# Public transport and level crossings

**SWOV Fact sheet, February 2021**

# Summary

This fact sheet describes the road safety aspects of public transport and of level crossings – places where road and rail networks intersect. Public transport vehicles comprise buses, trams, light rail vehicles and trains. This fact sheet relates to road casualties involving a public transport vehicle: suicide and casualties caused by a lack of social safety (violence in public transport) are not discussed. Apart from public transport and level crossings, the road safety of taxis is also addressed.

In number of registered casualties, public transport crashes compare favourably to private transport crashes. The actual number of public transport casualties is unknown, since the number of road deaths for each vehicle category (bus, train, tram/light rail) is not registered separately (by Statistics Netherlands). The registered[1] public transport crashes mainly involve crash opponents and much less often occupants of the public transport vehicles themselves. In 2010-2019, the police registered an average annual number of 21.2 road deaths in crashes *with* a bus, tram or train and only 0.6 road deaths *in* a bus, tram or train. Casualties among crash opponents mostly concern vulnerable road users (pedestrians, cyclists or (light) moped riders). To improve road safety of public transport several measures may be taken, such as infrastructural measures (safe layout of separate bus lanes and tram tracks, safe level crossings), proper maintenance of the public transport infrastructure, a more crashworthy design of bus, train, or tram fronts, or systems that facilitate emergency stops. For occupants, safety may be improved by a crashworthy interior.

A relatively large number of train crashes occur at unprotected crossings of passenger routes, where barriers or warning lights are missing. Before 2028, ProRail aims to abolish all unprotected crossings by protecting them, turning them into split-level crossings or making them inaccessible to the public. To improve safety around the railway tracks, rules concerning hazardous road user behaviour are enforced by a.o. use of smart cameras.

Since not much recent research about public transport safety is available, we sometimes had to revert to somewhat older studies. The transition toward self-driving cars may have consequences for public transport safety; for example when self-driving shuttles take over some of the public transport routes.

1. BRON figures (Bestand geRegistreerde Ongevallen in Nederland, police crash registration Netherlands). Note: this register is incomplete).

# 1 How many casualties are caused by public transport crashes?

The actual number of public transport casualties is unknown, since the number of road deaths for each vehicle category (bus, train, tram/light rail) is not registered separately (by Statistics Netherlands). The registered[2] public transport crashes mainly involve crash opponents and much less often occupants of the public transport vehicles themselves. Thus, in 2010-2019, the police registered an average annual number of 21.2 road deaths in crashes *with* a bus[3], tram or train and only 0.6 road deaths *in* a bus, tram or train.

Road deaths in crashes with a bus, tram or train as crash opponent mostly concerned vulnerable road users (mainly pedestrians or cyclists; see *Figure 1*).

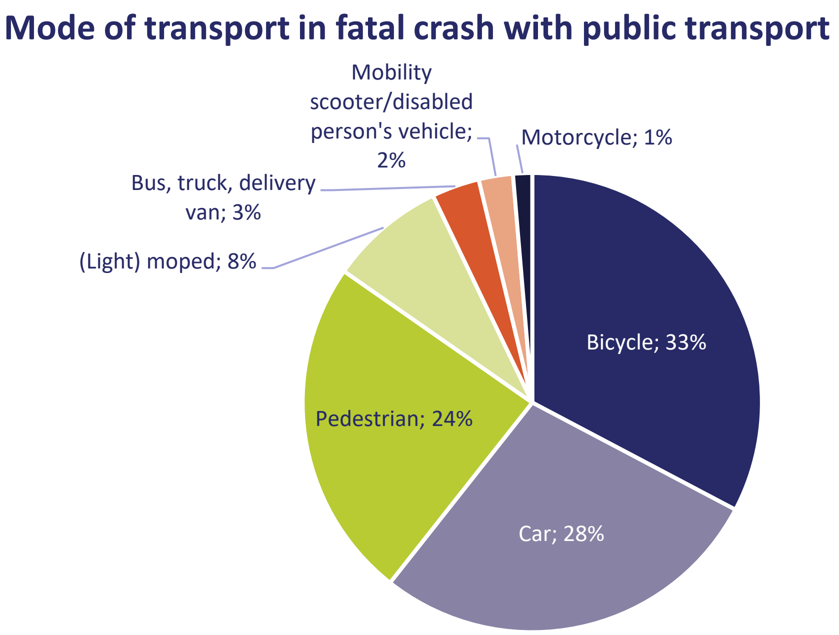


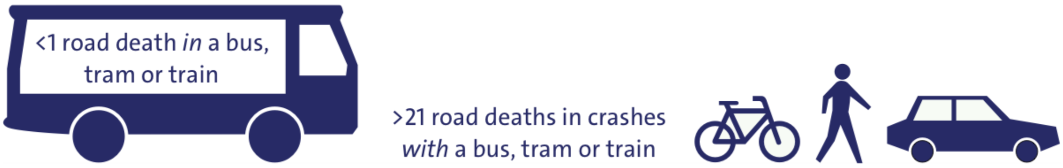

*Figure 1. Distribution of the registered number or road deaths by mode of transport in crashes with a bus[iii], tram or train as crash opponent in 2010 – 2019.*

Since 2009, the number of serious road injuries has been too unreliable to determine. What we do know is that fewer serious road injuries are sustained *in* a bus, tram or train, than in crashes *with a bu*s, tram or train [1] [2].

[2] BRON figures (Bestand geRegistreerde Ongevallen in Nederland, police crash registration Netherlands). Note: this register is incomplete).

[3] Excluding coaches.

Average annual number of road deaths in public transport crashes




# 2 How safe is public transport compared to private transport?

Using public transport is much safer than using private transport. When considering the number of registered road deaths per billion kilometres travelled in 2009-2017, the risk of sustaining fatal injuries is significantly higher for private transport (bicycle, (light) moped, motorcycle, car) than for public transport (see *Table 1*). At the same time, public transport vehicles do cause a relatively large number of serious injuries and road deaths among crash opponents (also see the question *How many casualties are caused by public transport crashes?*).

*Table 1. The risk of fatal road injuries by mode of transport per billion kilometres travelled (2009 – 2017)*[4]*. Sources: Statistics Netherlands (mobility data) and BRON (registered road deaths).*

| Mode of transport | Kilometres travelled (billion) | Road deaths | Risk of fatal injuries (road deaths per billion kilometres travelled) |
|---|---|---|---|
| Pedestrian | 42.591 | 523 | 12.28 |
| Bicycle | 132.413 | 1,203 | 9.09 |
| (light) moped | 9.718 | 457 | 47.02 |
| Motorcycle | 8.673 | 451 | 52.00 |
| Car | 1,204.534 | 1,929 | 1.60 |
| Bus (public transport only) | 36.178 | 4 | 0.11 |
| Train/tram | 161.147 | 1 | 0.01 |

For passengers, travelling by public transport is the safest option, although they do have to walk or cycle to and from a bus stop or station. Compared to driving, walking and cycling are relatively risky modes of transport. Sometimes, pedestrians are in a rush to catch a bus, cross the road too carelessly and get hit by a motorised vehicle [3].

4. Because of a trend break in mobility data (ODiN) since 2018, a more recent survey of the risks (covering a prolonged period) cannot be provided.

# 3 Which crash types involving buses and trams are most common?

In crashes with buses and trams, most casualties occur among crash opponents. This mainly concerns vulnerable road users (especially pedestrians and cyclists; also see the question *How many casualties are caused by public transport crashes?*).

Unfortunately, information about public transport crash types, other than train crashes, can only be found in older studies. In an exploratory study of the 1999-2002 crash files of Connexxion (a Dutch (sub)urban public transport company), the following five crash types were identified [4]:

1. Crashes on (separate) bus lanes.
2. Blind spot crashes.
3. Braking buses resulting in rear-end collisions.
4. Driver distraction resulting in a crash; This crash type mainly caused casualties among crash opponents and sometimes also among those aboard the bus.
5. Crashes without crash opponents, but resulting in injuries of people on board.

In a study of tram crashes in Amsterdam, Rotterdam, The Hague and Utrecht, the following three crash types are mentioned [5]:

1. Crashing with left-turning traffic or with road users who are unfamiliar with their environment and are therefore searching for their destination, resulting in inattentiveness.
2. Drivers, cyclists and pedestrians ignoring red traffic lights.
3. Crashes with pedestrians and cyclists who, while crossing, do not hear or see the tram coming, either on the tram track or in mixed traffic areas (sometimes because they are listening to music or using their mobile phones).

# 4 Is the public transport infrastructure (bus lanes, tram tracks, stops) safe?

Registered crashes show that particularly vulnerable road users are involved in public transport crashes. For that reason, locations shared by buses/trams and vulnerable road users are most risky.

Bus and tram stops are a weak part of the public transport infrastructure in terms of road safety. 1998 research of tram crashes shows that, in order to catch the tram, pedestrians cross the road at the location of the tram stop and do not always use pedestrian crossings [6]. To discourage such 'illegal' crossing behaviour, fences are often installed between the stop tracks. This tram stop layout is not always uniform [7], which runs counter to one of the principles for safe road design (see SWOV Fact sheet *Principles for safe road design*). Design uniformity strengthens the recognisability and predictability of traffic and helps reduce human errors [8].

Tram rails are hazardous for – especially – cyclists. Their bicycle wheels may slip into the rails and they may take a fall. Other (or motorised) two-wheelers may skid on the slippery tracks in wet weather conditions [9] [10].

In Melbourne, research has shown that buses are less often involved in crashes when they drive on designated bus lanes (mostly at the right side of the road [11]). Designated tram tracks and bus lanes seem safer than roads which allow trams and buses to mingle with other traffic [12]. At the same time, drivers turning into a side street may run into conflict with buses, and pedestrians will have to cross a wider road which leads to a higher risk. In addition, sufficient space for widening the road to create a bus lane is not always available [11]. When building a bus lane it is important to limit speed differences between buses and other road users and to safeguard interaction between buses and other, mainly vulnerable, road users (such as pedestrians and cyclists [12].

# 5 What are the main factors in crashes with trams and buses?

## Vehicle size

A public transport vehicle is intended to transport several people and is therefore relatively large and heavy. For that reason, crash opponents, often vulnerable ones, sustain more serious injuries in crashes involving a bus or tram [13] [14] [15]. The design of the bus or tram front also affects injury severity. The (relatively) flat fronts of buses and trams increase injury severity, as casualties slam into the steal fronts or glass windscreens at high speed [14] [16]. In addition, public transport vehicles have a longer braking distance than other motor vehicles because of their weight and, in the case of trams, because of the smooth surface of the rails [1]. Finally, a rail vehicle (tram or train) cannot swerve to avoid collision[14].

On account of its size, a tram or bus may also indirectly be involved in road crashes by blocking the sight lines of other road users. In 1997-2002 police reports of crashes near Paris, one of the the crash scenarios was that of a car overtaking a bus and overlooking a pedestrian [3].

## Separate priority rules for trams

Not all road users are well aware of the priority rules for trams being different [6]. If priority is not regulated by road signs or signals, trams always have right of way over other traffic. In 70% of tram crashes, research dating back to 2000 shows that crash opponents did not give the tram right of way, nor let it pass [1]. Warning signals, if sounded too late or too early, are not heeded and conflicting signals trigger incorrect reactions [7].

# 6 What are the most important factors in train crashes?

Trains have a longer braking distance than other motor vehicles because of their weight and the smooth surface of the rails [1]. In addition, a train cannot swerve to avoid collision[14].
The main causes of train crashes involving slow crossing traffic (pedestrians, ((light) mopeds, cyclists and mobility scooters) are: 1) passing around or under closed or closing barriers, not being fast enough (60%); 2) falling down and/or vehicle problems (30%). The main causes involving fast traffic are: 1) stopping or stranding on the level crossing (60%); 2) passing under or around closed barriers (25%); and 3) crossing too slowly (5%). At train stations, travellers are sometimes hit by a passing train [17]. Crashes at level crossings that are merely light-controlled are mainly caused by a failure to notice the level crossing or the flashing light, and/or the train on time (68%) [18]. Also see the question *How (un)safe are level crossings?*.

# 7 Why are seatbelts not mandatory in public transport?

In the urban area, seatbelts are not mandatory in public transport buses [19], because other considerations than safety apply. Frequent boarding and alighting make it impractical to require passengers to wear seatbelts. Seatbelt requirements would also prohibit standing passengers and adversely affect the transport capacity of buses, trams or trains [20]. Seatbelts are, however, required in coaches and in buses that drive ≥ 100km/h. Not much is known about the safety benefits of seatbelts in trams and buses. Mathematical models and simulation models resulted in estimates that wearing (especially three-point) seatbelts in buses may reduce injury severity in case of a roll-over crash, provided all occupants wear them properly [21]. No account was taken of possible injuries sustained because of the seatbelts. An analysis of train crashes showed that seats with seatbelts possibly increase injury risk, compared to seats without them [22].

# 8 Are seated passengers safer than standing passengers?

In trains, trams and buses, passengers are allowed to either stand or sit down. In the event of a major brake delay, standing passengers run a higher risk of taking a fall and getting hurt than seated passengers, and older standing passengers even more so [23]. In public transport, major brake delays occur less often than in cars. This is because of the weight (mass) of the public transport vehicle and because of the smooth surface of tram and train rails.

A review, mostly based on studies of falls in buses and other public transport, shows that, in a bus or tram, the risk of a fall and subsequent injury (not following a crash) is relatively low: only 0.3-0.5 travellers per million kilometres take a fall [24]. Older bus passengers do run an increased risk of serious injuries after a fall [25]. Older standing passengers more often take a fall than younger passengers, not only when the bus suddenly brakes, but also when it accelerates, particularly soon after boarding [26]. Some driver manoeuvres, such as pulling away, overtaking, changing lanes, and turning appear to increase the risk of more serious injuries for standing passengers [25].

# 9 Is crash risk relatively high for taxi or Uber drivers?

Research into taxi crashes in 2001-2018 shows that the number of serious taxi crashes increased from 2015 to 2018, particularly in cities such as Amsterdam and Utrecht [27]. Young taxi drivers do not prove to be overrepresented. A possibly higher risk for Uber drivers could not be determined. Uber taxis were included in the selected crashes, but the analysis could not distinguish between different types of taxi providers [27].

# 10 How (un)safe are level crossings?

From 2012 to 2016, Prorail registered an annual average of 32 railway crashes; they accounted for an annual average of 13 fatalities or serious injuries [18]. The Netherlands thus take fifth place in a list of 28 safest railway countries (of all EU countries, plus Switzerland and Norway), after corrections for the number of train kilometres and population density [18].

*Table 2* shows the number of railway crashes for passenger lines, which are responsible for almost all fatalities and serious injuries (97% in 2012-2016), identified by the extent to which the crossing is protected.

*Table 2. Number of level crossings, crashes and fatalities for passenger lines*[5].

| Crossing category (passenger lines) | Number of railway crossings | | Annual number of crashes | | Annual fatalities and serious injuries | |
|---|---|---|---|---|---|---|
| Protected by lights and barriers | 1507 | 63% | 20.8 | 65% | 10.6 | 79% |
| Protected by lights only | 19 | 1% | 0.2 | 1% | 0 | 0% |
| Unprotected –public level crossing | 117 | 5% | 3.2 | 10% | 2.2 | 16% |
| Unprotected private level crossing | 214 | 9% | 0.6 | 2% | 0.2 | 2% |
| Total number of passenger lines | 1857 | 78% | 24.8 | 78% | 13.0 | 97% |

In 2012-2016, most road casualties occurred at Active Level Crossings (ALCs; see *Figure 3*). But, relatively speaking, more casualties occurred at Passive Level Crossings (PLCs; *Figure 3*) in that same period. Passive level crossings accounted for approximately 16% of all railway deaths and serious injuries, while PLCs made up only 5% of the main railway network (see *Table 2)*. When the railway intersects with a private road, electric fences and St Andrew's crosses[6] are often missing; however, on these roads crossing traffic is extremely limited.

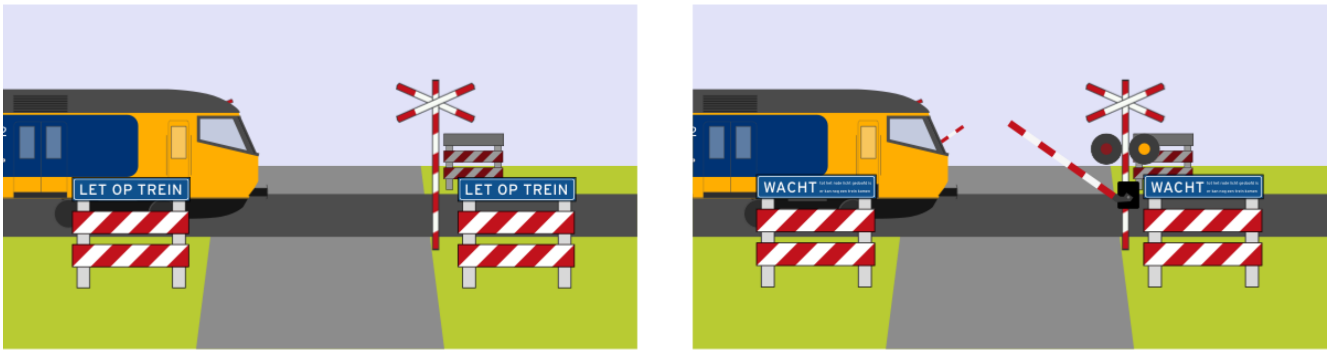



*Figure 2. Left: illustration of a Passive Level Crossing (PLC), usually only protected by St Andrew's crosses*[6] *and warning signs. Right: illustration of an Active Level Crossing (ALC) protected by (half) barriers, St Andrew's crosses, warning signs, sound and light alarms.*

In defiance of barriers and warnings, travellers still cross the railway quite frequently. Also see the question [*What measures are taken to improve road safety around railway tracks?*]

5. Table 2 originates from research by the Dutch Safety Board [18]. The number of level crossings is the mid-2017 number, the annual number of crashes/casualties are averages for 2012-2016. The percentages (per column) are expressed as values for the entire main railway network (passenger lines and freight lines combined: 2.375 level crossings, annual number of casualties for the entire railway network 13,4).
6. A St Andrew's Cross is a red/white cross indicating the number of tracks at a level crossing, each cross indicates one track.

# 11 What measures are taken to improve road safety around railway tracks?

Several measures are taken to improve road safety around railway tracks. The Ministry of Infrastructure and Water Management and Prorail are working on two programmes to improve railway safety: the PLC programme and the National Level Crossing Improvement Programme (NLCIP) [17] [18](see below). Furthermore, the frequently used Flitsmeister app now also warns drivers when they approach a passive level crossing which is known to be hazardous [28].

## PLC programme – approach to unprotected level crossing

The purpose of the PLC programme (PLC = Passive Level crossing; NABO in Dutch = Niet Actief Beveiligde Overweg) is to protect or abolish all public PLCs for passenger lines before 2028, or to render them publicly inaccessible [18]. The crossings will be protected (33%), will be turned into split-level crossings (16%), will be abolished (47%) or rendered publicly inaccessible (4%) [17] [18]. Abolishing unprotected level crossings will probably prevent most PLC crashes and casualties, even if the safest level crossing is one at which road users cross a railway track at split-level. Or as ProRail concluded: ‘the safest level crossing is no crossing’ [29].

## NLCIP

The NLCIP (NLCIP = National Level Crossing Improvement Programme; LVO in Dutch = Landelijk Verbeterprogramma Overwegen) aims to improve level crossings throughout the Netherlands by e.g.: optimising closure periods (the time a level crossing is closed), influencing traveller behaviour, making level crossings more conspicuous, or by offering a safe way out to individuals caught between closed barriers [30]. In 2018, Prorail started a pilot with smart cameras at two level crossings in the town of Hilversum to facilitate fining for misconduct at level crossings. The cameras are able to observe deviant behaviour, such as red light negation or stopping on the level crossing. Most fines (80%) were imposed for red light negation. In addition, drivers regularly stop on the level crossing or drive onto it while traffic at the other side is jammed [31]. Every week, enforcement activities take place at different level crossings throughout the country to fine pedestrians and cyclists for dangerous behaviour (a.o. slalom behaviour, walking or riding around closed half-barriers) [31].

# 12 What measures may improve road safety of buses and trams?

Several measures may improve road safety of public transport. They may be subdivided into three categories: infrastructure, vehicle, and behaviour.

## Infrastructure

Sustainable Road Safety advises to align traffic flows and modes of transport in speed, direction, mass, size and degree of protection (also see SWOV fact sheet *Sustainable road safety*). The objective is to design the traffic environment in such a way that serious crashes are prevented, and to reduce injury severity when crashes are inevitable. The weight and size of public transport vehicles requires them to be separated from slow and vulnerable road users to a maximum extent. This will be achieved by creating well-situated, designated bus lanes and tram tracks. At locations where the road is shared, reliable and timely tram alert facilities could also improve safety [7]. In principle, buses should be allowed to stop on the carriageway on low-speed roads. Each bus stop should, however, be examined for road safety consequences (for example: does a stop location leave enough space for other traffic to pass?). If not, creating a bus bay may be a solution [32].

Masking effects along a track or road which may cause public transport drivers to overlook vulnerable road users should be remedied. Crossing a bus lane or tram track may also be discouraged (by a gravel or grass bed between tram tracks and/or fences between tracks/bus lanes) [5] [6].

Finally, infrastructure maintenance is also important. When servicing tracks, switch breaks and defects or track twists should be noticed and repaired on time [33] [34]. Such anomalies could result in derailments and, thus, in crashes.

## Vehicle

Appropriate design of (the front of) public transport vehicles could limit injury severity for vulnerable road users. A pedestrian will be left with fewer injuries if the tram front does not have protruding elements, if there is enough space underneath the tram and if the tram has underrun protection [16]. Passengers could be protected by chairs that do not have protruding or sharp elements, and by soft and yielding arm and back rests [4].

Public transport vehicles are often equipped with systems to reduce crash risk. Trams are equipped with an automatic sanding system that sands the rails in case of an emergency stop, which increases friction and reduces braking distance [14]. Truck drivers are supported by systems for blind spot detection and signalling, which allow them to detect cyclists and pedestrians around the blind spot of their trucks [35]. These systems could also increase the road safety of (public transport) buses and trams. Finally, automatic pedestrian detection could improve the road safety of buses and trams as well [36].

### Behaviour

For the safety of public transport passengers, drivers should avoid manoeuvres that increase the risk of a fall, such as sudden acceleration, taking sharp turns, and heavy braking [25]. Misconduct by road users on level crossings should be discouraged and fined with the help of more smart cameras and by drawing attention to the dangers by a public service campaign (also see the question *What measures are taken to improve road safety around railway tracks?*).

# Publications and sources

**Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.**


[1]. RvTV (2000). *Veiligheidsrisico's van de Nederlandse stadstram*. Raad voor de Transportveiligheid, Den Haag.

[2]. Temürhan, M. & Stipdonk, H.L. (2016). *Touringcars en verkeersveiligheid. Vergelijking van de veiligheid van bussen met auto's [Coaches and road safety. Safety of coaches and cars compared]*. R-2016-18 [Summary in English]. SWOV, Den Haag.

[3]. Brenac, T. & Clabaux, N. (2005). *The indirect involvement of buses in traffic accident processes*. In: Safety Science, vol. 43, nr. 10, p. 835-843.

[4]. Davidse, R.J., Mesken, J. & Schoon, C.C. (2004). *Ongevallen met bussen. Een verkennende studie aan de hand van Connexxion-dossiers [Accidents with busses. An exploratory study using Connexxion files]*. D-2003-14 [Summary in English]. SWOV, Leidschendam.

[5]. Stoop, J.A.A.M. (2008). *Onderzoek en interviews veiligheid stadstrams*. Kindunos Veiligheidskundig Adviesbureau B.V. in opdracht van ministerie van Verkeer en Waterstaat, DGP, Gorinchem.

[6]. Arcadis (1998). *Overweg met de sneltram. Onderzoek naar de veiligheid van sneltramkruisingen*. Eindrapport 672/CE98/1733/13479. Arcadis in opdracht van Ministerie van Verkeer en Waterstaat, Directoraat Generaal Goederenvervoer, Rijksverkeersinspectie (RWS, DGG, RVI), Den Haag.

[7]. Roeleveld, R.M. (2017). *Botsende concessies: een onderzoek naar structurele oorzaken van incidenten tussen trams en zwakkere verkeersdeelnemers binnen het vervoersgebied van HTM*. Contribution to the Nationaal verkeerskundecongres 2017, 1 november 2017, Zwolle.

[8]. Schagen, I.N.L.G. van & Aarts, L.T. (2018). *DV3 – Huidige situatie, maatschappelijke trends en wensbeelden. Kader voor de visie Duurzaam Veilig Wegverkeer 2018-2030 [Sustainable Safety version 3 – current situation, societal trends and ideals. Framework for the second advanced*

*Sustainable Safety vision for the period 2018-2030*. R-2018-6A [Summary in English]. SWOV, Den Haag.

[9]. Hertach, P., Uhr, A., Niemann, S. & Cavegn, M. (2018). *Characteristics of single-vehicle crashes with e-bikes in Switzerland*. In: Accident Analysis & Prevention, vol. 117, p. 232-238.

[10]. Maempel, J.F., Mackenzie, S.P., Stirling, P.H.C., McCann, C., et al. (2018). *Tram system related cycling injuries*. In: Archives of orthopaedic and trauma surgery, vol. 138, nr. 5, p. 643-650.

[11]. Goh, K.C.K., Currie, G., Sarvi, M. & Logan, D. (2014). *Bus accident analysis of routes with/without bus priority*. In: Accident Analysis & Prevention, vol. 65, p. 18-27.

[12]. Zwerts, E., Keppens, M., Adriaensen, J., Mol, J. de, et al. (2009). *Verkeersveiligheid op vrije tram-en busbanen*. Universiteit Gent. Instituut voor Duurzame Mobiliteit, Gent / ARCADIS Belgium, Antwerpen.

[13]. CROW (2007). *Leidraad inpassing trams in stedelijk gebied: is de uitzonderingspositie van de tram qua snelheid en voorrang houdbaar bij Duurzaam Veilige inrichting?* Publicatie No. 249. CROW Kenniscentrum voor verkeer, vervoer en infrastructuur, Ede.

[14]. RvTV (2003). *De 'vrije' trambaan. Veiligheidsstudie tramongevallen: botsveiligheid, infrastructuur en de bestuurlijke factoren*. Raad voor de Transportveiligheid, Den Haag.

[15]. Nævestad, T.O., Elvik, R., Milch, V., Karlsen, K., et al. (2020). *Trafikksikkerhet i busstransport: En analyse av kravene som Ruter stiller til bussoperatørene i kontrakter*. Transportøkonomisk institutt, Oslo.

[16]. Weber, T., Muser, M. & Schmitt, K.U. (2015). *Optimising the design of tramways to mitigate injury risk in pedestrian impacts*. In: IRCOBI Conference Proceedings.

[17]. ILT (2018). *Veiligheid op het spoor. Jaarverslag Spoorwegveiligheid 2017*. Inspectie Leefomgeving en Transport, Ministerie van Infrastructuur en Waterstaat, Den Haag.

[18]. OvV (2018). *Overwegveiligheid. Een risicovolle kruising van belangen*. Onderzoeksraad voor Veiligheid, Den Haag.

[19]. Rijksoverheid (2020). *Wanneer moet ik de autogordel gebruiken?* Ministerie van Infrastructuur en Waterstaat. Accessed on 10-04-2020 at https://www.rijksoverheid.nl/onderwerpen/verkeersveiligheid/vraag-en-antwoord/wanneer-moet-ik-de-autogordel-gebruiken.

[20]. NRC.nl (2017). *Waarom hoef je geen gordel om in bus en trein?* Accessed on 18-02-2020 at https://www.nrc.nl/nieuws/2017/03/07/waarom-hoef-je-geen-gordels-om-in-bus-en-trein-7153759-a1549173.

[21]. Albertsson, P., Falkmer, T., Kirk, A., Mayrhofer, E., et al. (2006). *Case study: 128 injured in rollover coach crashes in Sweden—Injury outcome, mechanisms and possible effects of seat belts*. In: Safety Science, vol. 44, nr. 2, p. 87-109.

[22]. RSSB (2007). *Passenger containment: a review of research carried out by RSSB on behalf of the rail industry and core recommendations*. Rail Safety and Standards Board (RSSB) Limited, London.

[23]. Asociación RUVID (2012). *Safety of standing passengers in urban buses*. ScienceDaily. Accessed on 18-02-2020 at www.sciencedaily.com/releases/2012/10/121022080357.htm.

[24]. Elvik, R. (2019). *Risk of non-collision injuries to public transport passengers: Synthesis of evidence from eleven studies*. In: Journal of Transport & Health, vol. 13, p. 128-136.

[25]. Li, D., Zhao, Y., Bai, Q., Zhou, B., et al. (2017). *Analyzing injury severity of bus passengers with different movements*. In: Traffic injury prevention, vol. 18, nr. 5, p. 528-532.

[26]. Silvano, A.P. & Ohlin, M. (2019). *Non-collision incidents on buses due to acceleration and braking manoeuvres leading to falling events among standing passengers*. In: Journal of Transport & Health, vol. 14, p. 100560.

[27]. Aarts, L.T. & Bos, N.M. (2019). *Ernstige verkeersongevallen met taxi's. Een analyse over de periode 2001-2018 in Nederland en een aantal Nederlandse gemeenten*. R-2019-12. SWOV, Den Haag.

[28]. AD (2019). *Flitsmeister waarschuwt nu ook voor gevaarlijke overwegen*. Algemeen Dagblad. Accessed on 17-02-2020 at https://www.ad.nl/binnenland/flitsmeister-waarschuwt-nu-ook-voor-gevaarlijke-overwegen~a683558f/.

[29]. Volkskrant (2018). *ProRail gaat op eigen initiatief onbewaakte overwegen afsluiten*. Volkskrant. Accessed on 27-03-2020 at https://www.volkskrant.nl/nieuws-achtergrond/prorail-gaat-op-eigen-initiatief-onbewaakte-overwegen-afsluiten~b61b3b6a/.

[30]. ProRail (2018). *Jaarverslag 2017. Verbindt. Verbetert. Verduurzaamt*. ProRail B.V., Utrecht.

[31]. ProRail (2019). *Slimme camera's tegen gevaarlijk gedrag op overwegen*. ProRail. Accessed on 18-02-2020 at https://www.prorail.nl/nieuws/slimme-camera-s-tegen-gevaarlijk-gedrag-op-overwegen.

[32]. CROW (2010). *Addendum Handboek Halteplaatsen*. CROW publicatie 233. CROW Kenniscentrum voor verkeer, vervoer en infrastructuur, Ede.

[33]. OvV (2008). *Ontsporingen bij RandstadRail*. Onderzoeksraad voor Veiligheid OvV, Den Haag.

[34]. SpoorPro (2019). *Prorail vreest spoorspattingen door hitte*. SpoorPro. Vakblad voor de spoorsector. Accessed on 18-02-2020 at https://www.spoorpro.nl/spoorbouw/2019/06/24/prorail-vreest-spoorspattingen-door-hitte/?gdpr=accept.

[35]. Connekt (2010). *Dodehoek Detectie- en Signalerings Systemen (DDSS): Onderzoek naar de werking en de mogelijkheden*. Connekt, Delft.

[36]. Sirry, A.M., Kargbo, A., Martinovic, D., Luga, F., et al. (2018). *Autonomous pedestrian detection in transit buses*. Worcester, Worcester Polytechnic Institute.

# Colophon

**Reproduction is allowed with due acknowledgement:**
SWOV (2021). *Public transport and level crossings*. SWOV Fact sheet, February 2021. SWOV, The Hague.

**URL Source:**
https://www.swov.nl/en/facts-figures/factsheet/public-transport-and-level-crossings

**Topics:**
Transport mode - Other modes of traffic; Infrastructure

**Figures:**
---

**Prevent** crashes
**Reduce** injuries
**Save** lives

**SWOV**

**SWOV Institute for Road Safety Research**

PO 93113

2509 AC The Hague

Bezuidenhoutseweg 62

+31 70 317 33 33

info@swov.nl

www.swov.nl

**@swov** / @swov_nl

**linkedin.com**/company/swov