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"It's pathological": Exploring gaps in the whole-systems approach for managing operations and safety risk at a fully automatic rail level crossing

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Abstract

There are 23,500 level crossings in Australia. In these risky environments, it is important to understand what human factor issues are present and how road users and pedestrians engage with crossings. On-site observations were performed over a 2-day period at a 3-track active crossing. This was followed by 52 interviews with level crossing users. Over 700 separate violations were recorded, with representations in multiple categories (e.g. going through flashing lights >2s after starting flashing; stopping on crossing). Time stamping revealed that the crossing was active for 59% of the time in some morning periods and trains could take up to 4-min to arrive following first activation. Users experienced frustration due to delays caused by the frequency of trains, which increased likelihood of risk-taking. Analysis of interview data identified themes associated with congestion, safety, and violations. This work offers insight into context specific issues associated with active level crossing protection.

1. Introduction

Although accidents or crashes at rail level crossings (RLX) are relatively infrequent, collision risk is high due to their catastrophic consequences. There are ~23,500 RLXs in Australia and in the 10y from 2002 to 2012, there were 601 reported road vehicle collisions at RLXs and 92 collisions with a person [1]. The financial costs of RLX collisions are high, estimated at $32M per year excluding rail operators and infrastructure costs [2], while the human cost is incalculable. Over 2000 to 2009, ~27% of collisions between road vehicles and trains occurred at active RLXs with boom gates – this was higher than at any other type of public crossing [3], but when adjusted for exposure and traffic density, RLXs with boom gates and flashing lights have less accidents or crashes than any other type of RLX [3]. The downside to current active RLX design is the growing link with traffic congestion usually created by extended closure times. As one may expect, congestion is worse during peak periods when road traffic and train frequencies increase. The ideal solution is grade separation (i.e. constructing an over- or underpass). Given that active RLXs with boom gates have fewer crashes and fatalities per vehicle than passive RLXs, they are considered to be the "gold standard" for safety when grade separation is not viable, but there may also be environments where active protection is not enough, and where the setting simply does not justify the capital costs of grade separation. The congestion and delays associated with RLXs may lead to risk-taking behaviour by road users and pedestrians.

In theory, motorists should have a good understanding of the rules relating to RLX use, but drivers still need to make decisions and this rests on their judgment, which allows for human error. Human error is problematic at RLXs and police statistics show that up to 95% of collisions at RLXs are caused by motorists' poor performance [4]. Reason [5] suggests that poor performance occurs because of errors or violations. Errors include skill-based attentional slips, lapses of memory, and mistakes relating to rules or knowledge. Violations are actions (or lack thereof) that infringe on rules and regulations, whether intentional or unintentional. Understanding the reasons for the behaviour of road and level crossing users is a vital element in developing interventions aimed at modifying behaviour to improve safety. Increasing the understanding of user behaviour may allow us to inform interventions that modify the behaviour of motorists and therefore reduce errors and violations. The aim of this case study was to investigate the interactions of road users and pedestrians at a rail level crossing in Victoria, Australia. The level crossing involved in the study was recently identified for grade separation, evidently providing an ideal ground for research. The objective was to identify substantive human factors associated with safety at the location, and develop a good understanding of the existing level crossing user culture.

2. Methodology

Research Approach

Figure 1 provides an overview of the methods and activities undertaken. Field observations were performed over 2-days by two researchers. Data were collected at peak (7-9am; 4.30-6.30pm) and off-peak (9.30am-4:00pm) periods. Observational data were manually coded and violation categories included: entering the crossing after activation; entering before barriers had risen and lights had stopped flashing; going around lowered barriers; and stopping or queuing over the RLX when inactive. The data capture scheme distinguished between RLX users that were first to violate. RLX activation was time stamped. Fifty-two interviews were undertaken with lemployees of local businesses, train commuters, and local police officers. Data were transcribed using 3 stages of qualitative analysis. The first identified units of information that addressed research aims, and in the second, these units were organised into categories. In the third, these were classified into meaningful subcategories derived from the road safety context. Thematic analysis was then carried out [6, 7] using *NVivo* (QSR Ver.10).

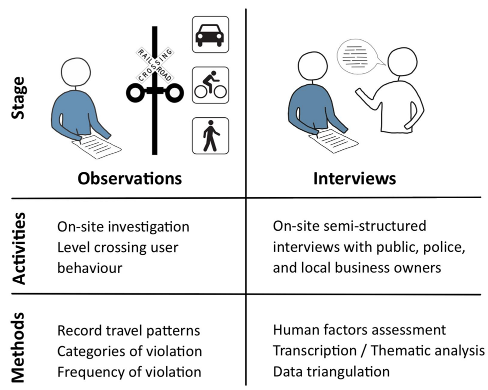

Figure 1 – Overview of methods

Aviation Road Rail Level Crossing

The RLX selected for study was in a rural town ~21km from Melbourne called Aviation Road Level Crossing (Figure 2). The RLX was located directly beside a train station and a Royal Australian Airforce (RAAF) military base, and designed with a single pedestrian maze on the west side to gain access to and from the base, station and small local business district. The RLX had 3-tracks with a maximum line speed of 130km/hour and road speed of 50 km/h. The average train traffic was 289 trains per day and the average road traffic was 16,456 vehicles per day (as at 5/2/2013). The road servicing the RLX was divided into two lanes with roundabouts situated in both directions (~20m away on either side). Stopping on the RLX was not permitted and yellow box marking/cross hatching was present on the RLX for southbound traffic to clearly indicate this though such marking was not present for northbound traffic. Yellow marking was also present at the southern roundabout but not at the northern roundabout. The RLX was representative of complex level crossings located in metropolitan areas around Australia where congestion and safety are issues. A Hobson's Bay Council survey found that the RLX was active (boom gates down) for ~two thirds of the morning and afternoon peak hours [8]. Various issues at the RLX had already been recognised such that the national Australian Level Crossing Assessment model ranks is as 16th highest risk and Victoria have added it to the list of 'marked for removal' crossings [9].

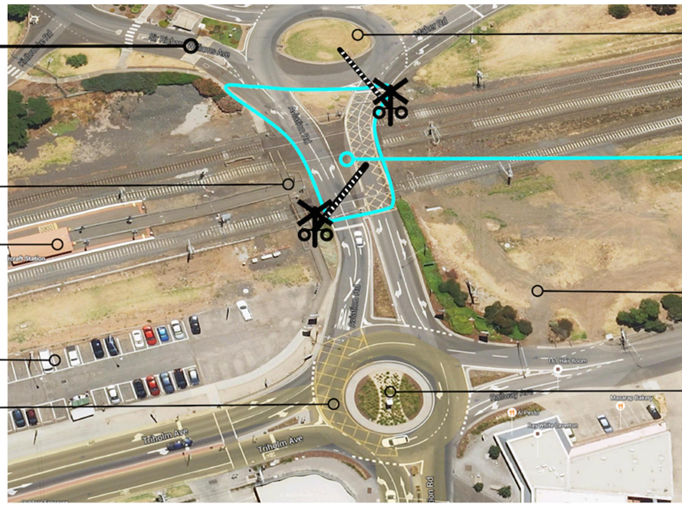

Figure 2: Topographical Google Earth view of the Aviation Road Rail Level Crossing

3. Results

More than 700 separate road user and pedestrian violations were recorded over the 2-day period. Table 1 shows the mean frequency count of the violation categories recorded by the researchers.

Table 1: Mean frequency count of road-user and pedestrian violations during peak and off-peak hours at Aviation Road Level Crossing over a 2-day period

Category	Peak			Off-peak			Total
	Road[1]	PED[2]	**Total**	Road[1]	PED[2]	**Total**	
Entering flashing lights (<2s after flashing starts)	10	3	**13**	8	-	**8**	**21**
Entering flashing lights (>2s after flashing starts)	26	41	**66**	11	13	**24**	**90**
Entering crossing before flashing lights have stopped flashing / booms have completely risen	18	1	**19**	35	1	**36**	**55**
Stopped on level crossing	91	-	**91**	107	-	**107**	**198**
Yellow box/hatching violation	66	-	**66**	105	-	**105**	**171**
Going around lowered boom gates	1	-	**1**	-	-	**-**	**1**
Going around/above No Entry gate	-	56	**56**	-	15	**15**	**71**
Cutting across the road	71	-	**71**	24	-	**24**	**95**
Bike riders not dismounting and going through pedestrian gates	-	1	**1**	-	2	**2**	**3**
Totals	283	102	**384**	290	31	**321**	**705**

[1]Violations on road mainly comprising road-users (e.g., cars, buses, motorcycles) and crossing pedestrians
[2]Violations on the pedestrianised areas, mainly comprising pedestrians but also cyclists

A total of 198 vehicles were stopped on the RLX (91 peak; 107 off-peak). A large number of flashing light violations was also observed. A third were carried out within 2s of activation. A total of 53 road-users (18 peak; 35 off-peak) were observed entering the RLX before the lights had stopped flashing, many before the gates were fully raised. The largest concentration of violation types for pedestrians was to go through flashing lights more than 2s after activation and via the no entry gates. Many pedestrians jaywalked under side rails and around the active boom gates. In general, the public at this RLX was not averse to placing themselves at risk in order to "beat" or catch an approaching train. Time stamping of activation/deactivation revealed that for every hour, the RLX was closed 11.3 times during the morning peak, 8.3 times during the off-peak, and 10.5 times during the early afternoon peak. There was large variability in closure times, largely from trains travelling at different speeds. Multiple trains often traversed the RLX at similar times and an average of 1.3 trains traversed the crossing per closure. During the morning peak, the RLX was closed for 1h 8 min out of a 2h window. The remainder of the day, the RLX was closed 20.5 min per hour. During the early afternoon peak, the RLX was closed 24 min per hour. Consequently, the RLX was closed for 59% of the time during morning peak hours, and 35% of the time during the off-peak and early afternoon peak. The RLX was activated at a set distance and did not account for whether the train would stop at the station. For this reason, platform work for non-express metropolitan services had the effect of activating the RLX for long periods; for one train traversal, the RLX was closed for ~2 min at a time (ranging from 1-to-4 min).

During interviews, participants were asked to describe the RLX in one word. Most responses were negative as shown in Figure 3 (words said more frequently are given greater prominence). Other unsolicited descriptions included *"it's pathological", "hectic," "crazy," "stupid," "ridiculous," "confusing."* The most commonly expressed feeling relating to the crossing was frustration: *"In the big scheme of things ten minutes doesn't sound like much but it is very frustrating sitting there not moving, waiting for a train, and you can't see any trains in either direction"* [Ppt_047]. Analysis identified several themes including congestion, safety, and violations. The following sections provide an account of these themes with excerpts were relevant.

Figure 3: Word cloud of 1-word descriptions of the RLX

3.1 Congestion

A key issue was the level of congestion around the RLX. Congestion in the morning was said to span ~2 km and cause hold-ups on the nearby freeway: *"They're in the exit ramp to the point they're actually stopped on the freeway; they've got nowhere to go […] it's massive."* [Ppt_043]. Almost all interviewees who used the RLX as motorists said they rarely travelled through it without having to stop and always experienced long delays in peak times. The cause of widespread congestion was considered to be the length of time the RLX was activated. Interviewees noted it was not unusual for the time between activation of the RLX and train arrival to be ~3 min. Added to this, the frequency of trains resulted in barriers remaining lowered for extended periods, "*You can sit there and you have three or four trains come through and you're just sitting there, sitting there, sitting there.*" [Ppt_017]. The view that train scheduling/frequency caused congestion was unanimous. Interviewees referred to the lag between RLX activation and train arrival: *"I find it strange that the barriers will be down for, I've never timed it but it feels like a good 2 or 3 min before a train arrives"* [Ppt_046]. The infrastructure and location of various road elements in relation to each other were also considered to cause of congestion: *"…I just think it's in a really bad location. And particularly the roundabouts and things near it"* [Ppt_042]. Pedestrian access to the military base increased congestion because drivers waited for pedestrians to cross when they entered the base and because people were required to show their passes at the security gate.

3.2 Safety

Safety of all RLX users was a major concern and risk-taking was considered high as a result of motorist frustration, lack of parking, and lack of facilities to assist pedestrians. Thus, the collision risk between trains and vehicles was also considered high, "*I've never seen any […] trains hit vehicles or anything at that particular crossing but you know it's almost just a matter of time*" [Ppt_044]. Accident potential at was also considered high as a result of motorists occupying the wrong lane to the direction they desired. This was considered deliberate, for example motorists driving in the wrong lane in order to *"push"* their way into the correct lane ahead of vehicles. However, interviewees also stated that it was often caused by unclear lane markings and lack of signage at the RLX, which led to confusion and uncertainty. The infrastructure itself was thought to be a major cause of safety risks. Insufficient and poorly located car parking was thought to increase danger for train commuters. The car park on the Southwestern side of the RLX was said to be at capacity early in the morning and commuters had taken to illegally parking in a vacant block of land on the opposite side of the road and walked to the station. The route from this area to the station did not include pedestrian crossings that allowed commuters to traverse to and from the train station safely or easily. When pedestrians weaved between cars to cross the road, they had to climb over or through a railing on the other side and had been seen to slip or fall when doing.

3.3 Violations

Almost all interviewees reported seeing violations committed frequently and admitted committing violations themselves. A risky action was to drive off after barriers had risen but lights were still flashing. Possible reasons given included frustration from having to wait, and not understanding the rules. This behaviour was not considered to be unsafe by some. Another key violation was failing to stop when lights had begun to flash just before barriers lowered. A reason given included frustration caused by delays incurred from train frequencies: *"…I'm the first car there and I think 'I know that if I don't go through now I'm going to be sitting here for sometimes 25 minutes.' It can take that long. I've counted. I think the most I've seen is 7 trains come through"* [Ppt_046]. Interviewees said they understood road rules such as not stopping on hatchings or on the tracks and roundabouts, and ensuring they used the correct lane for their destination. However they argued that it was unavoidable at times and were often caught out by actions of other road users.

Violations committed by pedestrians occurred throughout the day but especially during peak times. When the RLX was activated, a gate closed across the pedestrian pathway next to the track along which the train approached, preventing pedestrians from walking across the track. An emergency exit gate was available in case pedestrians were caught on the track when the pedestrian gate closed. However, pedestrians routinely use the emergency exit gate to bypass the pedestrian gate. Several interviewees stated that they committed this violation but checked for police or other authorities before doing so. It was also noted that once one person bypassed the pedestrian gates, a lot of other people do so too, *"They're like lemmings"* [Ppt_033]. Interviewees reported that motorists had occasionally committed violations by driving around lowered boom gates. The majority of these occurred when the RLX had been activated for an extended period of time (several minutes) without trains arriving. It had also occurred on occasions when the RLX was believed to be faulty. An extreme example reported by a police officer was an incident in which a group of people held up the barrier for others to drive under. Some cyclists also used the pathway despite a sign indicating that cyclists were not allowed to do so. Although this is a violation, one interviewee stated that he used the pathway because it was much safer than the road, because *"cars don't see bicycles"* [Ppt_030]. Almost all cyclists on the road went through the level crossing immediately as the barrier started to rise.

4. Discussion

The design and mobility in the environment (e.g. single lane approaches, roundabouts, desire to enter military base; desire to access freeway) caused delays that had far-reaching effects. A large number of unsafe acts were recorded where motorists drove through the RLX less than 2s after the lights started flashing. As there is no warning or caution signal at RLXs, this is a necessary period of grace as drivers cannot react and stop instantaneously. It may be argued that 2s is a very short period to allow in the absence of cautionary signals, but the road speed at the RLX is low. Based on the location of the roundabouts, build up of congestion, increase in frustration and motivation to avoid further delays, the period of grace was exploited. The findings show that multiple trains traversed the crossing at similar times with an average of 1.3 per closure. However, these times did not appear to be synchronised, and resulted in RLX closure over extended periods. This was because the gap between trains was not sufficient to reopen the gates and because trains tended to take so long to arrive. Thus when the RLX was open, many motorists had habituated to simply entering it in the expectation that they would make it across before the next train arrived in an attempt to avoid being held up. Risk-taking by pedestrians was frequent and, at times, highly dangerous, not only in terms of weaving between stationary cars but also crossing the road while vehicle traffic was moving, and walking alongside the track and standing next to it when trains were oncoming. Bypassing the pedestrian gate was also very common and people often engaged in this when a train was approaching. During interviews, several people who admitted bypassing the pedestrian gate argued that they were capable of making their own decisions about whether it was safe to cross. Taken together, the findings of this case study showed that the peculiarities associated with the context of the Aviation Road RLX created a specific type of culture, and conditions that primed chronic road congestion issues, lengthy waiting times, and a likelihood of transgressions/violations by all types of road user. However, while there were peculiarities at this crossing, the findings are likely to be general as they are related to congestion and frustration issues. Based on this, one may assume that a lot of RLXs on the same line are likely to have similar issues.

5. Conclusion

This study offers important insight into context specific issues associated with active RLX protection. The RLX reviewed was scheduled for grade separation during the study, making the case particularly valuable for upgrading problematic level crossings, and its broader generalisabilty.

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