfaces. If all riders used the appropriate differential setting for the ground surfaces then there is more likely to be a net benefit with a lockable differential. Consequentially, it is **not** recommended that it be a requirement to fit a differential that can be locked or unlocked.

13. Rollover warning placard

13.1 The proposed requirement

Options 2 to 5 in the Consultation RIS requires an additional warning on quad bikes alerting the rider to the risk of rollover. Industry has generally agreed that an additional warning label would be an acceptable requirement. This is a low-cost item, which reinforces the concerns and trauma described earlier. The suggested wording in the Consultation RIS is shown in Figure 29.

! WARNING !

HIGH RISK OF ROLLOVER DEATH AND INJURY EVEN ON FLAT TERRAIN

AVOID STEEP INCLINES

AVOID RIDING ACROSS SLOPES

PLAN YOUR RIDE

Figure 29. Proposed safety warning (Source: Consultation RIS)

13.2 Concerns with the rollover warning placard

Some respondents to the consultation RIS question whether the additional warning labels would be effective.

The FCAI in its submission to the Consultation RIS stated:

> *"It is unknown what effect an additional rollover warning label would have on safety. If it was to be applied, it would at least need to be coherent with the existing label requirements of the ANSI/SVIA standard so as not to confuse the rider and have appropriate place to locate it on the vehicle so as not to hide other warning labels."*

Honda in its submission to the Consultation RIS stated:

> *"Nevertheless Honda accepts that there is possible benefit in applying a specific warning label about the risk of rollovers and adding the information to the owner's manual."*

Polaris in its submission to the Consultation RIS stated:

> *"Polaris would not be averse to including a "risk of rollover" label, contingent on the content of such a label."*

13.3 Recommendation

While the safety benefit of having an additional warning label is unclear, the cost of doing so is minimal.

Given that rollovers have a greater proportion of fatalities and that there is a clear objective to mitigate the risk of rollover, it is recommended that a rollover warning placard be required.

14. Review of the options and recommendations

14.1 General comments

The safety issues with quad bikes and SSVs when used on rural properties have been documented in Section 2 of this report and in Mitchell (2013), McIntosh and Patton (2013; 2014), Grzebeita et al (2015a), Grzebeita et al (2015f). These statistics have not been disputed other than with anecdotal evidence. Further the primary safety concern is lateral roll over and the ability of the vehicle to resist rollover. This has been a primary focus of Workplace Health and Safety Authorities, some user groups and the ACCC.

Quad bikes require riders to use skills involving "active riding" where the rider uses his or her weight to assist when riding on slopes and around corners (see Section 7.4). It is the need for riders to use this driving style that puts riders at risk who do not or cannot ride "actively". There are a wide range in riders' skills that will affect the ability of riders to control quad bikes. SSVs do not require the same "active riding" ability.

It is recommended that quad bikes be designed to allow for riders who have a limited skill range given that the rider is cognisant of their own abilities. This will require the vehicles to be as predictable as possible.

Given that lateral rollover leads have a high risk of fatalities, it is important that considerable effort is made to reduce the propensity for quad bikes and side-by-side vehicles to rollover and if they do rollover to reduce the harm to the riders. As reported in Section 1, there were 13 fatalities with SSVs over the 2011-17 period that resulted in the SSV rolling over and when occupants were not wearing seatbelts.

14.2 Transition periods

The Consultation RIS provided an example of transition periods for illustrative purposes. These were:

Phase 1 (6 months):	Quad bikes required to meet the US Standard; and
	Quad bikes required to display any additional warnings or instructions.
Phase 2 (12 months):	Vehicles are required to be tested to certain criteria in accordance with a safety star rating system;
	Vehicles required to display the awarded safety star rating at the point of sale.
Phase 3 (24 months)	General-use quad bikes must meet specific design requirements.

The manufacturers and distributors of quad bikes have responded that the transition periods are too short. Honda, in its submission to the Consultation RIS, indicated that any design changes or the development of a new model would take longer than the 24 months specified in the Consultation RIS.

The illustrative transition periods in the Consultation RIS indicate a logical order of requirements. In the first phase, there is almost no impact on the vehicle manufacturing and distribution industry as most quad bikes comply with the current US standard or appropriate European standard.

The second phase requires current vehicles to be tested; the manufacturers are not required to change any characteristics of their vehicles. Poorer performing quad bikes will have a lower star rating.

It the third phase, quad bikes might need to be redesigned, depending on the particular minimum requirements, it will take the longest time to implement.

The precise transition periods should be based on times indicated in the Consultation RIS unless the manufacturers can collectively indicate that this is unworkable.

15. Critical review of the requirements for Option 2

The Requirements for Option 2 are stated in the Consultation RIS as:

> ***"Option 2****: make a mandatory safety standard in relation to quad bikes and SSVs that:*
>
> - *adopts the ANSI/SVIA 1–2017 US Standard for quad bikes*
> - *requires post manufacture testing for quad bikes and SSVs in accordance with the requirements of a safety star rating system and the disclosure of the star rating at the point of sale*
> - *requires an additional warning on quad bikes alerting the operator to the risk of rollover"*

15.1 Adoption of the ANSI/SVIA 1-2017

Section 4 lists the major parts of the ANSI-SVIA 1-2017 standard. Vehicle stability is evaluated through rearward pitch stability and this alone does not address the issues of lateral stability and forward pitch stability. Current quad bikes comply with the US ANSI-SVIA 1-2017 standard and the adoption of this standard alone will not improve the safety of these vehicles. Roy Deppa, in his submission to the Consultation RIS stated:

> *"While I agree with the ACCC view that adopting the ANSI standard is a good idea, I cannot help but point out the obvious: it will have no or very little effect on the safety issues associated with Quad Bikes."*

A more extensive standard is required to improve the lateral stability of quad bikes. This will be discussed as part of Option 4.

It is recommended that quad bikes be required to comply with the US Standard ANSI/SVIA 1–2017 or an equivalent European standard. However, it is recommended that the rearward pitch stability be measured with a tilt table and not using the method outlined in ANSI/SVIA 1–2017 and discussed in Section 4.1.

15.2 Star rating system proposed in the Consultation RIS

The TARS safety star rating criteria are listed in Appendix A of the Consultation RIS and include:

- Static stability evaluation on a tilt table for lateral roll, forward pitch, rearward pitch and in a number of different load configurations.
- Dynamic handling evaluation using understeer and oversteer characteristics, lateral transient response times, and the bump obstacle perturbation tests.
- Rollover crashworthiness evaluated using quad bike ground contact load tests, SSV occupant retention system tests, quad bike and SSV rollover tests and SSV ROPS load strength assessment

The comments in this section are based on the view that one star rating system should be for quad bikes and another star rating system for SSVs. This is supported by comments from manufacturers and distributors.

The evaluation of Quad bikes and SSVs using a star system should be based on the same principles. Some tests would be the same or very similar for the two vehicle types though the limiting values for the points rating could vary.

The star rating system proposed in the Consultation RIS consists of the elements listed in Section 5. There are 15 tilt table tests to establish static stability. The dynamic handling requires multiple runs in both directions for dynamic lateral stability, steady state turning for understeer-oversteer characteristics, steering response times and for the bump obstacle response.

The evaluation of Quad bikes and SSVs for rollover crashworthiness are different. Quad bikes are evaluated through ground contact load tests and full-scale rollover tests in three directions (lateral roll, rearward pitch and forward pitch) and without a CPD and with a ATV Lifeguard ® OPD or a Quadbar™ OPD; giving 9 rollover tests. SSVs are evaluated with occupant retention systems testing, rollover tests in three directions (lateral roll, rearward pitch and forward pitch) and a ROPS load strength assessment.

The TARS team recommended additional points are allocated for attributes like a lockable differential with a default position of being unlocked on vehicle start-up and for seatbelt interlocks. Grzebeita (2015a) provides the following details for allocating a star rating. They stated:

> *"The Star Rating is based on five equal divisions of the 85 points:*
>
> | | |
> |---|---|
> | *One STAR* | *= ≤ 17pts;* |
> | *Two STARS* | *= 18 to 34pts* |
> | *Three STARS* | *= 35 to 51pts* |
> | *Four STARS* | *= 52 to 68 pts* |
> | *Five STARS* | *= 60 to 85pts"* |

Refer to Grzebeita (2015a) for more details.

The amount of testing is significant and a simpler system is preferred in the first instance. The author of this report considers that the construct of the star rating system, as it is proposed in the Consultation RIS and in Grzebeita at el (2015a) is complicated and the important measures may not be clearly identified from the resulting star rating. It is not clear that high values from the star ratings necessarily provide the optimum vehicle configuration. At present, all general-use quad bikes have about the same star rating with points ranging from 28 to 32. The rating points for all sports and youth quads are between 37 and 41, although the star ratings may differ. See Figure 30, which is based on values presented in Grzebeita et al (2015a). The points allocated to each aspect are very similar. It is difficult to use the points scheme to discriminate between different general-use quad bikes when they have the same star rating at present. In the future, quad bike improvements should give a broader star rating range.

The rating points for SSVs are in a broader range from 49 to 64 points. This gives 3 and 4-star ratings. Refer to Figure 31.

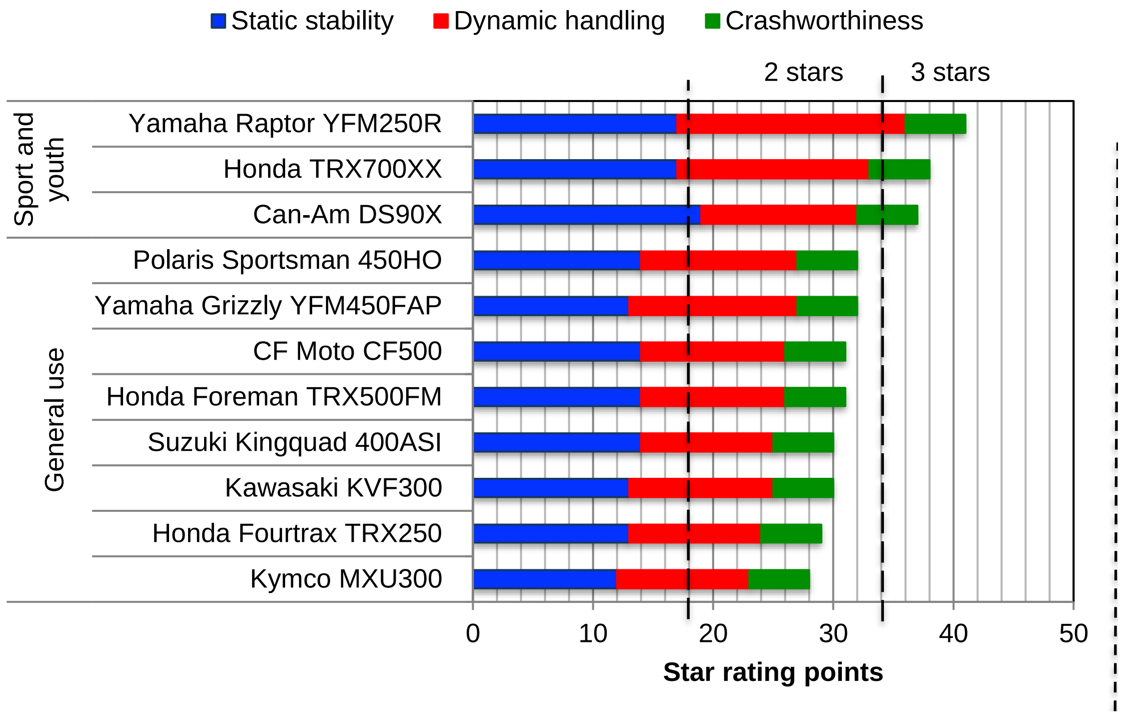

Figure 30. Star rating points for quad bikes

Figure 31 Star rating points for SSVs

15.3 Static stability requirements in the star rating system

The requirements here are based on the discussion presented in Section 6, and in particular Section 6.7.

Section 6.6 has discussed the effect of lateral stability on vehicle safety. It was concluded that the available data was unable to show a statistically significant relationship, but the data from Scheer et al (1991) does show a trend of reducing crash rates as the lateral stability increased. It is argued that making the vehicles more stable will reduce the vehicle's propensity to rollover. The general crash statistics, in Section 2, show that lateral rollover has a significant risk of fatalities. The potential for lateral rollover is reduced with more stable vehicles. Consequently, actions to improve lateral stability should be supported even if the data do not show statistically significant trends at this time.

For static stability, it is recommended that two measures be used. The first being the lateral roll measured by the minimum tilt table ratio (TTR values) for tests with the vehicle facing to the left and to right across the tilt table. The second is the minimum TTR for a forward and rearward pitch tilt test. In each case the vehicle has only the 50th PAM ATD rider or driver attached; that is additional loads are not added to the quad bike for this testing.

The US Standards ANSI/ROHVA 1-2016 and ANSI/OPEI B71.9-2016 both require an SSV to be evaluated on a tilt table for stability in all four directions and with a driver plus passenger and loaded to the gross vehicle weight rating (GVWR). These data for compliance testing for these standards should form part of the star rating system for SSVs.

15.4 Dynamic handling and steering characteristics in the star rating system

The requirements here are based on the discussion presented in Section 7, and in particular Section 7.7.

The Consultation RIS proposed using understeer and oversteer characteristics to evaluate dynamic stability. A number of submissions have indicated that it does not matter whether the vehicle understeers or oversteers, so long as the vehicle is predictable and the extent of the oversteering or oversteering is not excessive. This is discussed in Section 7.6.

The author is not able to provide a rational test for predictable dynamic handling at this stage and recommends that the vehicle manufacturing and distribution industry assist in finding a suitable measure.

It is recommended that the dynamic handling assessment need not include a dynamic limit on lateral acceleration at which the vehicle tips onto two wheels, as the performance can be predicted from static stability measurements with some confidence (see Section 7.7). It is also recommended that the lateral transient response, not be included in the appraisal or dynamic handling as it is dependent on the ground-tyre interaction characteristics, which are variable and unpredictable (see Section 8.5).

15.5 The bump test in the star rating system

The requirements here are based on the discussion presented in Section 9, and in particular Section 9.6. The bump test evaluates a vehicle's response to a vertical impulse.

A relationship between safety and the measure from the bump has not been possible to derive. In section 9.4 it is concluded that, regardless of an indication of potential injury reduction, it is reasonable to expect that a reduction in the effect of riding over a bump will affect dynamic stability and reduce the rollover rate. A vehicle's response to a vertical impulse has been examined by Macmillan and discussed in Section 6 as being a major contributor to vehicle rollovers. Limiting the propensity of vehicles to rollover will reduce the significant trauma associated with incident type

Consequently, it is recommended that the response of the vehicle to a single 150 mm bump test with an impact speed of 25 km/h be used as part of the star rating system. The bump test should be applied to both quad bikes and SSVs.

15.6 Requirement for a rollover warning placard

Section 13 discusses the use of an additional warning placard be a required. It is noted and recommended that the additional warning placard be a requirement. The safety benefit of having an additional warning label is unclear, the cost of doing so is minimal.

Given that rollovers have a greater proportion of fatalities and that there is a clear objective to mitigate the risk of rollover, it is recommended that a rollover warning placard be required.

15.7 Star information provided to the consumer

As a final point, if the star rating system is based on four major elements with the static stability subdivided into lateral and longitudinal, it may be possible to include on the same rating tag (perhaps in smaller lettering) the rating for each element. This would give greater transparency to the approach. The four measures are: lateral stability, longitudinal stability, dynamic handling predictability and bump response test. The minimum recorded tilt angle and the average vertical acceleration from the bump test and (when developed) a test to demonstrate predictability steering and handling performance could be provided rather than indicating the number of stars based on the range that includes the value. It is recommended that this concept of displaying the underlying attributes to the star rating be investigated.

Until there is a broader range of performances from vehicles of one type, the star rating system will not provide consumers with any reasonable measure to discriminate between the vehicles of a particular type. A more descriptive approach using recorded values is likely to more informative.

Figure 32 shows a hang tag from a letter from the US Consumer Product Safety Commission to the Recreational Off-Highway Vehicle Association [62]. This hang tag describes the measure and its acceptability. This approach to describing the key attributes of a star rating system is recommended.

15.8 Future development of the star rating system

The further development of the star rating system will be enhanced if improved data can be collected to provide a clearer understanding of a causal link between the performance measures and increased safety outcomes for users. This is a difficult task and may take some time to amass the data to provide statistically significant results.

[62] Letter is included as Appendix 1 in Grzebeita et al (2015d)

Evaluating the relative weights of the components of a star system will always be a point of disagreement. The TARS team used an expected exposure to different conditions to weigh the different factors. It will be difficult to derive a set of weightings for field data and an agreed set of factors needs input from a range of sources.

A star rating system allows manufacturers to demonstrate improved performance attributes. The star rating system is an indicator of performance, although a single star rating may not provide the consumer with sufficient information to guide their purchase. Some purchasers may prefer some attributes over others and the single star rating indicator may not provide this detail. A standard on the other hand sets minimum standards, which may at times be less than preferred performance attributes.

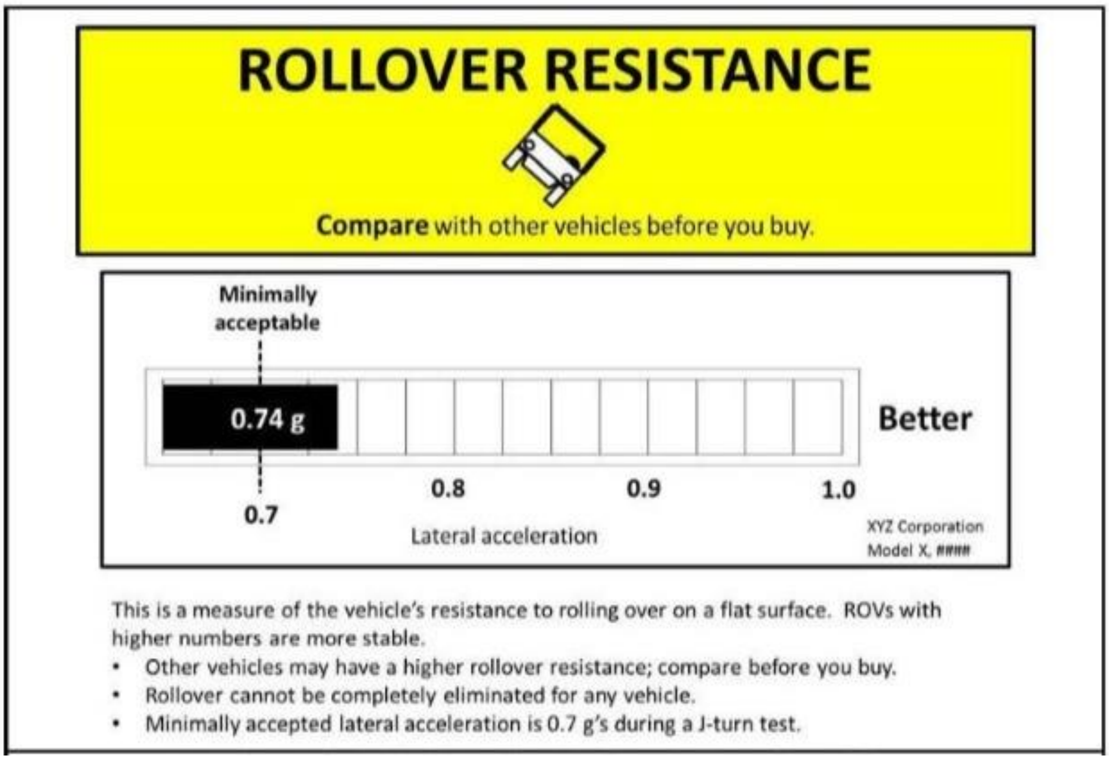

Figure 32. CPSC recommended hang tag for SSV type vehicles

16 Critical review of the requirements for Option 3

The Requirements for Option 3 are stated in the Consultation RIS as:

> ***Option 3****: make a mandatory safety standard that satisfies all of the requirements of option 2, and in addition requires general-use model quad bikes to be fitted with an operator protection device (OPD).*

Section 11 broadly discusses the benefits and issues of having an OPD installed on a quad bike.

16.1 Safety benefits of fitting CPD to quad bikes.

Section 11.2 outlines a study of injury statistics from Queensland hospitals, a quad bike tour company case study, a fleet managers survey and the individual workplace riders survey. These investigations and surveys have been consistent in showing that the use of CPDs is beneficial. However due to small sample sizes, the results are not statistically significant. Whilst these surveys have limitations, taken together the benefits outweigh the harm from the fitting of CPDs. This is not to say that injuries will be eliminated with the use of effective CPDs. One of the reviewers of the research by TARS stated [63]:

> *In conclusion, the studies main key findings that OPDs [CPDs] on balance appear to be effective in reducing serious chest injuries as well as rollover related serious injuries, plus that helmets are effective in reducing injuries, are supported by the study data."*

The author of this report considers that this statement is accurate and reasonable.

The use of simulations to further explore the safety outcomes of CPDs has been extensive, but, in the opinion of the author, fails to fully document the necessary validation process that would give a reader confidence that the simulation results available at this time, can reflect the potential benefits or harm and provide reasonably accurate predictions of the crash outcomes.

It is recommended that, in accordance with Option 3, tested and effective CPDs be required to be integrated into the design of general-use quad bikes.

16.2 A standard for CPDs

Section 11.8 lists the minimum CPD design considerations in the Consultation RIS. This section also discusses the broad structural requirements.

It is recommended that the proposed energy absorption requirements as outlined in the Consultation RIS be used for lateral loadings in the first instance. There is a need for clearer definitions of the minimum vertical and longitudinal load requirements. One solution is to have the corresponding longitudinal energy absorption requirement that the energy in Joules equal 1.4 times the vehicle mass in kg. This is consistent with the statements made by Mr Robertson from Quadbar, in his submission to the Consultation RIS.

It is recommended that the requirements of the survival space need to be developed through vehicle manufacturing and distribution industry participation. It should be based on the requirements presented in the ANSI/ROHVA 1-2016, the ANSI/OPEI B71.9-2016 standards and the New Zealand guidelines [64] when describing the performance of ROPS.

It is recommended that the requirements of the survival space need to be developed through vehicle manufacturing and distribution industry participation.

[63] See TARS (2017)

[64] New Zealand Guidelines for the Design, Construction and Installation of Rollover Protective Structures (ROPS) for All Terrain Vehicles

17. Critical review of the requirements for Option 4

The Requirements for Option 4 are stated in the Consultation RIS as:

> ***"Option 4**: make a mandatory safety standard that satisfies all the requirements of option 2, and in addition requires general-use model quad bikes to meet minimum performance tests for mechanical suspension, stability and dynamic handling. It also requires that all wheels be able to rotate at different speeds."*

17.1 ACCC proposed testing requirements

The ACCC has provided details of the required testing as follows:

> ***"Minimum Stability Test Requirements***
>
> *Stability of general-use model quad bikes is measured using a tilt table using a 50th Percentile Adult Male (PAM) Hybrid III (H3) Anthropomorphic Test Dummy (ATD) as a simulated rider positioned in a standardised seating position, as described in Annex E Stability Test Procedure. The coefficient of stability for each direction (forward or rearward pitch, and lateral roll) is calculated as Tan (Tilt Table Angle at two wheel lift).*
>
> *The measured Tilt Table Ratios (TTR) for stability in Forward (TTRpf) and Rearward (TTRpr) pitch and in Lateral Roll (TTRst) shall comply with the minimum requirements identified below:*
>
> - *Rearward Longitudinal stability (rearward pitch): The Tilt Table Ratio for rearward pitch (TTRpr) measured with a 50 PAM H3 ATD shall be equal to or greater than 1.0.*
> - *Forward Longitudinal stability (forward pitch): The Tilt Table Ratio (TTR) for forward pitch (TTRpf) measured with a 50 PAM H3 ATD shall be equal to or greater than 1.10*
> - *Lateral Stability (lateral roll): The Tilt Table Ratio (TTR) for Lateral Roll stability (TTRst) measured with a 50 PAM H3 ATD shall be equal to or greater than 0.80*
> - *For Sport and Youth quad bikes, the stability requirements stipulated in US ANSI/SVIA 1–2017 Section 9, Pitch Stability shall apply.*
>
> ***Minimum Mechanical Suspension Test Requirements***
>
> *General-use model quad bikes shall be fitted with a mechanical suspension system suitable for the machine to perform its intended function of driving in a variety of terrain types and provide appropriate bump attenuation for the rider and passenger.*
>
> *The minimum wheel articulation shall be 150 mm for all wheels. This articulation is to be centred about (approximately half available for compression and half for rebound) the suspension position when the articulation is measured with a 50th PAM H3 ATD seated on the saddle in a normal riding position.*

> *General-use model quad bikes shall achieve a bump response of less than 2.0g when tested in accordance with the Bump Response Test Procedure in Attachment D*
>
> *Springing and damping properties shall be provided by components other than the tyres.*
>
> *For Sport and Youth quad bikes, the mechanical suspension requirements stipulated in US ANSI/SVIA 1–2017 Section 4.3 shall apply.*
>
> ***Vehicle Handling Test Requirements***
>
> *The fundamental handling characteristics of general-use model quad bikes are to be determined using the Dynamic Test procedures described Attachment D, Quad Bike Dynamic Handling Test Procedure.*
>
> *Performance Requirements. The understeer gradient obtained from the testing shall be positive for values of ground plane lateral acceleration from 0.10 g to 0.50 g. Negative understeer gradients (oversteer) shall not be exhibited by the vehicle in the lateral acceleration range specified.*
>
> *Sport and Youth quad bikes are not subject to this requirement.*
>
> ***Safe Cornering Device***
>
> *General-use model quad bikes shall be constructed such that each of the wheels can rotate at different speeds at all times, in order to allow safe cornering on hard-surfaces. If a vehicle is equipped with a lockable differential, it must be designed to be normally unlocked.*
>
> *The differential lock selection device shall be "self-explaining", in that the rider shall be able to readily determine if the switch is in the "locked" or "open" position.*
>
> *Sport and Youth quad bikes are not subject to this requirement."*

The review of the requirements is discussed in the next sub-sections.

17.2 General requirements for an extended standard

Standards should be developed to improve the quality of products in line with broader community expectations. The quality is improved if the product is safer to use. Standards provide a mechanism for continual improvement as standards are upgraded from time to time.

Standards should not significantly affect the market, but they should provide a means to withdraw unsatisfactory (or unsafe) products from the market place. Accordingly, minimum standards need to be chosen carefully. Over time the minimum values can be increased. This will encourage manufacturers to innovate and develop improved designs.

A standard for quad bikes and SSVs should provide performance-based measures but not dimensions. The standard should not restrict manufacturers' ability to innovate.

Testing to the requirements in a standard should be as simple as reasonably possible so that the results are as repeatable and reproducible as possible. Testing is improved if it can be done autonomously, as demonstrated by SEA Limited and illustrated in Figure 16.

Where possible, a standard should be consistent with international standards or standards from another country. The US is a large market for quad bikes and therefore most quad bikes and SSVs are manufactured to the US standards. Thus, safety standards should build on the US standards ANSI/SVIA 1-2017, ANSI/ROHVA 1-2011, ANSI/OPEI B71.9-2016, SAE 2258 Light Utility Vehicles or European standard EN 15997 as a basis. With these comments in mind the following sub-section will discuss the author's recommendations for an extended standard over those listed above.

17.3 Recommended requirements for a standard

It is recommended that the proposed requirements in the standard address the three primary issues that were included in the star rating system. These are:

- Static stability and in particular lateral stability,
- The response to a vehicle traversing a 150 mm bump, and
- The predictability of the vehicle's steering characteristics.

Each of these will be discussed in turn.

17.4 Static stability requirements in a standard

As for the star rating system, the quad bikes are to be tested for static stability on a tilt table. A 50^{th} PAM ATD is to be positioned in the driving seat or on the saddle. The minimum lateral and the minimum longitudinal tilt table ratios (TTRs) will then be used in the standard.

Figure 7 in Section 6.8 illustrates the likely minimum lateral roll TTR and the minimum longitudinal pitch TTR for general use quad bikes evaluated by the TARS team and with a 50^{th} PAM ATD.

The Consultation RIS suggested limits of 0.8 for the lateral TTR and 1.0 for minimum longitudinal TTR [65]. If these limits were applied immediately, then no commercial quad bike tested by TARS would meet the standard.

In Section 6.1 and 6.2, the research by Macmillan (2017) indicated that the soil or ground conditions on most rural properties could only establish longitudinal and lateral wheel forces given by tan θ being in the range 0.5 to 0.7. Vehicles with higher TTR values (than 0.7) would slide rather than rollover in a quasi-static state. Significantly higher TTR values give diminishing returns.

If the minimum requirement for the lateral roll TTR was chosen to be 0.55 and the minimum longitudinal pitch values was to be 0.80, then the shaded area in Figure 7 shows the acceptable characteristics. This would exclude three of the eight vehicles tested by the TARS team.

It is recommended that in the first instance, the minimum lateral TTR value be 0.55 and the minimum longitudinal pitch be 0.80. As mentioned above, this would allow all but three of the general use quad bikes, tested by TARS, to meet this proposed standard because the expected longitudinal pitch TTR values are above 0.8 (see Figure 7). It is

[65] It is acknowledged that the Consultation RIS has a higher value for the forward TTR. However, in line with the discussion a minimum value is chosen for both forward and rearward pitch.

also likely that the three quad bikes that may not meet the proposed limits would be able to do so by increasing their lateral stability.

As with any standard, the requirements should increase over time and the increased minimum levels should be established with vehicle manufacturing and distribution industry. This is discussed further below.

17.5 Dynamic stability and handling requirements in a standard

At present the ACCC Consultation RIS indicates that the performance requirement be that the *"understeer gradient obtained from the testing shall be positive for values of ground plane lateral acceleration from 0.10 g to 0.50 g"*. That is the quad bike should understeer at all levels of lateral acceleration.

There is no information in the literature to suggest that a requirement that excludes oversteering vehicles is warranted. Refer to section 7.2 and 7.5. Accordingly, the author of this report cannot recommend the Consultation RIS requirement in a standard.

Sections 7.6 and 7.7 indicate that it is more important for the steering characteristics to be predictable, although an appropriate test has not been developed. The important aspects of the steering characteristics, based on the steering angle versus lateral acceleration, are considered to be gradients and the deviation of the steer angle from the measured Ackermann steer angle.

In line with the star rating system, a test to evaluate the predictability of the vehicle should be developed in the future. The standard should support the star rating and improve the safety and predictability of quad bikes available in Australia.

At this stage, a recommended test protocol for evaluating the predictability of a vehicle's steering characteristics is not available and a test is, therefore not recommended. It would be sound practice to develop and verify the value of any test through the star rating system.

17.6 Bump impulse response

The requirements here are based on the discussion presented in Section 9, and in particular Section 9.7. The bump test evaluates a vehicle's response to a vertical impulse at the rear wheels.

As it was for the star rating, there is no established relationship between safety and the vertical acceleration of the hip of the ATD from the bump impulse response test. In Section 9.4 it is concluded that, regardless of an indication of potential injury reduction, it is reasonable to expect that a reduction in the effect of riding over a bump will affect dynamic stability and reduce the rollover rate. A vehicle's response to a vertical impulse has been identified by Macmillan and discussed in Section 6 as being a major contributor to vehicle rollovers. Comments by Roy Deppa [66] indicate that a log or a tree root can affect the steering causing unpredictable steering responses and potentially making the quad bike uncontrollable. Limiting the propensity of vehicles to rollover will reduce the significant trauma associated with incident type.

[66] Personal communication from Roy Deppa.

There is not an established relationship between the vertical acceleration measured in the bump impulse test and a reduction in injuries, but there is a strong causal link. Given this causal link, it is recommended that this test be used in a standard.

Figure 22 shows the maximum acceleration for a general-use quad bike traversing a 150 mm high half round obstacle. The ACCC Consultation RIS indicated that minimum acceptable vertical acceleration should be 2.0 g. This would cause five general-use quad bikes tested by TARS to fail this requirement. If the recommended minimum limit for the maximum vertical limit is 2.5 g, two general-use quad bikes tested by TARS would then be unable to meet this standard.

Consequently, it is recommended that the response of the vehicle to a single 150 mm bump test with an impact speed of 25 km/h be used as part of the extended standard. It may be applied to SSVs as part of a star rating system, but the minimum design requirements in Option 4 only apply to quad bikes.

17.7 Minimum wheel articulation

The ACCC Consultation RIS indicated that the *"minimum wheel articulation shall be 150 mm for all wheels. This articulation is to be centred about (approximately half available for compression and half for rebound) the suspension position when the articulation is measured with a 50th PAM H3 ATD seated on the saddle in a normal riding position."*

It is not recommended that this requirement be included in an extended standard, as it is a dimension and not a performance requirement. Requiring particular dimensions may restrict manufacturers' ability to innovate. Requiring a minimum wheel articulation may have a negative impact on other quad bike characteristics. Figure 23 shows that the maximum acceleration in a bump test is not affected by quad bikes having a smaller wheel articulation (refer to Section 10).

17.8 Use of an open differential

The requirement to have a differential that allows the wheels to rotate at different speeds was discussed in Section 12. Some of the vehicle manufacturers and distributors are against this requirement on the basis that it also allows one wheel to slip and for the traction to be lost. An open (or unlocked) differential does allow for the vehicle to ride over hard surfaces without the need for "active riding". A differential that can be locked or unlocked, provides for an appropriate differential setting to be used when riding on different ground surfaces.

There is no clear evidence that a requirement to install a lockable differential would reduce the crash rate significantly. The safety benefits accrued on hard firm surfaces would be a maximum of 6 per cent if all sealed road crashes and injuries were eliminated from the use of an open differential. The potential risk of harm associated with using an open differential on unsuitable surfaces is not known, but at least 74 per cent of serious injuries occurred in areas where an open differential is likely to be problematic.

It is not recommended that a lockable differential be a requirement.

17.9 Future development of the standard

As for the star rating system, the further development of the standard will be enhanced if improved data can be collected to provide a clearer understanding of a causal link between the performance measures and increased safety outcomes for users. This is a difficult task and may take some time to amass the data to provide statistically significant results.

A star rating system allows manufacturers to demonstrate improved performance attributes. The star rating system is an indicator of performance, although a single star rating may not provide the consumer with sufficient information to guide their purchase. Some purchasers may prefer some attributes over others and the single star rating indicator may not provide this detail. A standard on the other hand sets minimum standards, which may at times be less than preferred performance attributes. This point is also discussed in the submission to the Consultation RIS by Down Under Dirt Bike Sales.

A standard is more effective if it is developed with vehicle manufacturers and distributors and other industries' collaboration. It is recommended that the vehicle manufacturers and distributors be encouraged to participate in developing appropriate standards, otherwise the ACCC and others should seek their own independent advice to determine appropriate requirements and implement them in the standard

18. Recommendations

In the previous sections, the author of this report has made a number of recommendations in Sections 15, 16 and 17 for Options 2, 3 and 4 proposed in the ACCC Consultation RIS. These recommendations are consolidated in this section. Option 5 is based on a combination of the Options 2, 3 and 4 and the recommendations for these options apply to Option 5.

18.1 Recommendations for Option 2

It is recommended that:

- Quad bikes conform to the US ANSI/SVIA 1-2017 standard for ATVs, or the European standard EN 15997. However, it is recommended that the rearward pitch stability be measured with a tilt table and not using the method outlined in ANSI/SVIA 1–2017 and discussed in Section 4.1.
- The latest version of the ROHVA standard (ANSI/ROHVA 1-2016) or the ANSI/OPEI B71.9-2016 standard would be appropriate to adopt for SSVs as they contain requirements for all the main safety features and measures of static and dynamic stability.
- A star rating system be introduced although in a different form to the one proposed in the ACCC Consultation RIS.
- An additional placard be affixed to quad bikes warning of the propensity of quad bikes and SSVs to roll over.

With regard to the star rating system, it is recommended that

- There should be a star rating system for quad bikes and another one for SSVs, even though some tests would be the same or very similar for the two vehicle types.
- The star ratings need to be easily explained the consumer and its construct needs to be as transparent as possible.
- The key factors or measures to develop the star rating are
  a. static stability and in particular lateral stability,
  b. the response to a vehicle traversing a 150 mm bump at 25 km/h and
  c. the predictability of the vehicle's steering characteristics.
- Appropriate measures for the star rating should be developed with manufacturers and the Federal Chamber of Automotive Industries.
- Simpler testing protocols be developed using autonomous vehicles to increase test result reliability, repeatability and reproducibility.

For particular measures, it is recommended that:

- For static stability, it is recommended that two measures be used; namely lateral roll measured by the minimum tilt table ratio (TTR values) with the vehicle facing in both directions and the minimum TTR for a forward and rearward tilt test.
- 50th PAM ATD rider or driver is used in the tests and the vehicles be unloaded.
- The response of the vehicle traversing a 150 mm bump at 25 km/h be used
- Manufacturers and distributors be asked to assist in finding a suitable measure for the predictability of a vehicle's dynamic handling.
- The concept of listing the individual measures for lateral stability, longitudinal stability, dynamic handling predictability and bump response test on the star rating tag be investigated.
- Manufacturers and distributors be asked to assist in refining the bump test to use a matrix of bump heights and speeds to improve the test's applicability to field conditions.

Further, it is recommended that:

- The dynamic handling assessment **not** include a dynamic limit on lateral acceleration.
- The lateral transient response **not** be included in the appraisal of dynamic handling.

18.2 Recommendations for Option 3

It is recommended that tested and effective OPDs be required to be integrated into the design of general-use quad bikes.

It is recommended that the proposed energy absorption requirements for lateral loadings as outlined in the Consultation RIS be used in the first instance. There is need for clearer more definitions of the minimum vertical and longitudinal load requirements.

Further, it is recommended that the requirements of the survival space need to be developed through vehicle manufacturers and distributors participation. It should be based on the requirements presented in the ANSI/ROHVA 1-2016, the ANSI/OPEI B71.9-2016 standards and the New Zealand guidelines [67].

18.3 Recommendations for Option 4

It is recommended that the proposed requirements in the standard address the three primary issues that were included in the star rating system. These are:

- Static stability and in particular lateral stability,
- The response to a vehicle traversing a 150 mm bump, and
- The predictability of the vehicle's steering characteristics

The testing procedure should be the same as specified in the star rating system as part of Option 2. It is recommended that simpler testing protocols be developed using autonomous vehicles to increase test result reliability, repeatability and reproducibility.

The issue is the selection of minimum requirements. It is recommended that a staged approach be used with the minimum requirements increased over an intermediate time frame.

It is recommended that in the first instance, the minimum lateral TTR value be 0.55 and the minimum longitudinal pitch TTR value be 0.80.

It is recommended that the response of the vehicle to a single 150 mm bump test with an impact speed of 25 km/h be a performance requirement. In the short term the recommended minimum limit for the maximum vertical limit is 2.5 g and, in the future, this limit should be reduced. The bump test should be applied to quad bikes only.

It is recommended that manufacturers and distributors be asked to assist in refining the bump test to use a matrix of bump heights and speeds to improve the test's applicability to field conditions.

The extended standard as outlined here is considered to be a starting point. It is recommended that the extended standard as outlined here be enforced after 24 months. Further it is recommended that the details of the testing be further developed and that the minimum requirements be extended and refined in same 24 month period. Finally it is recommended that the revised extended standard with increased minimum values over those listed here should be enforced in 48 months after the initial implementation time recommended in the Consultation RIS.

[67] New Zealand Guidelines for the Design, Construction and Installation of Rollover Protective Structures (ROPS) for All Terrain Vehicles

It is **not** recommended that the proposal to evaluate the understeer gradient using the constant radius test be included in the standard and, subsequently the requirement that the gradient be positive for lateral accelerations from 0.10 g to 0.50 g be not used; that is, the vehicle continually oversteers in this lateral acceleration range.

In line with the star rating system, it is recommended that an appropriate test protocol to evaluate the predictability of the vehicle steering characteristics be developed in collaboration with the vehicle manufacturing and distribution industry. It is **not** recommended that this test be applied until the test is evaluated through further testing. The star rating system may be an appropriate method to gain further knowledge about a suitable test requirement for this steering characteristic.

Based on the assumption that some riders may use the unlocked differential on unsuitable surfaces, the potential risk of harm is likely to outweigh the benefits of using an unlocked differential on hard surfaces. If all riders used the appropriate differential setting for the ground surfaces then there is more likely to be a net benefit with a lockable differential. Consequentially, it is **not** recommended that it be a requirement to fit a differential that can be locked or unlocked.

It is not required that it is in the unlocked position when the quad bike is started, but rather that it remains in the condition it was when last used.

18.4 Recommendations for Option 5

The recommendations for Option 5 include all those for Options 2, 3 and 4.

It is recommended that:

- Quad bikes conform to the US ANSI/SVIA 1-2017 standard for ATVs, or the European standard EN 15997. However, it is recommended that the rearward pitch stability be measured with a tilt table and not using the method outlined in ANSI/SVIA 1–2017 and discussed in Section 4.1.
- The latest version of the ROHVA standard (ANSI/ROHVA 1-2016) or the ANSI/OPEI B71.9-2016 standard would be appropriate to adopt for SSVs as they contain requirements for all the main safety features and measures of static and dynamic stability.
- A star rating system be introduced although in a different form to the one proposed in the ACCC Consultation RIS.
- An additional placard be affixed to quad bikes warning of the propensity of quad bikes and SSVs to roll over.

With regard to the star rating system, it is recommended that

- There should be a star rating system for quad bikes and another one for SSVs, even though some tests would be the same or very similar for the two vehicle types.
- The star ratings need to be easily explained the consumer and its construct needs to be as transparent as possible.
- The key factors or measures to develop the star rating are

a. static stability and in particular lateral stability,

b. the response to a vehicle traversing a 150 mm bump at 25 km/h and

c. the predictability of the vehicle's steering characteristics.

- Appropriate measures for the star rating should be developed with manufacturers and the Federal Chamber of Automotive Industries.
- Simpler testing protocols be developed using autonomous vehicles to increase test result reliability, repeatability and reproducibility.

For particular measures in the star rating system, it is recommended that:

- For static stability, it is recommended that two measures be used; namely lateral roll measured by the minimum tilt table ratio (TTR values) with the vehicle facing in both directions and the minimum TTR for a forward and rearward tilt test.
- 50^{th} PAM ATD rider or driver is used in the tests and the vehicles be unloaded.
- The response of the vehicle traversing a 150 mm bump at 25 km/h be used
- Manufacturers and distributors be asked to assist in finding a suitable measure for the predictability of a vehicle's dynamic handling.
- The concept of listing the individual measures for lateral stability, longitudinal stability, dynamic handling predictability and bump response test on the star rating tag be investigated.
- Manufacturers and distributors be asked to assist in refining the bump test to use a matrix of bump heights and speeds to improve the test's applicability to field conditions.

It is recommended that, in accordance with Option 3, tested and effective OPDs be required to be integrated into the design of general-use quad bikes.

It is recommended that the proposed energy absorption requirements for lateral loadings as outlined in the Consultation RIS be used in the first instance. There is need for clearer more definitions of the minimum vertical and longitudinal load requirements.

Further, it is recommended that the requirements of the survival space need to be developed through vehicle manufacturers and distributors participation. It should be based on the requirements presented in the ANSI/ROHVA 1-2016, the ANSI/OPEI B71.9-2016 standards and the New Zealand guidelines [68].

With regard to the requirements of an extended standard, it is recommended that the proposed requirements address the three primary issues that were included in the star rating system and use the same testing procedure. The key elements of an extended standard are:

- Static stability and in particular lateral stability,
- The response to a vehicle traversing a 150 mm bump, and

[68] New Zealand Guidelines for the Design, Construction and Installation of Rollover Protective Structures (ROPS) for All Terrain Vehicles

- The predictability of the vehicle's steering characteristics

It is recommended that a staged approach be used with the minimum requirements increased over an intermediate time frame.

It is recommended that in the first instance, the minimum lateral TTR value be 0.55 and the minimum longitudinal pitch TTR value be 0.80.

It is recommended that the response of the vehicle to a single 150 mm bump test with an impact speed of 25 km/h be a performance requirement. In the short term the recommended minimum limit for the maximum vertical limit is 2.5 g and, in the future, this limit should be reduced. The bump test should be applied to quad bikes only.

It is recommended that manufacturers and distributors be asked to assist in refining the bump test to use a matrix of bump heights and speeds to improve the test's applicability to field conditions.

In line with the star rating system, it is recommended that an appropriate test protocol to evaluate the predictability of the vehicle steering characteristics be developed in collaboration with the vehicle manufacturing and distribution industry.

The extended standard as outlined here is considered to be a starting point. It is recommended that the extended standard as outlined here be enforced after 24 months. Further it is recommended that the details of the testing be further developed and that the minimum requirements be extended and refined in same 24 month period. Finally it is recommended that the revised extended standard with increased minimum values over those listed here should be enforced in 48 months after the initial implementation time recommended in the Consultation RIS.

Further, it is **not** recommended that:

- The dynamic handling assessment include a dynamic limit on lateral acceleration.
- The lateral transient response be included in the appraisal or dynamic handling.
- The proposal to evaluate the understeer gradient using the constant radius test be included in the extended standard.
- That the test for predictable steering response be a requirement in an extended standard until the test is evaluated through further evaluation.
- A lockable differential be required to be fitted to a quad bike.
- It is not required that it is in the unlocked position when the quad bike is started, but rather that it remains in the condition it was when last used.

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AUSTRALIAN COMPETITION
& CONSUMER COMMISSION

Quad bike safety

Final recommendation to the Minister: Addendum

September 2019

Contents

1. Introduction

On 1 March 2019, the Australian Competition and Consumer Commission (ACCC) provided its Final Recommendation on a quad bike safety standard to the then Assistant Treasurer. This report, which forms an addendum to the Final Recommendation, provides an update on subsequent processes:

- On 6 April 2019, an exposure draft of the safety standard (the Draft Standard) was released for comment by 10 June 2019. The ACCC received 79 submissions in response.
- On 7 June 2019, the United States National Institute of Standards and Technology (NIST) submitted to the Department of Foreign Affairs and Trade (DFAT) a request for Australia to notify the World Trade Organization (WTO) Secretariat of the Draft Standard. The ACCC, via DFAT, notified the WTO of the Draft Standard on 17 July 2019 allowing Members nations until 7 August 2019 to provide comments. No comments were received from Member nations. One submission was received from a United States (US) industry stakeholder, the Specialty Vehicle Institute of America (SVIA).

2. ACCC recommendation

The Draft Standard (summarised in chapter 2 of the Final Recommendation) has not been substantively altered except in relation to spark arresters (quad bikes may comply with the spark arrester requirements in either the US Standard 5100-1d or the Australian Standard AS 1019-2000).

3. Further consultation processes: Summary of stakeholder feedback

3.1. Draft Standard submissions

Most responses could be placed into one of the following two groups:

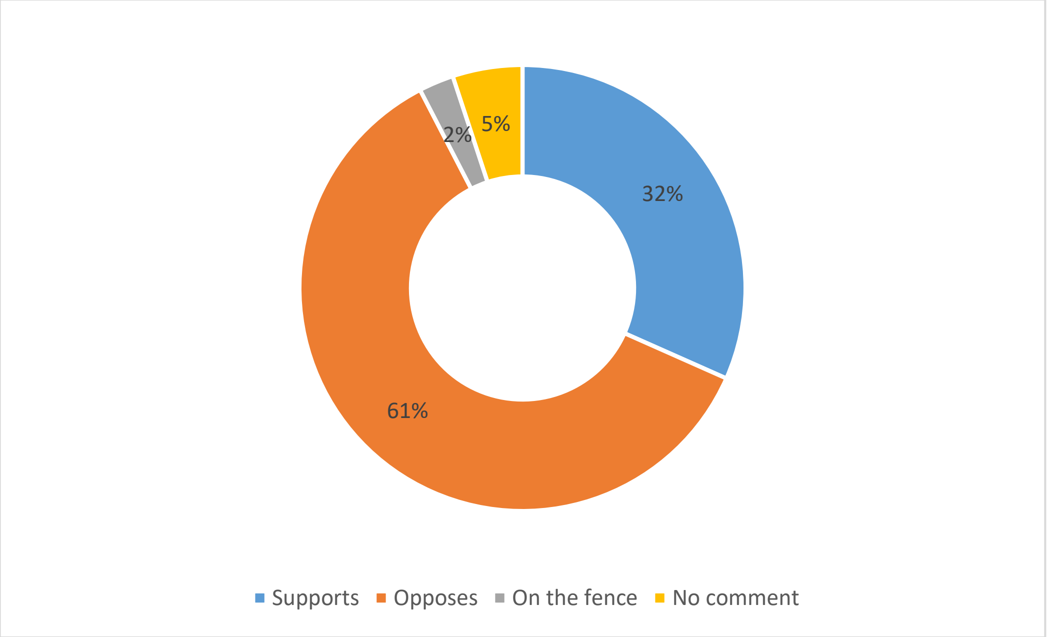
- Supports - ‘supports’ the Draft Standard without changes, or ‘supports’ but suggesting the Draft Standard should provide further protection (e.g. for children).
- Opposes - ‘opposes’ the whole Draft Standard, or ‘opposes’ in part (e.g. opposes Operator Protection Device (OPD) and/or static stability).

Figure 1 shows the number of responses supporting or opposing the Draft Standard.

In relation to these numbers, a website (www.banthebar.com) aligned with the Federal Chamber of Automotive Industries (FCAI) position encouraged those opposed to OPDs to make a submission and write to their Federal Minister.

Honda Australia reportedly distributed a bulletin to its dealers advising that it will withdraw from the quad bike market if the Draft Standard becomes law and calling for dealers to make a submission opposing the standard’s introduction. Yamaha Motor Australia made similar statements that it will cease quad bike supply if the standard is made.

Figure 1: Preference for the Draft Standard



A large number of the responses repeated common assertions made by the FCAI and manufacturers, and are a likely result of the campaign.

On the Draft Standard:

(a) Most respondents support the requirement to adopt sections of either the US Standard or the European Standard.

(b) Respondents who oppose the Draft Standard as a whole or oppose the requirement for OPDs commonly reported:

- deaths and injuries are all due to rider behaviour
- there is no credible evidence that OPDs provide a net safety benefit
- OPDs will lessen a quad bike's utility and create complacency with riders
- without a prescriptive standard for OPDs, it will make it difficult for manufacturers to decide whether a device provides the same or better protection as Quadbar or ATV Lifeguard
- businesses, families and communities will be affected if major quad bike manufacturers cease supply.

(c) A number of respondents fully support the Draft Standard, but consider that it does not go far enough to protect children from the dangers of riding quad bikes.

Common comments on the role of state and territory governments were:

(a) any legislation should be made nationally for consistency

(b) the medical sector strongly supports banning children under the age of 16 from riding adult sized quad bikes, noting Sean's law in the US

(c) helmets should be required not just when on the road, but whenever a quad bike is in use

(d) there should be continued awareness and education campaigns and consistent injury data collection

(e) other states should give subsidies for the fitting of OPDs to quad bikes currently in use

(f) it should be mandatory to have training and maintain a licence to operate a quad bike.

3.2. WTO notification submission

The comment received from the SVIA is broadly similar to the SVIA's 6 June 2019 submission to the Draft Standard. SVIA opposes the design requirements of the Draft Standard and advocates for complementary safety measures (e.g. helmets, training and banning child use). The SVIA's position is that US consumer protection practices, with a focus on complementary measures, are working.

4. Informing the options

This section supplements chapter 10 of the Final Recommendation by discussing eight additional issues raised in submissions on the Draft Standard:

(a) Spark arresters

(b) Static stability tests – use of a 50th percentile male test dummy

(c) Quad bike types

(d) Fitting points for OPDs

(e) Manufacturer and retailer obligations

(f) For OPD devices, what is the same or better level of protection?

(g) Commencement date

(h) US data.

This section 4 also summarises other developments since the Final Recommendation.

4.1. Spark arresters

The Draft Standard required all quad bikes to be fitted with a spark arrester that conforms to the Australian standard for spark arresters, AS 1019-2000. The US quad bike standard ANSI/SVIA 1-2017 requires quad bikes have a spark arrester that complies with the US spark arrester standard 5100-1.[1] The European quad bike standard EN 15997:2011 does not have a requirement relating to spark arresters.

In its submission, Honda was concerned that a requirement for quad bike manufacturers to comply with the AS 1019-2000 will take longer than the required 12 month transition period. This is based on a procurement lead time of around 6 months, and the time needed to develop, design, endurance test, and manufacture the engine-related part. Honda recommended that any standard should accept ANSI/SVIA 1-2017 without modification or 5100-1d (the current version of 5100-1) be allowed as an alternative to AS 1019-2000.

Victoria has a requirement under its *Forests (Fire Protection) Regulations 2014* (Vic) for non-stationery engines to have a spark arrester that meets the requirements of AS 1019-2000[2] for use in a fire protected area during the prohibited period. In South Australia, Forestry SA

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[1] US Department of Agriculture, Forest Service Standard for Spark Arresters for Internal Combustion Engines, 5100-1.

[2] Or to have a turbo charger or an exhaust aspirated air cleaner.

requires that all vehicles and equipment entering the forest during fire season must have an efficient spark arrester,[3] but does not specify a particular standard.

The ACCC compared the US standard 5100-1d and AS 1019-2000. The comparison found that the intent and key performance requirements in US standard 5100-1d and AS 1019-2000 are sufficiently similar, i.e. both aim to prevent release from the exhaust of carbon particles above 0.6mm in size that have sufficient energy to initiate fires. Consequently, the Draft Standard has been revised to allow a spark arrester to meet either the US Standard or the Australian standard. However, suppliers will still need to ensure that their products also meet any other applicable law such as the Victorian fire regulations.

4.2. Static stability tests – use of a 50th percentile male test dummy

The Draft Standard required that the static stability of general use and sports quad bikes be determined using tilt table tests with a 50th percentile average male test dummy (Anthropomorphic Test Device (ATD) – 50 PAM H3 ATD) positioned in a standardised seating position.

In its submission, Polaris raised concerns about use of a 50th percentile test dummy in the static stability tests, instead of tests being performed without a test dummy, because it unfairly disadvantages smaller, lighter all-terrain vehicles (ATVs) and would steer users towards the purchase of larger heavier ATVs. Polaris submitted that adding a test dummy to the testing procedure seeks to recognise the importance of the rider to the system but in fact introduces additional inequities into the testing protocol. These are:

- When a test dummy is placed above the existing centre of gravity (CoG) in this testing regime, it will effectively raise the CoG of the ATV + rider system. As the test dummy is a constant weight but the weight of the different ATVs vary, the effect of adding weight to the ATV above its centre of gravity will be more detrimental to small, lighter ATVs than it is to larger and heavier ATVs.
- The test dummy is placed in a fixed upright position and it stays perpendicular to the ATV when the table is tilted which is in the opposite manner to that which a real rider would be expected to lean in an actual riding scenario.
- Consistent positioning of the test dummy on the ATVs is critical to the outcomes of the testing. Polaris reports difficulty in attempting to consistently position the test dummy (even in a single position) on the various ATVs during the University of New South Wales Transport and Road Safety Research Unit (UNSW TARS) Australian Terrain Vehicle Assessment Program (ATVAP) testing. Different models do not have consistent seating positions so the positioning of the test dummy was largely subjective.
- The 50th percentile test dummy is very expensive and is primarily used to monitor injury outcomes and in this testing it is only being used as a 'dumb' stationary mass.

The ACCC contacted the lead researchers and engineers from the UNSW TARS quad bike project to follow up this issue. The UNSW TARS team advised that they accept removing the test dummy would make it easier for the manufacturers. However, the relative static stability of the different quad bike models varied when tested with and without a test dummy.[4] Thus, without the test dummy, the tests will not be as effective in determining the stability of individual vehicles under loaded (i.e. with rider) conditions.

[3] Forestry SA. Fire season requirements for contractors https://www.forestrysa.com.au/app/uploads/2017/07/17._Fire_Season_Requirements_for_Contractors1.pdf.

[4] Quad Bike Performance Project Part 1: Static Stability Results. Data on Pages 63 and 64. http://www.tars.unsw.edu.au/research/Current/Quad-Bike_Safety/Reports/Quad_Project_Final_Report1_Static_Stabilty_Test_Results_Jan-2015.pdf.

Troutbeck and Associates, in its review of the options for a safety standard (Attachment D to the Final Recommendation), supported the use of the 50th percentile test dummy, reporting (on page 19):

- It is recognised that the loadings and the orientation of the ATD will affect the results; it is not possible to account for the application of 'active riding'. Nevertheless, it is noted that these tests are routinely undertaken (e.g. by SEA Ltd) and because of their simplicity, they give repeatable and reproducible results.

The ACCC acknowledges the relevant points raised by Polaris but considers that quad bike static stability should be tested under loaded (i.e. with rider) conditions achieved by using a 50th percentile test dummy.

4.3. Quad bike types

In the Draft Standard, the following definitions were used:

- General use model (Type I) – A quad bike intended for recreational or utility use, or both, by an operator not less than 16 years of age
- Sports model – A quad bike intended for recreational use by an experienced operator not less than 16 years of age
- Youth model – A quad bike of appropriate size intended for recreational use under adult supervision by an operator under 16 years of age.

In its submission, Polaris raised concerns with the terms used to define different types of quad bikes. Polaris noted that the definitions of 'general use model' and 'sports model' are vague and rely on the presumption of 'intended use'. Polaris stated that the question of what specific design or physical criteria define a general use quad bike model is open to interpretation and needs to be resolved.

David Robertson (QB Industries), in his submission, reported that based on comments in social media, there was significant confusion about the Draft Standard. Mr Robertson reported that it appears some individuals and organisations do not understand the difference between the ACCC requirements for 'sports quads' and their use in recreation and those quad bikes used for 'work'.

To provide guidance, the Explanatory Statement includes a description of what a quad bike is and pictorial representations of different categories of quad bikes. The ACCC will also include this description in relevant guidance material.

4.4. Fitting points for OPDs

In its submission, Honda states that the fitting points on its quad bikes for Quadbar (trailer hitch (tow) tongue) and ATV Lifeguard (rear carrier rack) are not designed to withstand the loadings applied to them in the event of a rollover. Honda is concerned that if it fits these OPDs, a person who suffers an injury caused by the ATV Lifeguard or Quadbar could make a claim against Honda under Part 5-4 of the ACL on the basis that the mounting arrangements on the ATV for the device are not fit for purpose.

In his submission, Mr Ken Matthews (a motorcycle dealer who has sold Honda vehicles since 1991) also mentioned the issue of exceeding rack loading capacity during a rollover. Mr Matthews reported that the attachment of the Quadbar to the towbar interferes with the bike suspension, especially after about 6 months when he claims nylon guides become worn out.

The ACCC sought further information from QB Industries (manufacturer of Quadbar and Quadbar Flexi) and Ag-Tech Industries (manufacturer of ATV Lifeguard® and Quadguard®) on fitting points.

- QB industries reported that rollover tests had been performed with a Honda quad bike with a Quadbar. The Quadbar fitting point (tow tongue) was strong enough to take the loads in a rollover. After repeated rollovers there was no bending of the tow tongue. This included testing with forward pitch rollovers where there is the greatest load on the tow tongue.
- QB Industries advised that Linhai (which supplies quad bikes to Australia from China) developed a new fitting system for Quadbar to suit the design of their quad bikes and withstand the loadings in a rollover incident. The cost was $50.00 per unit.
- Ag-Tech Industries advised that the loadings applied to the carrier racks in the event of a rollover was considered when working out how to attach the ATV Lifeguard to the quad. Test results confirmed that mounting to the rear carrier rack would work.

The research discussed in the Final Recommendation supports the fitting of Quadbar and ATV Lifeguard. However, the safety standard also allows a general use quad bike to be fitted with, or have integrated into its design, a device that offers the same or better level of protection as a Quadbar or ATV Lifeguard. This will allow manufacturers such as Honda to develop designs for innovative OPDs or fitting points to protect operators. The Israeli ‘rear safety frame’, pictured on page 58 of the Final Recommendation, shows another alternative fitting method. The safety standard provides suppliers with a two year transition period until the requirement to supply a general use quad bike with an OPD commences.

4.5. Manufacturer and retailer obligations

The Motor Trades Association of Australia (MTAA), in its submission, advocated that the costs of the changes required under the safety standard should not be imposed on retailers but on manufacturers, governments, consumers and/or users. The MTAA also reported:

- Members are uneasy about being forced to fit OPDs to quad bikes that manufacturers say are not constructed to fit them, and are concerned about potential conflicts arising from warranty claims brought about by this circumstance.
- Members are concerned about being held legally responsible for any injuries or deaths attributed to retrofitted OPDs in an accident.

The MTAA’s view is that the manufacturer is responsible for supplying a compliant quad bike to the dealer, and recommended that sections 4, 8, 14 and 17 of the Draft Standard be amended to specifically reference where that responsibility lies.

The ACCC considers that the safety standard is not an appropriate place to explain how it interoperates with the other provisions of the ACL. The ACCC intends that manufacturers will be responsible for the provision of compliant quad bikes. To clarify the rights and obligations of manufacturers, dealers and other suppliers in the quad bike supply chain, the ACCC will develop guidance and educational material during the transition periods.

4.6. For OPD devices, what is the same or better level of protection?

The Draft Standard required general use quad bikes to be fitted with or have integrated into the design: an ATV Lifeguard, a Quadbar, or a device that offers the same or better level of protection.

A number of submissions (e.g. Aussie Powersports, Ross Macmillan, Honda and Polaris) raised concerns that 'the same or better level of protection' is not defined. Potential concerns include:

- unacceptable uncertainty for the manufacturer and regulator
- uncertainty whether an alternative device will need to meet the performance of one or both of the Quadbar and ATV Lifeguard
- test data on Quadbar and ATV Lifeguard not being publically available to allow comparison
- no specific functional requirements set down
- no benchmark or any objective criteria against which performance can be measured
- no minimum design or testing requirements set down, and
- may lead to use of sub-standard devices.

Principles-based regulation allows maximum flexibility among affected groups as to how they achieve compliance.[5] The ACCC's reasons for recommending a principles-based approach rather than the test in the Consultation Regulation Impact Statement are set out in section 10.4 of the Final Recommendation. The ACCC will also provide information in guidance material to assist manufacturers in determining whether an OPD provides the same or better level of protection as the ATV Lifeguard or Quadbar.

The ATV Lifeguard and Quadbar models referenced in the Draft Standard were as at the date of commencement. This has been revised to the models that were available for supply as at 6 April 2019 when the Draft Standard was released for comment. This reflects the models that were the subject of the research outlined in the Final Recommendation. However, the recommended standard also supports the manufacturers of ATV Lifeguard and Quadbar upgrading their models to provide the same or better level of protection. For example, in September 2019, QB Industries Pty Ltd replaced the Quadbar model with Quadbar Flexi.

4.7. Commencement date

Honda, in its submission, requests that the commencement date for the standard be based upon the date of import to Australia. Honda says that, as of 29 May 2019, about 65% of Honda ATV dealer stock is not the current year's model. Honda reports the 12-month transition period will be too short for dealers to sell prior year stock, dealers would be unable to affix hang tags to remaining stock as its static stability will not have been tested and thus this stock will not be able to be sold after the 12-months.

The ACCC's view is that 12 months is sufficient time for organisations across the supply chain to arrange to: undertake any lateral stability testing needed for each model to obtain tilt table ratio results for the hang tag; attach the hang tag to existing stock; ensure their stock has a warning label; update the owner's manual; and meet the specified requirements of the US or European Standard. Manufacturers would have sufficient time to test prior year models if necessary, noting that the tilt-table test would only need to be carried out for one representative vehicle of each model sold by a manufacturer. A longer initial transition period would unnecessarily delay safety benefits of the standard.

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5 See the *Australian Government Guide to Regulation* (2014) https://www.pmc.gov.au/sites/default/files/publications/Australian_Government_Guide_to_Regulation.pdf.

4.8. US data

The SVIA opposes the design requirements of the Draft Standard, and uses the US data to argue that complementary measures are working. However an analysis of data from the US Consumer Product Safety Commission (CPSC) does not support this position.

The US CPSC published its 2017 Annual Report of ATV-Related Deaths and Injuries in February 2019.[6] The data show that the number of fatalities declined steadily from 2007 to 2012 (Table 1 below), but there does not appear to be any reduction in the number of deaths per year since 2012. When annualised, there is a levelling off in US fatalities since 2012 which suggests that the previous strategies have reached maximum effectiveness and new approaches are now needed to improve quad bike safety (beyond the complementary safety measures advocated by the SVIA), as proposed in the Draft Standard.

Table 1. ATV-Related Fatalities for ATVs with 3, 4, or Unknown Number of Wheels**

Year	Reported number of deaths
2017	*295 **
2016	*531 **
2015	*585 **
2014	588
2013	589
2012	573
2011	622
2010	650
2009	720
2008	759
2007	832

* The data collection completion rate is 89% for 2015, 76% for 2016, and 29% for 2017. Fatalities recorded for these three years are anticipated to increase further as US states complete submissions of death certificates.

** The figures in the table above report deaths relating to ATVs with 3, 4 or an unknown number of wheels. Of those fatalities, at least 96.6% each year relate to 4 wheeled ATVs (quad bikes).

4.9. Other developments since the Final Recommendation

4.9.1. Fatalities

The Final Recommendation reported that over the period 2011-18, there were 126 recorded fatalities associated with quad bike incidents in Australia. Safe Work Australia has since updated this to 128.

In 2019 to date, there have been an additional eight reported fatalities. This brings the total number of fatalities since 2011 to 136.

[6] US Consumer Product Safety Commission 2017 Annual Report of ATV-Related Deaths and Injuries. February 2019 https://www.cpsc.gov/s3fs-public/atv_annual%20Report%202017_for_website.pdf?qLMnEEqa.T8KSOdW0r8qGqpUC7gQbqEd.

4.9.2. Quad bike industry

Major quad bike manufacturers and the FCAI generally support adoption of the specified requirements of the US and European Standards as proposed, and accept the requirement for hang tags and rollover labels. However, they oppose the requirements for OPDs and minimum performance for static stability in relation to general use quad bikes.

Not all quad bike manufacturers oppose the OPD and static stability requirements for general use quad bikes as proposed in the Draft Standard. A large importer of numerous brands of quad bikes, Mojo Motorcycles (not an FCAI member), stated on 7 May 2019 in the Weekly Times that it is committed to the Australian market and is prepared to comply with what is being recommended by the ACCC. Further, Linhai from China (a Yamaha subsidiary) has already supplied quad bikes to Australia that have OPDs fitted.

Other stakeholder groups have been campaigning to improve quad bike safety, including by making OPDs mandatory:

- On 24 and 31 July 2019, the National Farmers' Federation released statements calling upon the Australian Government to accept the ACCC's recommendations.
- On 3 July 2019, the President of the Country Women's Association, Tanya Cameron, held a press conference on the lawns of Parliament House.

4.9.3. Coronial findings

On 7 May 2019, the New Zealand Coroners Court handed down its findings on a quad bike fatality that occurred in 2015.[7] Coroner Windley found an OPD may have saved a dairy farm worker who was killed after being trapped underneath a quad bike in 2015. Since the death, the person's employer, LandCorp, which operated 137 properties in New Zealand, reportedly fitted all quad bikes with LifeGuard OPDs, and reported to the coroner that 'these systems have been responsible for avoiding serious harm in three rollovers since that time'.

On 30 July 2019, the Victorian Coroners Court handed down its findings on a quad fatality that occurred in 2017.[8] Coroner Spanos supported the recommendations set out in the ACCC's Final Recommendation.

4.9.4. Research

In August 2019, a New Zealand six-year review of patients admitted to hospital with injuries related to quad bike use was published.[9] The research concludes that, despite continued public debate and education on the safe use of quad bikes, injuries severe enough to require hospitalisation continue to occur.

In September 2019, an evaluation of crush protection devices (CPDs) was published by the University of California and University of Tennessee.[10] The research concludes that the Air-Quad, Quadbar and Lifeguard systems increase the crush protection zone, along with the distance between the seat reference point and the ground surface during a rollover accident.

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7 New Zealand Corners Court, delivered on 7 May 2019 by Coroner Windley.

8 Coroners Court of Victoria, Melbourne, delivered on 30 July 2019 by 3 August 2015 by Coroner Spanos available at: https://www.coronerscourt.vic.gov.au/sites/default/files/2019-08/GW_482117.pdf.

9 Janet Amey and Grant Christey 'A Six-year Review of Patients Admitted to Hospital with Injuries Related to Quad Bike Use' (30 August 2019) 132(1501) *The New Zealand Medical Journal* https://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2019/vol-132-no-1501-30-august-2019/7976/.

10 Farzaneh Khorsandi, Paul D.Ayers and Eric J.Fong, 'Evaluation of Crush Protection Devices for Agricultural All-Terrain Vehicles' (September 2019) 185 *Biosystems Engineering* 161-173.

4.9.5. Government initiatives

In May 2019, Tasmania became the third state to provide financial subsidies to farmers who install appropriately engineered and tested OPDs on their quad bikes. New South Wales and Victoria have offered similar subsidies since 2016.

In June 2019, the Victorian and New South Wales governments launched state-wide quad bike safety campaigns highlighting the dangers of quad bikes and the benefits of fitting OPDs.

On 5 June 2019, WorkSafe New Zealand published a policy clarification recommending CPDs on quad bikes, which noted that WorkSafe New Zealand had changed its advice about CPDs.

The Queensland government is developing the Tangalooma Island Resort case study to promote good quad bike safety practices for recreational quad bike activity providers and tourism operators.

5. The regulatory options

The processes outlined above have not changed the assessment of the regulatory options set out chapter 12 of the Final Recommendation.