

JUDY OSWIN
Consulting

Cardan Shaft Brake Review

Completed for Waka Kotahi

Version – Final

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Proactively Released

1. Background and Focus of this Report

This report was commissioned to review the post 2019 Waka Kotahi New Zealand Transport Agency regulatory approach to Cardan shaft brakes and consider whether the approach was appropriate and commensurate with the risk.

There were four fatalities associated with Cardan shaft brakes in the period 2012 – 2020. As a result of a 2018 fatal incident on a building site, Ryman Healthcare entered into an enforceable undertaking with WorkSafe. This included a requirement to make a \$450,000 one off payment to Waka Kotahi to undertake an educational campaign in relation to Cardan shaft brakes. In addition to delivery of the education campaign, the agency has undertaken a range of other actions designed to improve the safe operation of vehicles fitted with these brakes.

There have been a number of reports and submissions made in relation to these brakes over the past few years. As this report is commissioned for use solely within Waka Kotahi, a core level of knowledge of the issue will be assumed, although reference will be made to key actions and past recommendations where relevant.

The following material and line of enquiry underpins this work and its findings:

- Background material provided by Waka Kotahi, including reports obtained by the agency and communication and related materials.
- There has been one relevant finalised coroner's investigation (Loving 2017), with two outstanding.
- Advice was sought as to whether any WorkSafe investigations or reports had been produced into relevant incidents. Waka Kotahi was unable to locate any relevant reports.
- Discussions were held by the consultant with a number of Australian government regulators and industry experts.

The scope of work for this report focused on two key areas:

- Provision of an opinion as to the appropriateness of the Waka Kotahi response
- In developing this opinion, providing comparisons where possible with how Australia may have responded to similar issues.

This report is set out as follows:

Section 2 – Understanding the Risk

Section 3 – Risk Management and the Waka Kotahi Response

Section 4 – Overall Assessment

Appendix 1 – Risk Assessment Matrix.

1. Understanding the Risk

1.1 Specific risks with Cardan shaft brakes

There are a number of parking brake systems in use by vehicle manufacturers – Cardan shaft brakes are one form. Simplistically, the Cardan shaft system works by applying pressure to the driveshaft to stop it from moving (which is transferred to the rear wheels) while other parking brake systems tend to operate directly on the wheels.

Cardan shaft brakes are used in heavy vehicles made by a number of Asian vehicle manufacturers, and are sold in various countries around the world. This braking system is understood to be compliant with standards which apply in the countries in which the vehicles are manufactured and, at a minimum, some other countries where they are imported (e.g. Australia and United Kingdom). Testing commissioned by Waka Kotahi has confirmed that properly maintained and operated Cardan shaft brakes meet vehicle standards for safe brake performance.¹

Two key factors have been linked with incidents involving vehicles fitted with cardan shaft brakes:

- Poor maintenance leading to degradation of the system
- Operational use which is not in line with the vehicle manufacturers' instructions.

Vehicle manufacturers provide specific instructions as to the safe use of vehicles fitted with Cardan shaft brakes specifically:

- Avoiding parking on slopes; and
- Applying chocks to the wheels; and
- Setting the park brake fully – this may require more force than is required by other parking brake systems, particularly when the vehicle is loaded.

Cardan shaft brakes are fitted on heavy vehicles, typically with a gross vehicle mass of 3.5 – 12 tonne. They are usually not found in cars or on very large heavy vehicles.

1.2 Risk assessment

Risk is assessed based on consideration of two key factors:

- Likelihood of an event occurring
- Consequence of an event occurring.

These two factors considered together provide an overall risk assessment. Mitigations are then considered and the impact of these mitigations on the likelihood and consequence are reassessed.

It should be noted that in the case of Cardan shaft brakes, this is no longer a risk. It is now an issue, as the risk has eventuated in practice. However, the principles of the approach remain unchanged.

1.2.1 Likelihood of incidents involving Cardan shaft brakes

Since 2012 there have been four known fatalities associated with Cardan shaft brakes. Two have occurred off road (e.g.: on a farm) and two occurred on road.² There are also reports of other near misses, however Waka Kotahi does not have sufficient information to fully understand the nature of these incidents.

While it is evident that incidents related to Cardan shaft brakes failing to hold a vehicle in place have occurred, in rating risk likelihood, the number of incidents need to be considered in the context of vehicle numbers and relatively to other incidents.

¹ Independent testing was undertaken by Totoro Enterprises and Transport Specifications Ltd during 2018 and 2019.

² "On road" refers to on the road or roadside or a location connected to the road and accessible to the public.

Table 1 – Cardan shaft related fatalities compared to other workplace and road fatalities over a 10 year period (2012 – 2022)

	Annual average cardan shaft related fatalities	Average annual fatalities	Cardan shaft related fatalities as a percentage of total fatalities
Workplace related (i.e.: off road)	0.2	72 ³	0.28%
Total Road related	0.2	331 ⁴	0.06%
Total Heavy Vehicle road related	0.2	66 ⁵	0.30%

The frequency of incidents related to Cardan shaft brakes is relatively low within the overall context of workplace and road related incidents.

There are around 70,000 heavy vehicles fitted with Cardan shaft brakes which is approximately 35% of the New Zealand heavy vehicle fleet (including trailers) and 1.5% of the total vehicle fleet.⁶ While more complicated statistical analysis than is within the scope of this report would be required to fully consider the issue, on the surface of it, there is no glaring over-representation of Cardan shaft brake related incidents within the context of the overall heavy and total vehicle fleet.

While noting the relatively low level of fatalities which can be attributed to a Cardan shaft brake not holding a vehicle in place, there is nevertheless some evidence of a continuing brake related issue. Taking into account the probable additional incidents which have not resulted in fatalities, there is sufficient evidence to point to a likelihood of incidents in vehicles fitted with these brakes. Appendix 1 provides an outline of a typical risk matrix scoring and assessment system. Ultimately, it is a qualitative rather than quantitative based decision that determines any risk rating system, including the likelihood of a Cardan shaft brake failing to hold a vehicle in place. However it could be considered to be a moderate risk (likely to happen) which is a score of 3 on a 5 point scale.

1.2.2 Consequences of incidents involving Cardan shaft brakes

Given the fatalities that have arisen because Cardan shaft brakes have failed to hold a vehicle in place, the consequence is rated as severe (a score of 5).

The combination of the individual likelihood and consequence assessment scores would give a total score of 15 (3 x 5). This would place the unmitigated risk associated with Cardan shaft brakes as tolerable (a range of 10 – 16) which points to the need to take action in a timely manner and carry out improvement strategies.⁷

³ <https://data.worksafe.govt.nz/graph/summary/fatalities>

⁴ <https://www.transport.govt.nz/statistics-and-insights/safety-road-deaths/sheet/provisional-road-deaths>

⁵ <https://www.transport.govt.nz/statistics-and-insights/safety-annual-statistics/sheet/trucks>

⁶ Data provided by Waka Kotahi

⁷ See Appendix 1

2. Risk Management and the Waka Kotahi Response

Broadly, there are three potential responses to any risk:

1. Eliminate the risk
2. Mitigate the likelihood
3. Mitigate the consequences.

2.1 Eliminate the risk

There are two approaches which, in combination, would eliminate the risk related to Cardan shaft brakes in New Zealand:

- Require the existing fleet of vehicles to be retrofitted with a different type of parking brake
- Ban the future import of vehicles fitted with Cardan shaft brakes.

In considering whether it is appropriate to eliminate the risk in this way, three areas of inquiry are explored:

1. Whether Cardan shaft brakes are inherently unsafe
2. Appropriateness of relying on international standards to determine whether a vehicle may be imported
3. Economic and market impact of banning these vehicles and/or requiring retrofitting of alternate braking systems.

2.1.1 Are Cardan shaft brakes inherently unsafe

Investigations by Waka Kotahi with international countries including the United Kingdom and Australia have found no known systemic issues with the use of Cardan shaft brakes. Waka Kotahi advises that vehicles fitted with Cardan shaft braking units have been in use in vehicles in New Zealand for more than 50 years. Engagement with vehicle manufacturers' representatives in New Zealand, also failed to identify any systemic issues. It is unclear why the New Zealand environment has experienced more widespread issues with the safety of vehicles fitted with Cardan shaft brakes.

Two independent reports commissioned by Waka Kotahi established that Cardan shaft brakes are safe and perform the required function if maintained and operated correctly.⁸ However, as discussed in Section 2.1 there are a number of operational limitations which flow from the design of Cardan shaft brakes, particularly when the vehicle is parked on a slope or uneven ground. These operational limitations are not found, or at least not found to the same degree, in vehicles with other parking brake systems which operate directly on the wheels.

As vehicles fitted with Cardan shaft brakes are effective in holding the vehicle in place if they are properly maintained and used in accordance with manufacturer's guidelines, it would be incorrect to say that they are unsafe. However, they clearly pose a higher safety risk than other parking brake systems which do not have the same operational limitations.

⁸ This has been established through independent reports commissioned by Waka Kotahi – Tohoro Enterprises and Transport Specifications Ltd. Reports completed in 2019

2.1.2 Reliance on international standards

New Zealand has committed to the United Nations declaration of global standards and the harmonisation of vehicle standards programmes. Therefore, New Zealand's approach to vehicle importation is based on reliance on international standards. Specifically:

- new vehicles exported worldwide may meet any of the four internationally accepted standards to gain entry certification into New Zealand
- a used vehicle is accepted into New Zealand if it complies with the applicable standards in the country of manufacture.

New Zealand is primarily an importer of vehicles, rather than a manufacturer of vehicles, with a relatively high proportion of used vehicles imported. It is understood that this approach of placing reliance on international standards has been adopted due to the relatively small size of the New Zealand market and therefore limited ability to influence vehicle manufacturers.

In Australia, there are specific Australian Design Rules which all imported and locally manufactured or modified vehicles must meet. These standards are often closely aligned to other international standards, but do place particular requirements to meet Australian conditions – these may be factors related to usage; geography; temperatures etc. Australia, like New Zealand, is a small overall purchaser of vehicles in a worldwide context (approximately 1.5% of total vehicle sales) and therefore vehicles are not specifically designed to meet Australian requirements or conditions. However, manufacturers do make modifications to vehicles to enable them to meet Australian Design Rules.

In Australia, there are two key situations where a vehicle, which meets the Australian Design Rules, must be modified or withdrawn from sale.

- In addition to the road vehicles specific legislation, there are general consumer protection laws which focus on safe operation of an item. Any item, from a wheelbarrow to a car, can be recalled or withdrawn from sale because of safe operation issues, regardless of whether they meet any regulatory standards. These laws however do not extend to items used primarily for business purposes.
- The Motor Vehicle Standards Act has been relatively recently superseded by the Road Vehicles Standards Act. This has widened regulatory reach with regard to commercial vehicles, allowing for the recall of heavy vehicles which meet design standards but which present a safety risk. Particularly since the worldwide issues associated with Takata airbags, Australia has placed an increased focus on the performance of vehicle components even where they meet Australian Design Rules. Substantially more resource effort has been put into this area, with an increased number of vehicle recalls associated with the functional performance of vehicle components. Components deemed to have potential or actual safety issues, have had to be replaced. An example of a recent heavy vehicle recall was fuel injector lines.

The decision to rely on international standards, rather than setting New Zealand specific standards, is a much broader issue than is within the scope of this paper. It is assumed that New Zealand is not intending to revise its approach to vehicle standards in response to this one issue. To make a decision to refuse the import of vehicles fitted with Cardan shaft brakes would set a precedent which would leave the door open for further exceptions to be called for, or an overall change in the standards approach. It may also be viewed as a breach of New Zealand's commitment to the United Nations declaration of global standards and the harmonisation of vehicle standards programs.

2.1.3 Impact of banning and/or requiring retrofitting

There are two issues which would flow from a decision to ban or require fitting of alternate braking systems:

- Availability of vehicles
- Cost impacts.

Waka Kotahi advises that Asia is the primary source worldwide of trucks in the weight range of 3.5 – 8 tonne. Most of these vehicles are fitted with Cardan shaft brakes. Other key facts advised are:

- Europe manufactures vans of 3.5 – 8 tonne but not trucks.
- European trucks all have air brakes rather than Cardan shaft brakes but are over 8 tonne.
- The United States manufactures vehicles in the 3.5 – 8 tonne range. These are fitted with transmission rather than Cardan shaft brakes however, are generally large utility vans rather than trucks.

Vehicles fitted with Cardan shaft brakes make up approximately 35% of the total New Zealand heavy vehicle fleet. Therefore in the smaller heavy vehicle fleet (3.5 – 12 tonne), trucks fitted with Cardan shaft brakes would be a sizable portion of the overall pool. Banning future imports of vehicles fitted with Cardan shaft brakes would be a substantial disruption to the market with possible economic flow on consequences given these vehicles are primarily used for commercial purposes.

Waka Kotahi have advised that it is not possible to retrofit any braking system without a substantial modification to the vehicle and the resultant certification costs. Where it may be possible to retrofit a different braking system⁹ costs could range from approximately \$3,000 to upwards of \$20,000 depending on vehicle configuration. A total economic cost in excess of \$200M would be incurred and address only a portion of the existing vehicle fleet. There would also be an ongoing cost to retrofit braking systems for all future imports.

2.1.4 Finding:

Taking the action to ban the future import of vehicles with Cardan shaft brakes and requiring retrofitting is a theoretically viable approach. However, at this time it is not evident that this action is necessary on safety grounds:

- Two independent reports commissioned by Waka Kotahi established that Cardan shaft brakes are safe and perform the required function if maintained and operated correctly¹⁰
- There is not a broader systemic issue with Cardan shaft brakes outside of New Zealand (advice from Australia; United Kingdom, via internet searches and through engagement with New Zealand importers)
- The impact of actions taken to mitigate the risk (discussed in the following sections) is yet to be assessed.

⁹ Retrofit action is only possible for vehicles with air over hydraulic systems.

¹⁰ This has been established through independent reports commissioned by Waka Kotahi – Tohoro Enterprises and Transport Specifications Ltd. Reports completed in 2019

Further there are other, potentially significant, economic consequences of such an approach:

- Limited worldwide availability of replacement vehicles which do not use Cardan shaft brakes
- Cost of retrofitting parking brake systems in the current and future imported fleet
- Move away from commitment to align to international standards.

In my opinion, the decision to continue allowing the import of these vehicles and not requiring retrofitting of alternate brakes, is justified at this time. However, should the mitigations to address maintenance and understanding of the operations of the brakes (discussed in the following sections) prove to be ineffective over time, Waka Kotahi may need to reassess the options and appropriateness of eliminating this braking system from the fleet.

2.2 Mitigate the likelihood

Mitigating the likelihood of a road safety risk is a primary role of transport regulators. In the Safe System approach to road safety, a framework widely used by regulators, there are four key areas of policy intervention:

1. Safe speed
2. Safe roads
3. Safe vehicles
4. Safe people.

The last two of these four pillars are relevant when considering the Cardan shaft brake response. It is not possible from the information available to determine how much poor maintenance of vehicles, versus the decisions made by individuals, have contributed to the incidents involving Cardan shaft vehicles. For the purpose of this analysis, both are considered to be equally relevant.

It is important to note that much road safety policy is focused on mitigating rather than eliminating road safety risk. For example:

- Motorcycle riders are more likely to die or have serious injuries from an accident than car drivers. However, people are not prevented from riding motorcycles, but rather the risk is mitigated through features such as limiting pillion passengers and high powered cycles until an experience bank is built.
- Driving at lower speeds significantly reduces the likelihood of a serious or fatal accident however, speed limits of up to 100km an hour are allowed in recognition of the social and economic impacts of imposing low speed limits for long distance driving. This is mitigated through road design and supporting improvements in vehicle design.

2.2.1 Safe Vehicles

There are three key areas of relevance around safe vehicles:

1. Core functional design – do the components separately and together deliver a vehicle that is fit for purpose
2. Design elements that improve or enhance safety and minimise risk when there is human error
3. Maintenance of the vehicle to the manufacturer's standards.

Design and minimising human error risk

It has been established through the independent engineers' reports gained by Waka Kotahi, that properly maintained and operated Cardan shaft brakes perform as designed. However, as has been previously discussed, there are operational limitations with Cardan shaft brakes (not suited to parking on slopes or uneven ground without wheel chocks; pressure required to apply the brake fully, particularly when loaded). In this respect, Cardan shaft brakes do not minimise human error risk as well as other braking systems.

Given the design of Cardan shaft brakes, short of retrofitting alternate braking systems, there is no evident engineering solution to managing human error risk.

Maintenance

Vehicle maintenance issues are a known contributor to accidents, although not as significant as other factors such as speed and fatigue. In Australia, surveys of heavy vehicles in 2017¹¹ and 2021¹² found that brakes were the vehicle component most likely to not conform to standards. Results in 2021 found that 8% to 21% of brakes failed to meet standards, with greater levels of non-conformance in older vehicles. Therefore brake maintenance is an issue in Australia. Full air brakes were identified as the most likely to be defective, although there was no further break down of results by brake type.

Waka Kotahi has sought to address the issue of maintenance risk through changes to its periodic inspection regime. Prior practice has been to use a stall test to establish the maintenance status of Cardan shaft brakes. An internal departmental report into the state of the fleet and efficacy of the stall test found the following¹³:

- 12% of vehicles tested in 2021 did not pass a stall test
- In the same group of vehicles, 80% of the vehicles which passed the stall test did not pass the pull test
- While a vehicle may have passed a stall test, it may still fail to provide appropriate brake function if the cable was stretched beyond safe tolerance, which is difficult to determine during a stall test.

As a result of these findings Waka Kotahi has taken the following actions:

- Replacement of the stall test previously used as part of six monthly vehicle inspections with roller brake machine testing which is considered a superior test for detecting issues with Cardan shaft brakes. This change came into effect in late 2022. This has seen an increased number of vehicles not passing the park brake test.
- Issued safety alerts, videos, and other education and communication material to the vehicle service industry, the testing industry, freight industry, and manufacturers (importers and distributors), and vehicle owners outlining maintenance and inspection requirements.

The coroner's report¹⁴ into the death of Mr Loving in 2017 made a recommendation that brake testing should be done in reverse as well as forward. This recommendation has not been

¹¹ <https://www.nhvr.gov.au/files/201706-0576-nrbs-final-report.pdf>

¹² https://www.nhvr.gov.au/files/20211214_NRS2021_Full_Report.pdf

¹³ Report into Cardan shaft brakes. In-service testing and evaluation. Waka Kotahi March 2021

¹⁴ Office of the Chief Coroner of New Zealand Recommendations Recap A summary of coronial recommendations and comments made between 1 April and 30 June 2018

implemented due to the safety risk it would pose to inspectors. Waka Kotahi further advised that from an engineering perspective there is no reason why the test results would be different whether done in reverse or forward.¹⁵

As part of research underpinning this report there was identification of two key heavy vehicle safety trends emerging from design and maintenance issues (one related to buses and the other to freight vehicles). In both instances, the vehicle design created potential safety risks - oil dripping on to other vehicle parts which heated and caused a fire; friction of racks and mezzanine floors rubbing and catching fire. Proper maintenance of the vehicles eliminated the fire risk in both situations. Theoretically the issues could have been addressed through imposing vehicle design changes. However, a regulatory approach was not possible because the vehicles complied with Australian Design Rules and the National Heavy Vehicle Regulator (NHVR) is not allowed to establish vehicle design requirements which exceed those under the Australian Design Rules. The approach taken was industry led, with the full support and input of the NHVR. Industry bodies (Bus Industry Confederation; Truck Industry Council; Heavy Vehicle Industry Australia) developed practice guidelines on the safe maintenance of the relevant vehicle components. This approach was very successful in reducing incidents. Further, it was generally seen as a positive model because it allowed the industry to take a leadership role without introducing a layer of regulatory red tape.

Findings:

The actions taken by Waka Kotahi in relation to managing the 'safe vehicle' risk are considered sound in that:

- Efficacy of brake inspections has been improved through the introduction of roller brake machine testing which should see fewer vehicles with defective brakes in operation
- Testing is undertaken six monthly, which is considered an appropriate frequency
- Education material should ensure that the majority of inspectors and mechanics are aware of both how to test and maintain Cardan shaft brakes
- There is a clear rationale for not proceeding with brake testing in reverse as recommended by the coroner.

Overall, in my opinion, the actions taken by Waka Kotahi to mitigate the maintenance risks associated with vehicles fitted with Cardan shaft brakes are appropriate.

It is recommended that failure rates from inspections of Cardan shaft brakes should continue to be monitored over time. With the introduction of roller brake machine testing, an initial spike in failures is to be expected, and has occurred. This should settle after completion of the first 6 month inspection cycle and should be broadly in line with the results for other brake testing. Should failure rates remain high or rise over time, this would suggest that further maintenance related interventions may be required.

2.2.2 Safe People

In general, transport regulators seek to ensure people who operate vehicles on road are skilled and knowledgeable as part of licence training. Safe on road operation is overseen through licence sanctions and enforcement.

¹⁵ The brake is designed to self energise in both directions of application. This is similar to a standard drum brake unit used as a service brake at the wheels.

In relation to vehicles fitted with Cardan shaft brakes, this issue is somewhat more complex because:

- Specific operation of these brake systems is not part of general licensing skill development
- People will not generally refer to vehicle handbooks (such as those which outline the operational requirements for safe use of Cardan shaft brakes) before operating a vehicle which they believe they have core skills to drive
- If vehicles are not often parked on slopes, the need for wheel chocks and additional pressure to apply the brake may not be evident, even to regular users
- People may only drive vehicles fitted with these brakes intermittently and as a consequence have limited understanding of their operation.

Work commissioned by Waka Kotahi in 2020, found that driver knowledge of the operational factors relevant for safe use of Cardan shaft brakes was poor.¹⁶

Waka Kotahi has sought to build understanding of the requirements for safe operation of Cardan shaft brakes through:

- Direct communication with owners of vehicles fitted with Cardan shaft brakes, including provision of a sticker outlining the use of wheel chocks and application of the handbrake
- Education campaigns targeted at heavy vehicle owners e.g.: advertisements in trade and road based magazines; internet banners and content
- Engagement with vehicle importers/sellers to highlight the issue and seek their cooperation in drawing operational requirements to buyers' attention
- Mandatory requirement for a sticker on brake operation to be displayed in the cab of all relevant vehicles from April 2023.

These actions all appear appropriate. It is noted that the education and awareness campaigns will continue to occur during 2023 and beyond. The intent is to use the trend data coming from brake testing to target messaging e.g.: based on age, make, model, type, industry.

Any communication and education campaign will have less than 100% penetration and impact. Despite the best efforts of Waka Kotahi, some people will slip through the net or messaging may fade in people's minds over time.

The introduction of the stickers is seen as positive because it is directly in sight of drivers. In practice, people who drive a vehicle all the time will no longer 'see' the sticker. However, it would be expected to draw the attention of any new drivers and it is this group who are likely to benefit most from the alert, as regular drivers will hopefully be already aware.

Ultimately the level of success of these actions will be measured by:

- Penetration to the target audience
- The extent to which the message is understood and remains fresh in people's minds over time and is translated into action
- Availability of suitable wheel chocks when needed.

One factor which may improve the likelihood of penetration of messaging, including over time, is the fact that vehicles fitted with Cardan shaft brakes are predominantly owned by a business rather than a private individual for general road use. In a general sense, businesses should have a heightened awareness of the need to ensure worker safety (both a legislative and sound business obligation). It

¹⁶ Report into Cardan Shaft Park Brakes – In service testing and evaluation. Waka Kotahi March 2021

would be hoped that business owners would reinforce messaging about what is required for drivers using vehicles fitted with Cardan shaft brakes. However, it should be noted that a number of businesses may be sole owner/operator so they are potentially less aware of worker safety.

Australia has also used educational based programs to address safety issues. For example, there was a potential safety issue identified with the towing of trailers on a particular size ball coupling. Rather than banning the use of the coupling for towing trailers, which would have impacted most local government maintenance vehicles, a vehicle standards guide, which provided advice on installation and use of the couplings, was issued.¹⁷

Findings:

The actions taken by Waka Kotahi to manage the 'safe people' risk are considered sound:

- The educational campaigns have been targeted at impacted individuals and sectors
- The intent to continue education and communication and to target messaging to areas of identified continuing risk will increase the likelihood of benefits from these interventions
- The vehicle sticker will draw attention to the actions needed to park safely on slopes – particularly likely to be effective for new or recently new drivers who were not previously aware.

The following additional actions could be considered to further strengthen the response, particularly if after 12 months of implementation of the current and planned suite of actions by Waka Kotahi, there continue to be relatively high numbers of vehicles being presented with defective Cardan shaft brakes and/or pattern of incidents:

- Engaging with WorkSafe periodically to provide them with updates on the effectiveness of measures taken, particularly the impact on the number of brakes passing/failing the testing regime. WorkSafe are another mechanism for delivering targeted communication particularly with respect to the responsibility of employers to ensure a safe workplace and a trained and competent workforce.
- Potentially encouraging sellers of vehicles fitted with Cardan shaft brakes to supply a set of suitable wheel chocks with each vehicle on sale. It is noted that such an action would be beyond what would usually be considered the reach and role of a transport regulator, but is something that could be put forward as a positive contribution importers/sellers could make.
- Mandating the carriage of suitable wheel chocks in the vehicle as a requirement to pass a vehicle inspection.

While noting the potential additional actions put forward for consideration, in my opinion, the actions taken by Waka Kotahi to manage the 'safe people' risk are appropriate.

2.3 Mitigate the consequences

It is difficult to identify any mitigations that could positively impact the consequences of the brake failing to hold the vehicle in place. Once this occurs, there is a high risk of casualty and fatality. This highlights the significance of focusing on reducing the likelihood of an incident occurring.

¹⁷ <https://www.nhvr.gov.au/files/201709-0684-vsg16-50mm-ball-couplings.pdf>

2.3.1 Impact of mitigations on likelihood risk rating

The actions taken by Waka Kotahi to mitigate vehicle and people/use risks are considered sound and in my opinion are appropriate.

There is evidence that the introduction of roller brake machine testing is identifying maintenance issues that would have not been detected under the previously used stall test. Therefore the mitigation has demonstrably reduced risk.

It is too early to establish whether the educational campaign has had an impact on driver understanding of the correct operation of vehicles fitted with Cardan shaft brakes. A key part of this program, the requirement for display of a warning sticker, has yet to be implemented.

It is not clear whether maintenance or operational use were the main cause of the fatal incidents, or whether in fact it was a combination of both issues. In this context, it is difficult to determine how much of an impact the revised vehicle testing will have already had on risk reduction.

In my opinion actions taken to date would reduce likelihood risk rating from 3 to 2, leaving a total score (likelihood x impact) of 10 (5 x 2). On the scale used this would still place the risk in the tolerable range.¹⁸ However it is reasonable to posit that the likelihood of Cardan park brake related incidents could be significantly reduced if both of the following occur:

- an improvement in awareness of the operational requirements AND
- a change in behaviour flowing from increased awareness

Given the positive results with revised brake testing in addressing maintenance issue identification, if there is a significant increase in appropriate operational use awareness and actions, the likelihood risk rating could be reduced to 1 giving a total score of 5 (5x1) which would place the risk as acceptable.

Ultimately it will be the reduction in incidents and consequential injuries and fatalities which will determine whether the mitigations have been successful.

3. Overall assessment

In my opinion, the actions taken by Waka Kotahi are reasonable and commensurate with the risks that are presented by Cardan shaft brakes. There is every reason to believe that the mitigations will be effective in reducing the risk of future incidents. However, if after all outlined interventions have been in place for 18 months there continues to be a pattern of incidents involving vehicles fitted with Cardan shaft brakes then this should trigger the consideration of more interventionist actions such as banning import or requiring retrofitting of alternate brakes.

Given the risks associated with Cardan shaft brakes outlined in this report, there would be a need for the key mitigation interventions (testing using roller brake machines; requirement to have stickers fitted and some ongoing educational focus) to be in place in perpetuity. This is required because brakes will continue to require focused maintenance and new drivers will take over operation of vehicles fitted with Cardan shaft brakes.

It is important to highlight that it would be unreasonable to expect that there are never any future incidents involving Cardan shaft brakes. Brake failures and other mechanical and human factor

¹⁸ See Appendix 1

related incidents occur now and will continue to occur despite the best efforts of regulators. Therefore in assessing any future incidents involving Cardan shaft brakes, this needs to be considered in the context that not all risks can be eliminated. If such incidents remain rare then the mitigations should be regarded as effective.

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Appendix 1 – Risk Assessment Matrix

Risk assessments are typically represented in a matrix which assesses:

- The likelihood and consequence of an unmitigated risk
- The likelihood and consequence of a risk post mitigations

Risks are typically rated using a scoring scale. The following provides an example of a risk scoring and assessment system.¹⁹ This approach has been used in the assessment of risk described within this report.

Likelihood

Risk Score	Assessment	Description
1	Rare	Unlikely to happen
2	Unlikely	Possible to happen
3	Moderate	Likely to happen
4	Likely	Almost sure to happen
5	Almost certain	Sure to happen

Consequence

Risk Score	Assessment	Description
1	Insignificant	Will not cause serious injuries or illness
2	Minor	Can cause injuries or illnesses, only to a mild extent
3	Significant	Can cause injuries or illness that may require medical attention but limited treatment
4	Major	Can cause irreversible injuries or illnesses that require constant medical attention
5	Severe	Can result in fatality

Calculation of an Overall Risk Rating and Response

An overall risk rating is calculated by multiplying the likelihood and consequence. Therefore likelihood x consequence = risk rating.

The following provides a guide as to the response that should be made to the risk rating.

Risk Level	Assessment	Action Required
1 – 4	Acceptable	No further action needed. Control measures encouraged
5 – 9	Adequate	Further analysis may be required
10 – 16	Tolerable	Risk must be reviewed in a timely manner and improvement strategies put in place
17 – 25	Unacceptable	Activities should be ceased until mitigations are developed and endorsed

¹⁹ Adapted from the work of Safety Culture. <https://safetyculture.com/topics/risk-assessment/5x5-risk-matrix/>