PATTERNS IN NZ TRUCK/BIKE CRASHES

Authors: **Glen Koorey**
PhD, ME(Civil), BE(Hons), BSc, CMEngNZ
Principal – Senior Traffic Engineer & Transportation Planner
ViaStrada Ltd
Contact: glen@viastrada.nz

Alistair Woodward
PhD, MMedSc, MBBS
Professor, Head of Epidemiology and Biostatistics
University of Auckland
Contact: a.woodward@auckland.ac.nz

Hamish Mackie
PhD, MSc, BPhEd (Hons), CNZHFE
Director – Principal Researcher
Mackie Research Ltd
Contact: hamish@mackieresearch.co.nz

ABSTRACT

There has been an unusually high number of cycling fatalities in New Zealand during the past year; what has been particularly noticeable is the increased proportion that involved heavy vehicles. Between November 2016 and December 2017, ten of the 17 cycling fatalities due to a motor vehicle featured a truck, well above the long-term average. The Cycling Safety Panel, convened by the Transport Agency to investigate cycling crashes in NZ, made a number of recommendations in 2014 for improving cycle safety around heavy vehicles, including the introduction of side under-run protection, better training for truck drivers and cyclists, and investigation of new in-vehicle bicycle detection technologies. However, to date there has been limited progress on implementing these recommendations.

This paper investigates the factors involved in recent truck/bike crashes (injuries and fatalities) to identify common patterns. A number of themes emerge including a high number of cases where the truck driver reportedly did not see the person cycling. Next steps should be to carry out a “safe system” analysis of cases to understand how multiple system failures are resulting in truck/cycle fatalities. In turn, this could be used to set out a logic for interventions (regulatory, engineering, vehicles, etc) that are likely to prevent complete system failure. Among the interventions there is a fundamental question about the ethics of road environments where trucks and cycles share the same road space. The findings will be compared with the Panel’s earlier recommendations, to assess the likely effectiveness in preventing or mitigating the crashes that have occurred if these initiatives had been implemented.

1 INTRODUCTION

There has been an unusual spate of cycling fatalities in New Zealand during the past year, with 16 involving a motor vehicle recorded to date in 2017[1]; well above the five each recorded in 2015 and 2016, and the long-term average over the past decade of about nine a year. What has been particularly noticeable is the increased proportion recently that involved heavy vehicles. Between November 2016 and December 2017, ten of the 17 cycling fatalities involving a motor vehicle featured a truck (59%), well above the long-term average of about 30%.

Cycling safety has gained significant prominence in New Zealand in recent years, particularly following the Coronial Review in 2013 (Matenga 2013). A Cycling Safety Panel was convened by the Transport Agency in 2014 to investigate cycling crashes in NZ; the three authors of this paper were all members of the Panel. The Panel's final report made a number of recommendations for improving cycle safety around heavy vehicles, including the introduction of side under-run protection, greater training for truck drivers and cyclists, and investigation of new in-vehicle bicycle detection technologies. However, to date there has been limited progress on implementing these recommendations.

This paper investigates the factors involved in recent truck/bike crashes[2] (both injuries and fatalities) to identify common patterns. This will build on the previous analysis of all cycle fatalities in New Zealand undertaken by Koorey (2014), and also include non-fatal injury crashes involving trucks. A "safe system" approach will also be introduced as a way to determine all potential causative mechanisms that may contribute to these crashes and corresponding interventions (engineering, behaviour, regulatory, etc). The findings will be compared with the Panel's earlier recommendations, to assess the likely effectiveness in reducing or mitigating the crashes that have occurred if these initiatives had been implemented.

2 LITERATURE REVIEW

2.1 Cycling Safety Panel

The Cycling Safety Panel is a group comprising ten experts in the cycling sector that was convened in 2014 by the Ministry of Transport and the NZ Transport Agency to make recommendations to improve on-road safety outcomes for people cycling in New Zealand. The Panel's final report (Cycling Safety Panel 2014) contained 35 recommendations, including 15 "high priority" ones, covering a range of intervention areas. Since then, approximately two-thirds of the recommendations have come to fruition or are being progressed (NZTA 2016).

The following recommendations from the Panel's report were particularly relevant to cycling safety around trucks (although other recommendations would also have some influence):

HIGH PRIORITY ACTIONS

- *RCAs identify urban and rural high-density freight routes popular with cyclists. Where possible, consider alternative routing, for either freight or cycling. Where this is not possible, manage travel speeds and/or provide physical separation, intensive intersection treatments and wide protected turning and passing lanes. Align and prioritise this work with the New Zealand Cycle Trail's Network Expansion Project.*
- *Trial mandatory minimum passing distances when drivers overtake cyclists (one metre is suggested for speed limits up to 60km/h, and 1.5 metres for speeds that are 61km/h and*

[1] There have also been two on-road cycling fatalities in 2017 where no other vehicle was involved.

[2] Note that this paper will focus on trucks and not consider buses as well. Typically bus crashes with cyclists have numbered only 30-40% those of truck crashes, and the last cycle fatality involving a bus was in 2007.

above).

- *All employees who drive a heavy vehicle as the primary activity of their employment must receive cycle safety-specific driver training.*
- *Develop and provide training and resources for cyclists to raise awareness of the risks of riding near heavy vehicles.*
- *The Ministry of Transport and the Transport Agency, in consultation with industry representatives, complete investigations of the cost-effectiveness of truck side underrun protection and other vehicle technology improvements such as collision detection systems, additional mirrors or cameras.*

MEDIUM PRIORITY ACTIONS

- *Reduce vehicle speeds on routes where cycle and freight traffic are unable to be separated.*
- *Work with the freight industry to improve safe driving practices and vehicle standards.*
- *Extend the Cycling Advocates' Network delivery of cycle/bus/truck workshops.*
- *Use ACC levies and insurance premiums to reward corporate responsibility and actions to improve cycle safety.*

It is rather dismaying to note that, three years on, there has been no tangible progress on some of the higher-priority recommendations, such as the introduction of truck safety measures or mandatory minimum passing distances.

2.2 Previous truck safety investigations

In 1996, Parliament's Transport Committee conducted an inquiry into the causes of fatal truck crashes on New Zealand roads. The Committee's report made 67 recommendations to improve truck safety, and highlighted seven key recommendations that should be implemented immediately. Most of these were largely focused on truck operator practices and the safety of their vehicles. A 2005 review of subsequent progress (OAG 2005) found that most of these key recommendations had been satisfactorily implemented.

As far as can be ascertained, the 1996 inquiry did not highlight truck/cycle crashes as a particular concern, and thus no recommendations appear to be directly targeted at this area. NZTA Crash Analysis System (CAS) data for the 1991-1995 period shows that 27 out of 86 cycle fatalities (31%) during this period featured a truck; however, these were a relatively low proportion of all road fatalities involving trucks (~5%). There were some recommendations that could indirectly affect cycling safety, such as attention to combating driver fatigue.

In his analysis of over 90 cycling fatalities in New Zealand since 2006, Koorey (2014) commented on the following aspects of heavy vehicle involvement:

Nationally, trucks and buses are only involved in about 6% of all cycle crashes. However, 21 out of the 73 multi-vehicle fatalities (29%) involved a heavy vehicle. Although the crash movements vary, a reasonably common incident involves a cyclist being caught on the lefthand side of a truck (possibly turning left) and being swept underneath the truck wheels. This highlights the benefits of truck front and side under-run protection (as used in other countries), something that groups such as CAN (the Cycling Advocates Network of NZ) has been calling to make mandatory here for over a decade (Porteous 2011).

Both drivers and cyclists also need to be aware of the blind-spot limitations when cyclists are near heavy vehicles. Experience of each other's position is a useful way to obtain the necessary empathy and understanding, and this is currently being achieved through "Road User Workshops" between cyclists and bus/truck drivers run by CAN (Koorey & Niquidet-Western 2012). Additional side mirrors focused on blind spots may also be very useful, as is now required in Europe.

2.3 Safe System analysis of cycle crashes

Mackie *et al* (2017) developed a cycling safety system model for New Zealand to identify key cycle safety interventions. As well as conventional considerations such as road environment factors and road user behaviour, the model also included consideration of cultural or social influences, as well as government policies/regulations and practices/standards for infrastructure, vehicles and users. Reviews of actual cycling fatality cases were used to identify where there had been "system failures" in the past. The study noted a range of initiatives to address cycling/heavy vehicle interactions, including tackling driver fatigue and distraction, cycle training about heavy vehicle hazards, and side under-run protection of trucks.

Stigson *et al* (2017) analysed cycle fatalities on Swedish rural roads between 2006-15. The potentials of several vehicle and infrastructure safety countermeasures were determined retrospectively for each case by analysing the entire chain of events leading to the fatal injuries, using a method that extended the traditional Haddon Matrix for crash and injury causation (Haddon 1980). For example, the analysis showed that 30-34% of the fatalities could have been prevented with the presence of cycle paths. The collision speed of the motor vehicle was one of the parameters having the highest influence on the risk of cycle fatality. Overall, it was estimated that 59% of the crash fatalities could have been prevented by either infrastructure or vehicle technologies.

A systematic case review process was used by Talbot *et al* (2017) to analyse cycle vs truck crashes in London between 2007 and 2011. Trucks turning left conflicting with pedal cyclists traveling straight ahead was a common crash scenario and key contributory factors identified included the riders not being visible to the truck drivers, road narrowing, and inappropriate positioning of cyclists.

3 CRASH ANALYSIS

The bulk of the crash analysis for this paper was undertaken using a dataset from CAS of all cycle injury and fatal crashes involving a truck since 2007, with a focus on those between 2012-16 (five years). In addition, the database of cycle fatalities since 2006 maintained by Koorey (2014) was also interrogated to ascertain any patterns. Updated to the end of 2017, 35 records in this database involve trucks (out of 109 fatalities involving motor vehicles, or 32%)[3].

3.1 Analysis of injury crashes

Figure 1 summarises the number of cycle injury crashes involving a truck in New Zealand over the past decade (note that the 2017 data may be incomplete, particularly regarding injury crashes). While the rise in truck-related fatalities in the past year stands out, the overall number of casualties is only somewhat above what has been seen over the last ten years.

Focusing on the last five complete years (2012-16), there were 146 injury and fatal cycle crashes involving trucks, resulting in 140 injuries and 11 fatalities. Only 16% of injuries were female, although 36% of fatalities were. Children under 15 years old made up 10% of casualties, while those aged 65 years and over comprised 12%.

[3] Note that the database maintained by Koorey includes a few crashes coded as "pedestrian" in CAS, including people walking their bikes, or riding a child's bike or unicycle legally deemed as a wheeled recreational device.

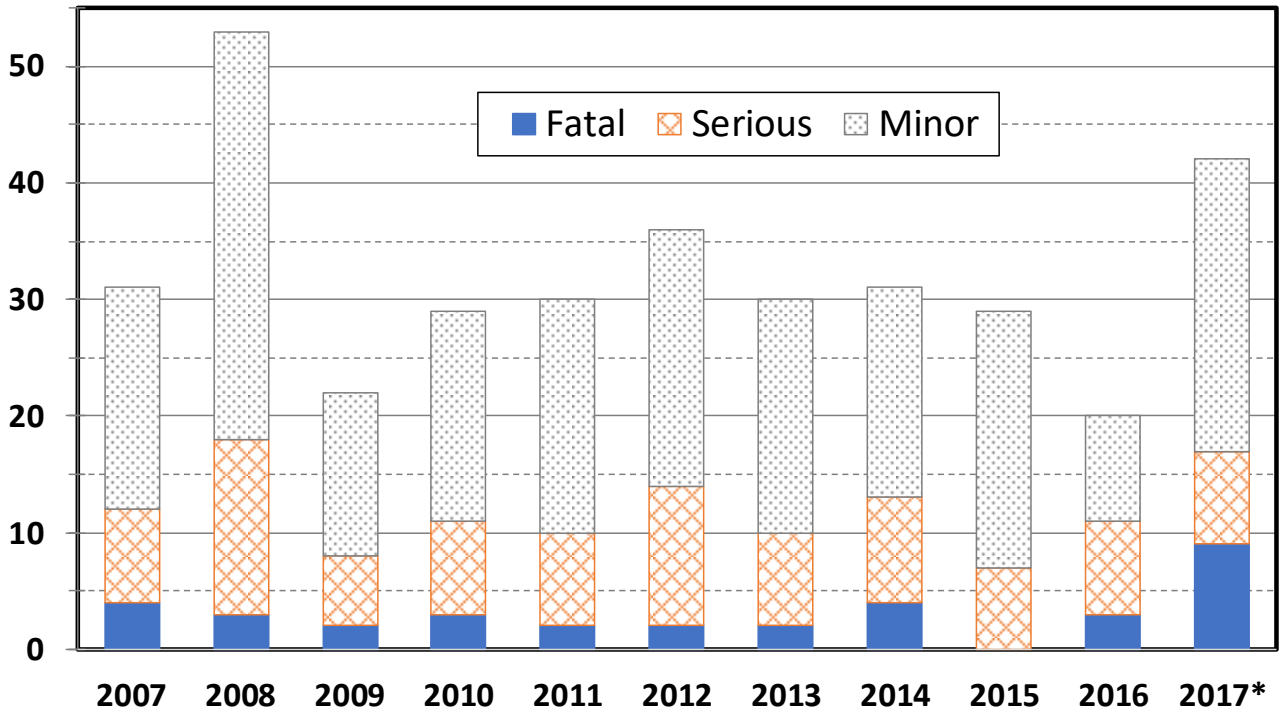
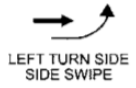
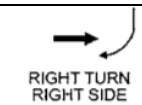


Figure 1: Time series of cycling fatal and injury crashes in New Zealand involving a truck

The top crash movement codes recorded in the 2012-16 group of crashes are shown in Table 1:

Table 1. most common cycle/truck crash movements

Crash movement	Code and description	Number (%)
	GB (Vehicle 1 sideswiped by Vehicle 2 turning left)	19 (13%)
	AO (Vehicle 1 overtaking Vehicle 2 - other)	15 (10%)
	JA (Vehicle 1 hit Vehicle 2 turning right from the left)	14 (10%)
	FA (Vehicle 1 hit rear end of Vehicle 2 stopped/moving slowly)	11 (8%)

Overall, there is a common theme of conflicting movements and/or incompatible speeds. By far, the biggest overall crash movement categories recorded were Type A* (AA to AO; overtaking and lane-change) with 41 (28%) and Type G* (GA to GO; Turning vs same direction) with 28 (19%).

Perhaps not surprisingly, given the predominance of cycling in urban areas, 112 (77%) of truck/cycle injury and fatality crashes occurred in urban areas (i.e. speed limits <80km/h), with 66% occurring on 50 km/h roads. “Major urban roads” (i.e. arterial local roads) are the road category with the greatest proportion of crashes occurring (40%). State highways (also typically higher volume roads) feature in a further 33% of crashes, roughly equally split between urban and rural. It is perhaps an indictment on the existing road network that so many people cycling appear to be getting injured or killed on busier roads, perhaps without having an alternative quieter route or separated cycleway to limit their exposure to traffic

Roughly half (53%) of truck/bike injury and fatality crashes occurred at intersections, and another 12% at driveways. The proportion at intersections was notably higher in urban areas (61%) than rural areas (29%), perhaps reflecting the higher intersection density in urban areas. Priority-controlled intersections (STOP, GIVE WAY) made up 36% of all crashes (including 8% at roundabouts), while traffic signals comprised 13%. Interestingly, while there were considerably more injury crashes at T-intersections than X-intersections (34% to 11%), fatalities were more over-represented at X-intersections (5 crashes to 1).

Looking at the crash factors recorded in CAS, the top factor groupings were:

- Poor observation – 79 (54% of crashes)
- Incorrect lane/position – 41 (28%)
- Failed to give way / stop – 38 (26%)

The majority of these factors were recorded against the truck driver, with the balance (typically about 25-30%) recorded against the person cycling. That aligns with the crash coding for driver fault, which has the truck driver primarily at fault in 71% of crashes and partly at fault in a further 3%.

It is interesting to note that excessive speed and alcohol/drugs are not reported as key factors in truck/bike crashes; only four crashes (3%) had either factor recorded. This perhaps reflects the professional nature of most people driving trucks, particularly in regard to alcohol or drug consumption while working.

3.2 Analysis of fatal crashes

Inspection of the 35 cycling fatalities involving trucks between 2007-17 identifies the following notable differences to the other 74 fatalities involving motor vehicles over the same period[4]:

- 57% of fatalities involving trucks occurred at intersections (compared to 30% involving other vehicles)
- 66% of truck-involved fatalities occurred on urban (<80km/h) roads (c.f. 42%)
- 49% of truck drivers did not see the cyclist beforehand (c.f. 30% of other drivers)
- 49% involved trucks passing the cyclist incorrectly or insufficiently (c.f. 34%)
- 46% of truck-involved fatalities occurred on state highways (c.f. 34%)
- 34% of cycling fatalities involving trucks were female (c.f. 18%)
- 15% of cycling fatalities involving trucks were non-NZ riders (c.f. 1%)
- Only one truck-involved fatality cited excessive speed or alcohol/drugs by a driver as a factor (c.f. at least 17%)

The high proportion of drivers who reportedly did not see the person cycling before the crash (and sometimes were not even aware afterwards that they had hit someone) is of particular concern and reflects somewhat the significant blind spots evident around a typical truck cab (see Figure 2). This factor may also explain the greater prevalence of truck fatalities at intersections, where side visibility of adjacent road users is even more critical. It is also intriguing to consider whether these issues affect less experienced riders more, which may include many women relatively new to cycling (still a growing demographic in New Zealand) and overseas riders who may not appreciate the potential dangers near trucks in New Zealand. Talbot *et al* (2017) found that women were similarly over-represented in truck fatalities in London.

[4] There were also at least 40 on-road cycling fatalities over this period that did not involve any motor vehicle, although that also included some due to medical conditions, such as heart attacks.

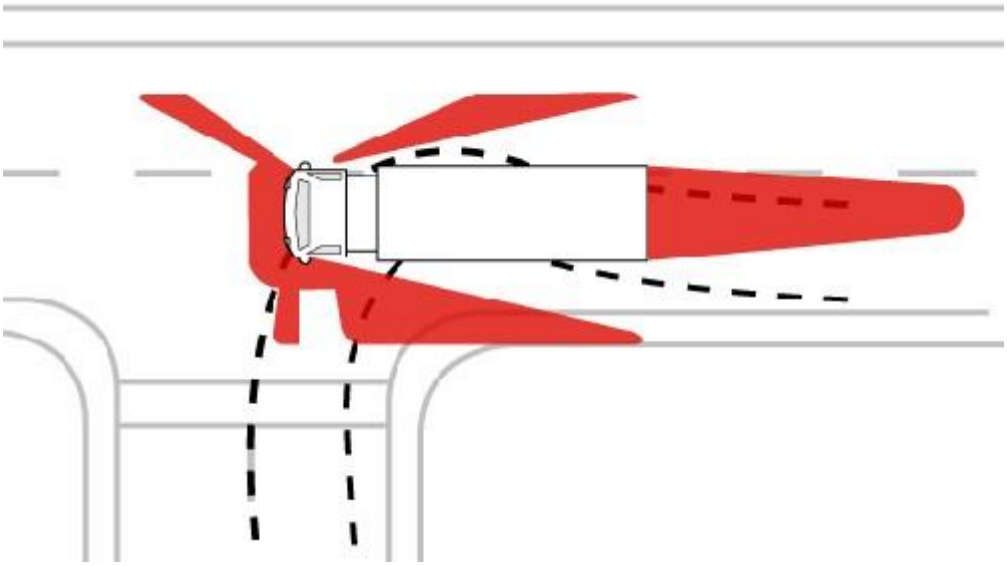


Figure 2: Blind spot areas around a typical truck (NZTA 2010)

From a detailed review of these cases, at least 19 (56%) of cyclist fatalities involving trucks featured movements that may have had a lower crash likelihood or severity if there had been side under-run protection and/or bike detection systems. A common scenario involves a left-turning truck colliding with a cyclist immediately to its left. Many of these protective measures may also benefit pedestrians, motorcycles, and light motor vehicles when around trucks.

It is too soon to determine whether the large spike in truck-related fatalities in 2017 may be simply random statistical variation. Cycling numbers appear to have increased somewhat across the major urban areas, particularly in places where there has been investment in cycleways. However, in major cities like Auckland and Christchurch the city-wide growth is still only 15-20% in the past year (AT 2017, CCC 2017). Truck numbers have also been increasing in the past few years after a decade of relatively little change, but the growth has typically only been about 2-3% pa. Looking at other crash factors, those that were more prominent in 2017 than the long-term average included more fatal crashes in the dark or during twilight, and more on rural roads.

4 TAKING A SAFE SYSTEM VIEW

The Government adopted a "Safe System" approach in its 2010-20 Road Safety Strategy (MOT 2010), and this framework was also used by the Cycle Safety Panel in their report. New Zealand's Safe System has a core vision of *'a safe road system increasingly free of death and serious injury'*; this was adapted by the Panel, to create a cycling-specific vision of *'a safe road network with zero fatalities and reduced serious injuries for people who cycle'*.

In New Zealand, the Safe System approach incorporates four principles:

- People make mistakes
- People are vulnerable (i.e. have limited tolerance to crash forces)
- Responsibility should be shared by system users, designers, enablers and regulators
- All parts of the system need to be strengthened (e.g. safer roads, vehicles, users, speeds)

With these principles in mind and as demonstrated by Mackie *et al* (2017), individual cycling fatality cases (or similar case types) can be analysed in more depth to understand the multiple system factors that come together to allow a serious injury or fatality to happen. This was reinforced by Talbot *et al* (2017) who also suggested that in response to multiple contributory factors, multiple interventions are needed to address these casualties. While an in-depth analysis of cases is not provided here, this is recommended for future analyses so that a comprehensive approach to

solutions can be achieved.

4.1 Potential Safe System solutions

In the meantime, a variety of different issues lend themselves to a range of diagnostic questions and possible types of solutions to consider:

- Is it just a case of better **infrastructure** in places where trucks and cyclists commonly mix? For example, truck routes separate from streets for bikes, more cycle lanes, separated cycleways, pathways, and intersection/crossing treatments.
- What about **speed** management? Lower speed limits are widely used in other countries, especially where it is not feasible/possible to separate cycling from motor traffic.
- Should we be focusing attention on **user behaviour** and training? The new NZ Cycling Education System (NZTA 2017) takes more of a system and life course approach to cycling safety and development and it includes the Share the Road programme (run by the Cycling Action Network), which specifically addresses how cyclists and truck drivers perceive and behave around each other. However, it is unknown whether this programme has sufficient reach to impact significantly at a country level.
- To what extent does the rise in truck/cycle fatal crashes simply reflect an increase in heavy vehicle **traffic**? What steps could be taken to reduce the numbers of trucks on roads that are commonly used by people cycling? Can a more strategic view of the road network minimise truck-cycle interactions?
- Do our **vehicles** need changes to their safety equipment? For bikes, that could be things like lighting and conspicuity aids. Meanwhile, should trucks include “friendlier” fronts/sides (e.g. side under-run protection) and make better use of safety technology such as mirrors and sensors? There is also a related question of whether trucks should actually be allowed to be produced and operate with considerable in-built blind spots.
- Are there **legislative** changes that need to happen? Some existing traffic rules are not really written with cycling in mind, e.g. issues around keeping left or overtaking on the left. Then there are gaps in the legislation, such as minimum safe passing distances.
- Do our workplace **health and safety** systems effectively manage the safety risks of commercial truck operations in proximity to people cycling? For example, are there sufficient incentives (financial, punitive or otherwise) for workplaces to maintain the quality and safety of their drivers and vehicles?
- Are **systems and processes** at central and local Government that are preventing good practice from happening? It is difficult to prioritise cycling within transport planning or (worse) often cyclists needs are completely overlooked. This was identified as a higher-level system failure earlier by Mackie *et al* (2017).

It is an interesting exercise to consider how different types of solutions might help reduce problems with trucks, such as:

- Separated cycleways might keep bikes away from trucks (although it can still be difficult to maintain that separation at intersections & side-roads).
- Lower speed limits might reduce the severity if a truck and bike are in the wrong place at the same time. However, the heavy weight of trucks does not require a lot of speed to have a devastating impact on an unprotected road user, and many people have been killed by trucks travelling at low speeds. For instance, left-turning truck/bike conflicts are due more to the geometry of the road than to speed.
- Cycle training/promotion might help make riders aware of the vast blind-spots around many heavy vehicles and how they should behave. These blind spots should also remind truck drivers that they need to be particularly vigilant for other road users.

- A minimum passing distance rule when overtaking cycles might provide more "margin for error", and raise general awareness about what is considered "safe" overtaking.
- Requirements for all trucks (or new ones at least) to fit side under-run protection and blind-spot mirrors could reduce the likelihood and consequences of collisions with bikes.ACC and NZTA fleet road-worthiness incentives might encourage companies to make more use of bus/truck Share the Road workshops.
- Local network planning could help to separate bus/truck routes from bike routes.

More fundamentally, the situations where cyclists and trucks find themselves sharing the same space should be carefully considered, as these situations generally do not reflect a Safe System. More ambitiously, as much as possible, trucks and cycles should not be sharing the same space where small errors can easily have fatal consequences. This has implications for truck access to busy urban environments and the prioritising of separation where access restrictions are not possible. If trucks and cycles must share space, then speed must be low, trucks must have appropriate safety features to prevent (as far as possible) harm to other road users, and there should be clear warning of the risks involved. A risk management framework, including acceptable levels of service where trucks and bikes might mix, could be helpful.

In addition to gaining a better understanding of the multiple system factors that come together in truck/cycle fatalities, the next step would be to assess the relative merits (costs, benefits, practicality) of Safe System solutions for prioritisation.

5 DISCUSSION

In the last decade, roughly a third of cycling fatalities in New Zealand have resulted from collisions with trucks. Common features of these fatal collisions relative to other cycling fatalities are the higher prevalence of intersections, urban roads, state highways and poor positioning by trucks when passing cycles. Another persistent aspect of many fatalities was the failure of the truck driver to see the person cycling before the collision; this applied particularly to crashes where the truck turned left and over-ran the adjacent cyclist.

In the last year (2017) there have been almost twice as many cycling deaths as the long-term average, and over half of these crashes have involved trucks. The reasons for the spike in cycling deaths are not well understood at this stage, and it is also too soon to tell whether the crashes involving trucks are following a different pattern to what has been observed before. However, the surge in the number of deaths, and the proportion of fatal crashes involving trucks, lends urgency to the issue of bike safety around heavy vehicles.

From discussions with government transport personnel (Macindoe 2017), it is our understanding that progress on many of these initiatives recommended by the 2014 Cycle Safety Panel has stalled at the Ministry of Transport. The *Safer Journeys Action Plan 2016-20* has an action item: *"Undertake initial investigation by December 2017 on the value of mandating the following safety standards or technology for vehicles entering the fleet: …under-run protection on heavy vehicles"*; to date we have seen no pertinent detail about this. Even then, that "initial investigation" would be three years on from the original recommendations. It is understood that there may be reluctance from the trucking industry to embrace the recommended measures, although at the very least requiring safety features for new vehicle imports only (i.e. no mandatory retrofitting required) would be a starting point.

There are other related recommendations (noted in section 2.1) that have also not made great progress since 2014. For example, a number of cases featured truck drivers passing a cyclist with insufficient clear room to safely do so, where the prudent approach would have been to either pass with a greater clear lateral gap or to wait until a safer opportunity for passing arose. A minimum mandatory distance when passing people cycling may have prevented many of these crashes from occurring, but progress has stalled since preliminary local research on this concept was undertaken (Balanovic *et al* 2016). Meanwhile, overseas we have seen significant development in

some of these areas in the past few years, including truck visibility design, minimum passing distance laws, road design improvements, lower speed zones, and restrictions on heavy vehicle movements in urban areas. London's *Construction Logistics and Community Safety* (CLOCS 2017) programme is a good example of pro-active initiatives in this space.

To advance cycle safety in New Zealand, a clear logic, starting with problem identification through in-depth case analyses, and following through to solutions that would clearly prevent a good proportion of these fatal and serious crashes, is needed. On the basis of the reviews carried out by the Cycling Safety Panel, and subsequent experience in similar countries to New Zealand (referenced above), we think there are strong grounds for proceeding immediately with two specific initiatives, minimum passing distance legislation, and side under-run protection and/or vulnerable road user proximity sensors. This would help to remove any rhetoric and potential avoidance of the issues.

6 CONCLUSIONS AND RECOMMENDATIONS

Crash analysis of truck related cycle crashes and subsequent consideration of a safe system fo truck/bike interaction has found the following conclusions:

- Truck crashes make up 30-35% of the long-term average proportion of cycling fatalities in New Zealand. However, 2017 saw a notable spike in both numbers and proportion of truck crashes, for no clear reasons.
- A common theme of truck injury crashes was scenarios that involved conflicting movements and/or incompatible speeds, e.g. a left-turning truck hitting a cyclist immediately to its left. Truck crashes were more likely to occur in urban areas and on busy urban arterial roads. The top crash factor groupings were poor observation, incorrect lane/position, and failure to give way / stop.
- Compared with other cycling fatalities, fatal crashes involving trucks had a higher proportion of intersections, urban roads, state highways and poor positioning by trucks when passing cycles. Another persistent aspect of many fatalities was the failure of the truck driver to see the person cycling before the collision.

It is recommended that the following actions be given key priority to reduce the likelihood and severity of truck/bike crashes:

- Building on the methods developed by Mackie et al. (2017), undertake a safe-system analysis of truck/bike crashes in New Zealand to better understand the direct and indirect factors that are leading to cycle fatalities. Firstly, the findings of Mackie et al. should be revisited and then any supplementary analyses could be carried out using the latest data (if needed).
- Implement mandatory minimum passing gaps when overtaking cyclists
- Require side-under-run protection and/or vulnerable road user sensors for all new imported trucks to New Zealand

Other initiatives that could also contribute to a lesser degree to cycle safety around trucks include further physical separation of cycles and trucks (by creating separated facilities or banning trucks on some routes), protected signal phasings at intersections, reductions of speeds in shared truck/bike environments, and further cycling-specific training of truck drivers and education about heavy vehicles for cyclists.

7 REFERENCES

AUCKLAND TRANSPORT (AT, 2017). *The Auckland Cycling Account 2016*. June 2017. *https://at.govt.nz/cycling-walking/cycling-walking-monitoring/auckland-cycling-account/*

BALANOVIC J., DAVISON A., THOMAS J., BOWIE C., FRITH B., LUSBY M., KEAN R., SCHMITT L., BEETHAM J., ROBERTSON C., TROTTER M., KORTEGAST P., BURTON J. (2016). Investigating the feasibility of trialling a Minimum Overtaking Gap law for motorists overtaking cyclists in New Zealand. *NZ Transport Agency Internal Report*, October 2016

CHRISTCHURCH CITY COUNCIL (CCC, 2017). Set your cycleway wheels in motion. *Newsline*, 2 October 2017. *https://www.ccc.govt.nz/news-and-events/newsline/show/2068*

CONSTRUCTION LOGISTICS AND COMMUNITY SAFETY (CLOCS, 2017). *The story of CLOCS*. *https://www.clocs.org.uk/about/*

HADDON W JR. (1980). Options for the prevention of motor vehicle crash injury. *Isr J Med Sci.*, Jan 1980, 16(1), pp.45-65.

HAWLEY G. & MACKIE H. (2015) *Evaluation of the Road Safety Trust cycling education project*. Report prepared for Cycling NZ and the Cycling Advocate's Network. 62pp.

KOOREY G.F. (2014), "Investigating common patterns in New Zealand cycling fatalities", *IPENZ Transportation Group Conference*, Wellington, 23-26 Mar 2014, 11pp.

KOOREY G. & NIQUIDET-WESTERN J. (2012), "Safer Cycling in New Zealand: Enabling Cycling Organisations to Deliver Cycle Safety Programmes", *Velo-City Global 2012 Cycling Conference*, Vancouver, Canada, 26-29 June 2012. *http://ir.canterbury.ac.nz/handle/10092/6831*

MACINDOE T. (2017). *Pers comm* to G.Koorey, Office of the Associate Minister of Transport, 15 August 2017.

MACKIE H., HAWLEY G., SCOTT R. AND WOODWARD A. (2017). Towards a safe system for cycling. *NZ Transport Agency research report 606*. 127pp. *www.nzta.govt.nz/resources/research/reports/606*

MATENGA G. (2013). *Cycling Safety in New Zealand: A Coronial Review*, Coronial Services of New Zealand, 11 Nov 2013. *http://www.justice.govt.nz/courts/coronerscourt/media-centre/news/cycling-safety-in-nz-review/view*

MATHEWSON N. (2014). Slow road to improve truck safety. *The Press*, Christchurch, Oct 4 2014. *http://www.stuff.co.nz/national/10578569/Slow-road-to-improve-truck-safety*

MINISTRY OF TRANSPORT (MOT, 2010). *Safer Journeys: New Zealand's Road Safety Strategy 2010-2020*. *http://www.saferjourneys.govt.nz/*

NZ CYCLING SAFETY PANEL (2014), *Safer Journeys for people who cycle: Cycling Safety Panel Final Report and Recommendations*, NZ Transport Agency & Ministry of Transport, Wellington, December 2014. *www.nzta.govt.nz/walking-cycling-and-public-transport/cycling/for-people-involved-in-cycling-programmes-and-projects/cycling-safety-panel/*

NZ TRANSPORT AGENCY (NZTA, 2010). *Safety tips for cyclists and truck and bus drivers*, September 2010. *http://www.nzta.govt.nz/resources/safety-tips-cyclists-truck-bus*

NZ TRANSPORT AGENCY (NZTA, 2016). *Cycling safety action plan: Making cycling safer and more attractive*. Progress Report, Dec 2016.

NZ TRANSPORT AGENCY (NZTA, 2017). *National Cycling Education System*, July 2017. *www.nzta.govt.nz/walking-cycling-and-public-transport/cycling/for-people-involved-in-cycling-programmes-and-projects/national-cycling-education-system/*

OFFICE OF THE AUDITOR GENERAL (OAG, 2005). *Progress in implementing key recommendations of the 1996 Transport Committee inquiry into truck crashes*, March 2005.

PORTEOUS D. (2011). Plea to protect cyclists. *Otago Daily Times*, 23 Nov 2011.

PRESS ASSOCIATION (2014). London to ban lorries which have no protection for cyclists and pedestrians. *The Guardian*, London, 30 January 2014. *https://www.theguardian.com/world/2014/jan/30/london-ban-lorries-no-protection-cyclists-pedestrians*

STIGSON H., RIZZI M., YDENIUS A., KULLGREN A. (2017). Fatal Bicyclist Accidents on Rural Roads. *6th Annual International Cycling Safety Conference*, 21-22 September 2017, Davis, CA, USA.

TALBOT R., REED S., CHRISTIE N., BARNES J., THOMAS P. (2017). Fatal and serious collisions involving pedal cyclists and trucks in London between 2007 and 2011, *Traffic Injury Prevention*, DOI: 10.1080/15389588.2017.1291938

8 ACKNOWLEDGMENTS

The authors would like to acknowledge the support of their colleagues on the 2014 Cycle Safety Panel for encouraging further investigations into this problematic safety area. They would also like to thank Richard Barter (CAN Share the Road Project Manager) for his input into discussions around this topic.