DUTCH
SAFETY BOARD

Level crossing safety

a hazardous intersection of interests

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The Hague, July 2018

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The Dutch Safety Board

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CONSIDERATIONS

Level crossings are dangerous

Level crossings are a familiar but also dangerous component of the Dutch landscape. Level crossings are an at-grade intersection between a railway line and a road, where the train always has priority. They originate from a time when trains ran slowly, there was limited road traffic and crossing-keepers fully closed the track by hand for safety. The crossing-keepers are gone now, trains have become much faster and quieter and there is much more road traffic crossing the railway. Trains travel at 140 km/h and it is impossible for them to stop in time or take evasive action. Collisions with pedestrians, cyclists or drivers are often fatal.

Focus on level crossing safety is waning

There are approximately 30 level crossing collisions every year and 11 people unintentionally lose their lives in level crossing accidents. This is fewer than 15 years ago, when the Dutch Transport Safety Board published a critical report on level crossing safety. The Safety Board believes this improvement in safety is positive but notes that the focus on and ambitions for level crossing safety at the responsible Ministry have waned: since 2010, the Ministry of Infrastructure and Water Management has not had a concrete objective for reducing the number of level crossing casualties and, moreover, local authorities are expected to pay 50% of the costs, even though they have no formal responsibility for level crossing safety. In a recent letter to the House of Representatives,[1] the State Secretary for Infrastructure and Water Management wrote about releasing more funds to tackle level crossings, which the Safety Board considers a positive development.

Nonetheless, the State Secretary wrote that she is sticking to the policy currently being pursued. This does not resolve the protracted administrative impasses that arise when improving level crossing safety – which the Dutch Transport Safety Board also noted 15 years ago. All of this is reflected in the figures: the curve for the number of level crossing casualties is levelling off, while it was clearly downwards prior to 2010.

The Ministry's attention is not appropriate for the situation on the Dutch railways.
The Netherlands is the only country in Europe with both a high volume of train traffic and a large number of level crossings, a combination that does not go well together. Moreover, the volume of traffic will only increase further on both the road and the railway. The Safety Board therefore expects the State Secretary for Infrastructure and the Environment will continue to work ambitiously on reducing the number of level crossing casualties. To achieve this, she must protect all unprotected level crossings in the short term, make the level crossings that are already protected even safer and significantly reduce the number of level crossings.

1 Letter to the House of Representatives, reference IENW/BSK-2018/57341.

Unprotected level crossings must be protected more quickly

Given the high speed at which trains currently travel, the Safety Board believes that unprotected level crossings are unacceptably dangerous. The likelihood of an accident at these level crossings is much greater than at protected level crossings because the road user is not warned of an approaching train and there is no physical barrier at all between the road and the railway. Therefore, the remaining unprotected level crossings must be protected as quickly as possible. However, the current policy encourages protracted discussions between the parties involved, as a result of which removing or modifying these level crossings is a very slow process. Unprotected level crossings must be tackled within a few years under a policy that does not become bogged down by substantive and financial discussions.

Protected level crossings must become even safer

There is also work to be done on the protected level crossings. The Safety Board has noted that the majority of accidents occur at protected level crossings. This is not because they are less safe than unprotected level crossings but because they represent the majority of level crossings and handle the majority of the road traffic. It is not as easy to improve the safety of protected level crossings as it is to improve the safety of unprotected level crossings. Nevertheless, the number of level crossing casualties and the severity of them can be reduced by providing additional safety measures at protected level crossings, which are based on the lessons learned from the proper investigation of accidents. However, the Safety Board notes that a significant proportion of the budget made available is being spent on a limited number of level crossings. At the same time, the Safety Board notes that all parties involved can learn more lessons from level crossing accidents. They should also study the approach of Switzerland and the United Kingdom who perform much better than the Netherlands in terms of level crossing safety.

Fewer level crossings means fewer accidents

New railway lines are being constructed without level crossings and no new level crossings are being built on existing railway lines. The Safety Board is amazed that there is no similar policy for the existing level crossings. This calls for an ambitious plan for reducing level crossings in the upcoming decades, taking account of the need of road users to reach the other side of the railway.

Responsibility

A further reduction in the number of level crossing casualties is necessary and achievable. In the long term, it is even possible for there to be no level crossing accidents. However, this will not be achieved with the current policy. Current policy is insufficiently ambitious and lacks vision. Furthermore, there is little understanding of where responsibility for level crossing safety is vested. The State Secretary has indicated that this is not her responsibility; it is ProRail's. Apart from the fact that the Ministry has not explicitly delegated this responsibility to ProRail, the Ministry retains ultimate responsibility for safety of the railways and the level crossings in any event. The outside world is given to understand that level crossing accidents are primarily attributable to the reckless behaviour of road users. However, research by the Safety Board has revealed that this is not the case in the majority of accidents. Moreover, this type of qualification creates the impression that many level crossing accidents cannot be prevented.

The Safety Board expects the State Secretary for Infrastructure and Water Management to ensure a significant reduction in the number of level crossing casualties through a targeted and ambitious level crossing policy.

RECOMMENDATIONS

The Dutch Safety Board has formulated the following recommendations.

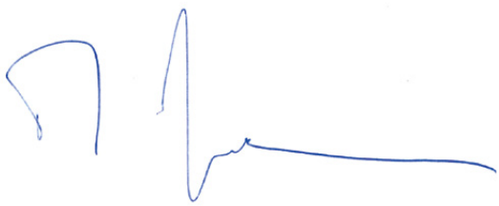
To the State Secretary for Infrastructure and Water Management:

1. **Within six months, merge the existing level crossing programmes (LVO and NABO) into a single overarching level crossing policy. With this policy, halve the number of level crossing accidents and level crossing fatalities within 10 years and reduce it to zero as quickly as possible.**
   The ultimate objective of the level crossing policy should be that there are no more level crossing accidents and no more level crossing casualties. The Safety Board considers it to be unacceptable that 11 people lose their lives every year on the government's rail network.

2. **Improve level crossing safety by basing the policy on:**
   a. Measures from other countries that have proved to be worthwhile, both in relation to the level crossing protection used, the number of level crossings and the administrative relationships.[2]
   b. An independent and scientifically underpinned analysis of the factors that play a role in level crossing safety and the demonstrable effectiveness of available measures.
   c. Integral accident investigation following an accident, by the rail network manager and road manager together, examining the factors in the accident (including the reason for the behaviour of level crossing users).

2 Paragraph 3.2 shows a number of examples of measures from other countries.

3. **Legally stipulate who is responsible for what and bears the costs for level crossing safety.**
   Administrative impasses about the desired solution and the funding for it were also raised by the predecessor to the Safety Board in 2003. The recommendation to resolve these impasses, made at that time to the Minister for Transport, Public Works and Water Management, has not been followed up. The Safety Board believes there is an urgent need for this to be done now, as part of the ongoing modernisation of railway legislation for example.



T.H.J. Joustra
Chairman Dutch Safety Board

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Secretary Director

TERMS AND DEFINITIONS USED

AHOB	Automatic Half Barriers (*automatische halve overwegbomen*)
EU	European Union
I&W	Infrastructure and Water Management (*Infrastructuur en Waterstaat*)
ILT	The Human Environment and Transport Inspectorate (*Inspectie Leefomgeving en Transport*)
LVO	National Level Crossing Improvement Programme (*landelijk verbeterprogramma overwegen*)
NABO	Not Actively Protected Level Crossing (*niet-actief beveiligde overweg*)
ZBO	Independent Administrative Agency (*zelfstandig bestuursorgaan*)

1 INTRODUCTION

1.1 Reason: questions about level crossing accidents

At the end of 2016 and early in 2017 there were three serious level crossing accidents, which prompted the Dutch Safety Board to open an investigation into level crossing safety. These accidents, which are described in brief below and in further detail in Appendix C, led the Safety Board to suspect that accidents were happening that could have been prevented.

Winsum	**18 November 2016**
A passenger train collided with a truck on an unprotected level crossing. Eighteen of the train's occupants were injured. The train and the truck were severely damaged, the train was completely derailed.	
Harlingen	**27 March 2017**
A train collided with a car on a private level crossing at a farm. The car's occupants, a father and his son, were killed. They had been visiting an event at the farm.	
Wouw	**28 April 2017**
A train and a truck were severely damaged in a collision at a protected level crossing. The front part of the train was derailed and ended up dangerously close to the track for trains in the opposite direction.	

Figure 1: Accident locations in Winsum, Harlingen and Wouw. (Photo Winsum: Dutch Safety Board, Photo Harlingen: Movares, Photo Wouw: Police)

These three accidents led to various questions being raised by the Dutch Safety Board.

The level crossing in Winsum was unprotected, the crossing in Harlingen only had flashing lights. The Safety Board wondered if these types of level crossings were still acceptable on the busy and high-speed Dutch railways.

A second question concerned the motivation for better protecting or removing level crossings. It seemed that safety improvements were only ever implemented *after* an accident had occurred. This was the case for all three of the aforementioned level crossings. This raised the question of whether there was a structural vision on how level crossing safety must be developed and what is required for this.

Finally, the Safety Board wondered if sufficient lessons were being learned from accidents at level crossings. Accidents similar to the three mentioned above had occurred in the past, at the same location or elsewhere. Were level crossing accidents investigated effectively and were the lessons learned from them being employed more widely?

1.2 Research question

The questions raised by the three accidents prompted the Dutch Safety Board to investigate the extent to which level crossings risks are effectively managed and whether improvements can be made. Following a brief exploratory study, the Safety Board opened a thematic investigation of level crossing safety in mid-2017.

Main question:
Can level crossing accidents be reduced further, and if so, how can this be achieved?

1.3 Types of level crossing

Protected an unprotected level crossings
A level crossing or railway level crossing is an at-grade intersection between a railway and a road. Level crossings allow people to cross the railway. Train traffic has priority at all times, so the road traffic must wait if a train is approaching. In the Netherlands, there are two types of level crossing: protected and unprotected.[3]

3 In the Network Infrastructure Regulations (Regeling hoofdspoorweginfrastructuur) these level crossings are indicated as 'actively protected level crossing' and 'not actively protected level crossing', respectively. De Safety Board considers the wording 'not actively protected' confusing, since it suggests that the crossing is not protected in an active way, but in another way. There is, in fact, no protection at all that warns for an approaching train. The Safety Board therefore, and for easier reading, prefers the wording 'protected' and 'unprotected'.
For the sake of completeness, it is mentioned that guarded level crossings do exist. A guarded level crossing is a level crossing with barriers that completely close the road, and where trains only are permitted onto the level crossing after it was verified that the crossing is clear of road traffic. The Network Infrastructure Regulations defines this type in a different way: the key point (check on obstacles) is not included in the regulations. There are hardly any guarded level crossings left in the Netherlands, but they are frequent in many other countries.

At unprotected level crossings, road users are only alerted to the presence of a level crossing by the St Andrew's cross and red and white warning railings at the crossing. There is no warning of an approaching train, nor is the level crossing closed while a train is passing (figure 2, left).

A protected level crossing has, apart from all measures at an unprotected level crossing, also an installation that alerts road users of an approaching train. Almost all protected level crossings in the Netherlands also have road barriers, which partially block the level crossing for road users while trains are passing. In this report, if we are speaking about a protected level crossing, we mean one protected with half barriers.[4]

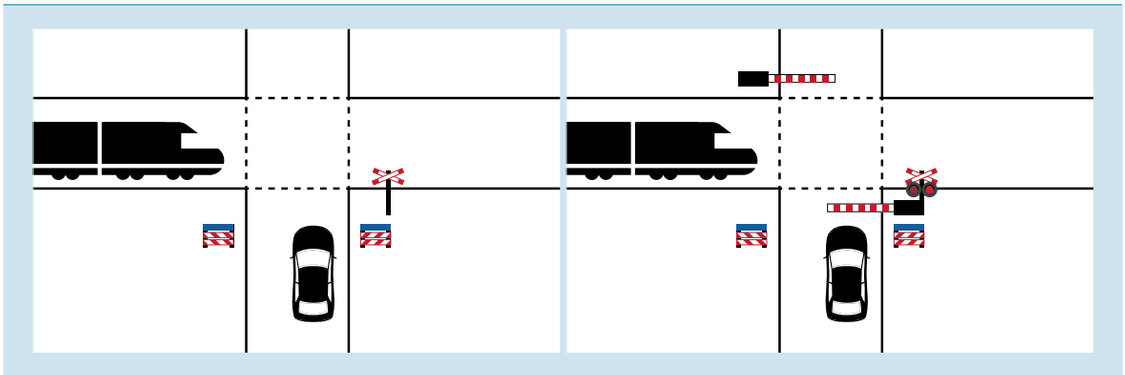

Figure 2: Schematic depiction of an unprotected level crossing (left) and a protected level crossing (right).

Public and private level crossings

Most level crossings are on public roads, but not all level crossings can be accessed by everyone. Private level crossings are located on private roads and are actually only accessible to 'entitled persons' who have right of way over the track, for example a farmer. The term 'private' only relates to the limited accessibility to road users; these level crossings are still located within the public rail network.

There are also 'private level crossings with a public character'. This is a private level crossing where the owner allows public traffic or a road that has gained public status in the course of time.[5] Such level crossings are also designated as 'public' in this report.

Main railways and special railways

The majority of railway lines are what is known as a main railway, where regular passenger and freight train traffic takes place. The majority of railways of this type mainly carry passenger traffic. In this report, these are indicated as 'passenger lines', although other train types may pass from time to time. The other lines, which do not carry passenger traffic, are indicated as freight lines. These are primarily found in ports and industrial areas,

4 There are protected level crossings without barriers, but in the Netherlands these are almost exclusively found on lines destined for freight traffic only. There are also level crossings without safety systems on freight and heritage railways, but these are protected by railway personnel.

5 Pursuant to the Roads Act (*Wegenwet, article 4.1*), a road has public status by definition if the owner of the road has allowed public use of it for at least 30 years.

In addition to the main railways, there is also a category known as special railways which includes, amongst others, heritage railways and industrial sidings. The latter railway lines form connections between a business and the main railway.

1.4 Scope

The focus of this report is on the safety of publicly accessible level crossings on passenger lines, because most trains run on these lines and this is where the majority of the casualties occur (see figure 3). Any points for attention applicable to private level crossings are reported separately in the text. The findings of the investigation with regard to level crossings on freight lines, industrial sidings and heritage railways are summarised in Appendix F.

Level crossing accidents resulting from suicide fall outside of the scope of this investigation.

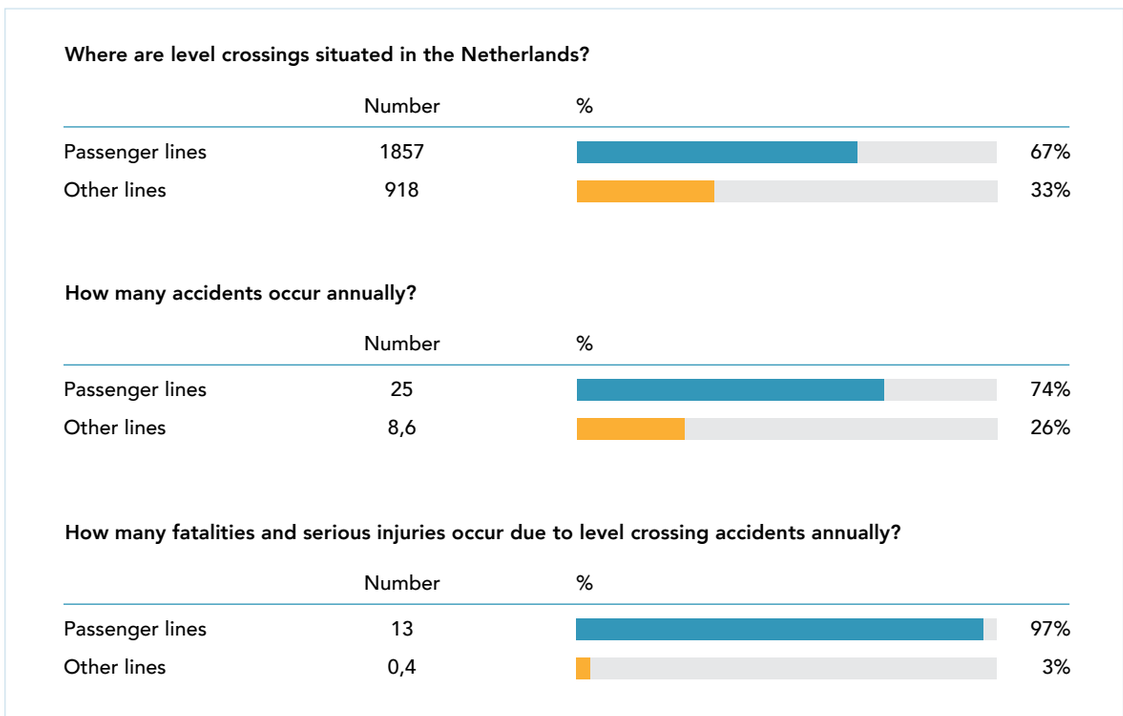

Figure 3: Distribution of level crossings, accidents and casualties across passenger lines and other lines (freight lines, industrial sidings and heritage railways)[6]

6 A further breakdown of the 97 percent of casualties and severe injuries on level crossings in passenger lines indicates that 96 percent occurs on public level crossings and 1 percent on private level crossings.

2 SAFETY PERFORMANCE

This chapter sets out how the safety of Dutch level crossings has developed in recent decades. It also compares level crossing safety in the Netherlands with other European countries to gain an impression of how the Netherlands is performing and to identify if anything can be learned from experiences gained elsewhere.

2.1 Level crossing safety significantly improved, pace of improvement is levelling off

Level crossing safety in the Netherlands has improved significantly over the last twenty years. The number of level crossing accidents in all main railways decreased by almost sixty per cent between 2000 and 2017, and the number of fatalities fell by seventy per cent in the same period.[7] The decrease has levelled off in recent years, which indicates that further measures may be required for a further reduction in the number of casualties. We will discuss this in greater detail in Chapter 4.

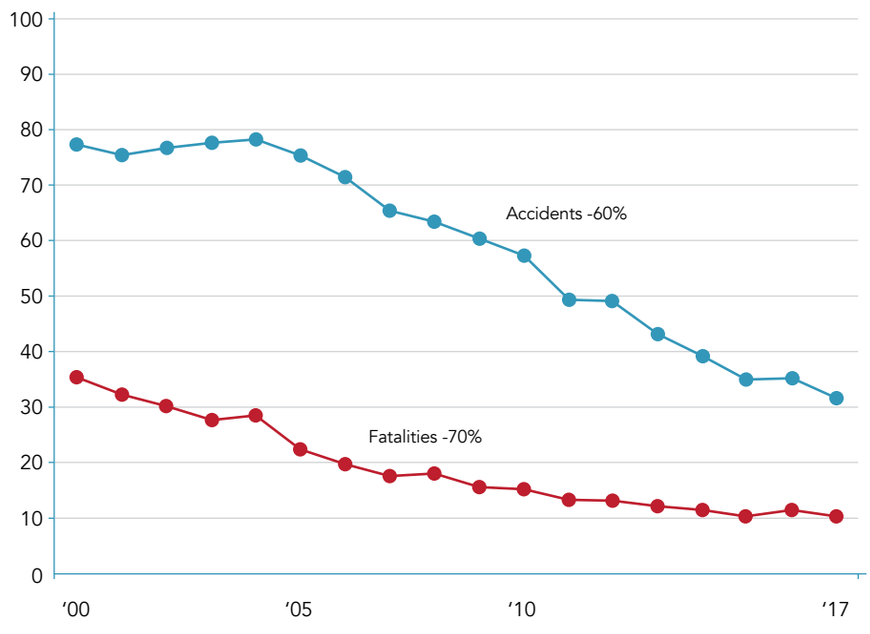

Figure 4: Developments in the number of level crossing accidents and fatalities resulting from a level crossing accident on main railways (based on the five--year average).

7 Based on the 5-year average of the number of accidents and the number of fatalities on the main railway network. Source: ProRail and ILT.

Between 2000 and 2016, the number of level crossings on the main railway network (passenger lines and freight lines) decreased by approximately twenty per cent, from approximately 3000 to 2400.

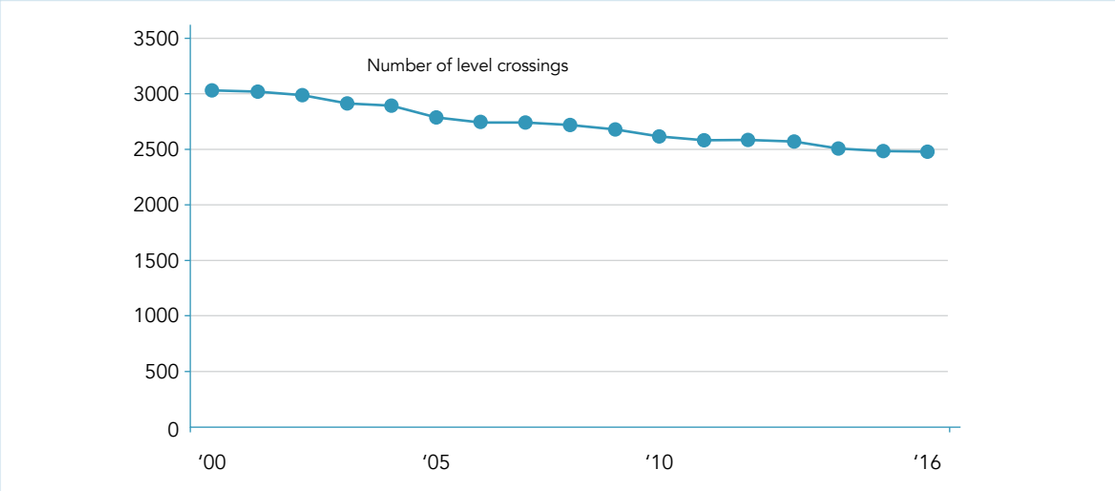

Figure 5: Developments in the number of level crossings on the main railway network.

The level of protection of level crossings improved in the 2000–2016 period. The proportion of level crossings protected by barriers increased from almost forty per cent to almost seventy per cent. Conversely, the number of unprotected level crossings and level crossings with bells and lights only decreased. The decrease in the number of level crossings and the improvement in the level of protection resulted from an active policy of the Ministry of Transport, Public Works and Water Management in the period up to 2010. This mainly comprised the fitting of half barriers to level crossings that were fitted with bells and warning lights only. This comprehensive approach probably explains the significant fall in the number of level crossing accidents and casualties in the period concerned.

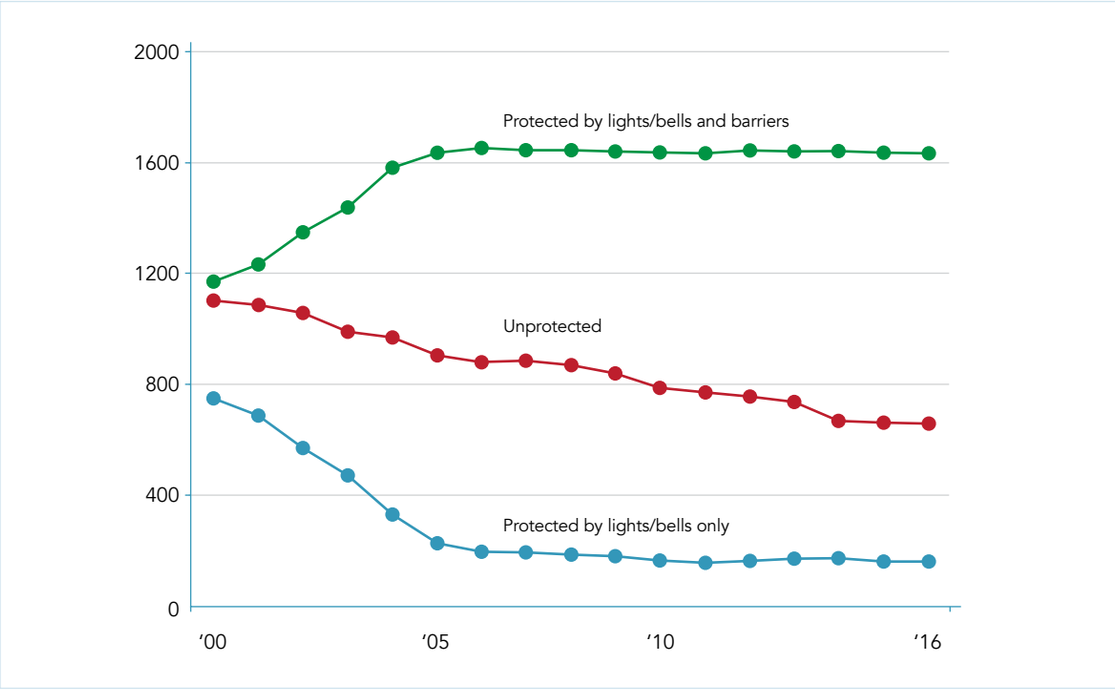

Figure 6: Developments in the level of protection of level crossings on the main railway network.

2.2 Differences between accidents at protected and unprotected level crossings

As revealed in figure 3, almost all fatalities and serious injuries in level crossing collisions in the Netherlands were on public level crossings on passenger lines. In absolute terms, most casualties occur on protected level crossings. In relative terms however, most casualties occur on unprotected level crossings.[8]

Most accidents and casualties occur on protected level crossings

Most of the public level crossings on passenger lines, approximately 1500 in total, are protected. This is also the type of level crossing where most of the level crossing collisions occur: a good three-quarters of all serious injuries and fatalities are found here.

As figure 7 shows, more than half of all fatalities and serious injuries occur in slow traffic on protected level crossings. The numbers of moped/bicycle riders and pedestrians involved in these accidents are more or less the same. The majority of accidents and casualties in fast traffic involve passenger cars.

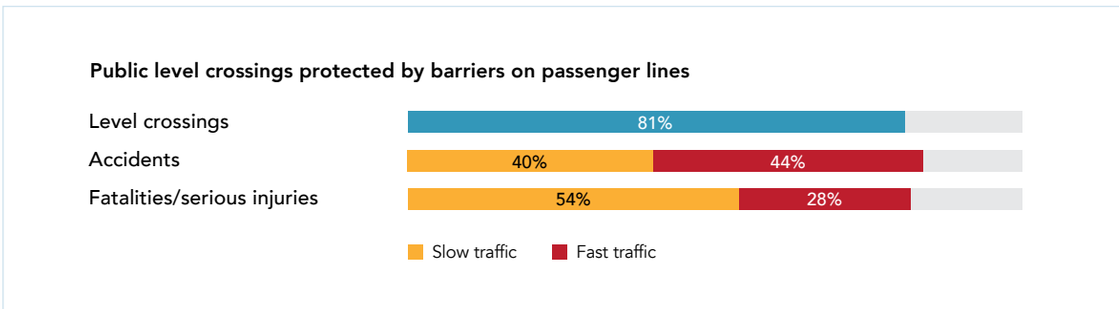

Figure 7: Public level crossings: most accidents, injuries and casualties in absolute terms.[9]

A relatively large number of casualties on unprotected level crossings

The number of accidents and casualties on over 100 public, unprotected level crossings on passenger lines is, in absolute terms, clearly lower than on level crossings protected by barriers. However, in relative terms, the accidents and casualties are over-represented; there are many accidents and many casualties in relation to the number of level crossings of this type. Most of the fatalities and serious injuries on these level crossing are in passenger cars. Occasionally moped or bicycle riders are involved; pedestrians are rarely involved in accidents.

8 The figures in the previous section show the long term developments since the year 2000. For the analysis of accident causes in this section, a more recent period was used in order to achieve a more actual picture of the types of accidents occurring. Therefore, the analyses in this section are based on data from the 2012–2016 period (see Appendix E).

9 The percentages relate to all level crossings, accidents and casualties on the main railway network.

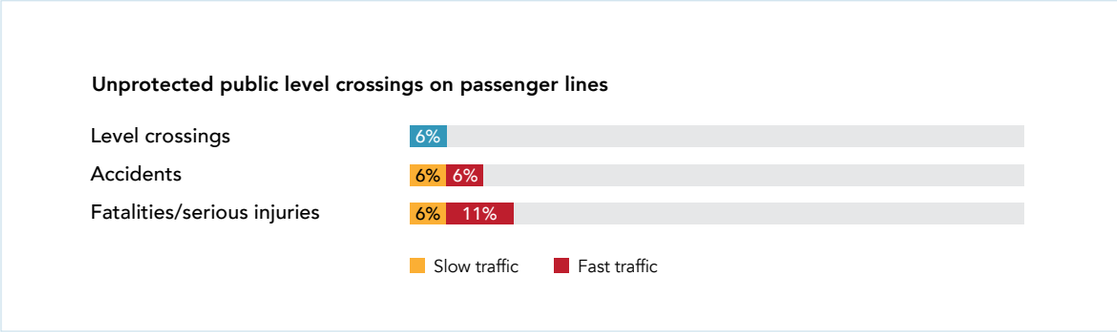

Figure 8: Unprotected level crossings: proportionally, a large number of accidents, serious injuries and fatalities occur.[10]

2.3 The Netherlands' level crossing safety in a European context

The developments in level crossing safety over the last twenty years are outlined in paragraph 2.1. Here, we compare Dutch level crossing safety in 2017 with that of 27 other European countries: the 25 other EU Member States that have a railway system[11] plus Norway and Switzerland.[12]

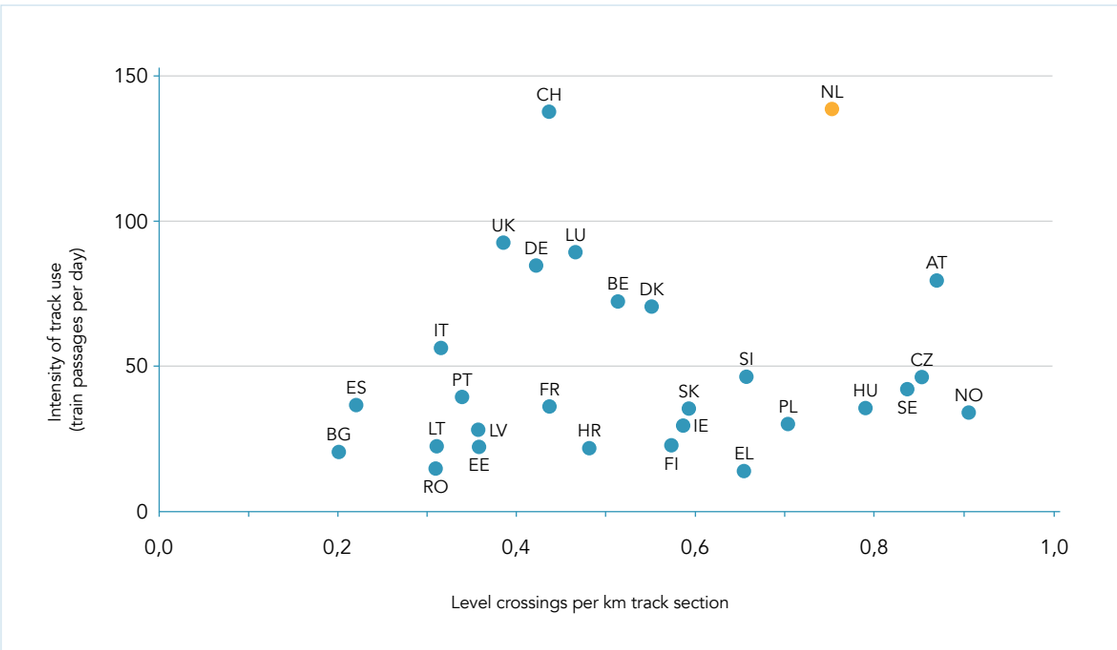

Figure 9: Track-use intensity and level crossing density in 28 European countries.

10 The percentages in figure 7 and figure 8 do not add up to 100% because they relate to all level crossings and all level crossing casualties on the main railway network; some of them are on level crossings on freight lines and on private level crossings. Together, those categories account for 30% of all level crossings on the main railway network, for 25% of all accidents and for less than 5% of all fatalities and serious injuries.

11 Malta and Cyprus have no railway lines.

12 The underlying data can be found in Appendix D. The data were provided by the European Union Agency for Railways and published in the documents *Railway Safety Performance in the European Union 2016 and Safety Interim Report 2017*, as well as on the Eurostat website.

The figure above shows that, within Europe, the Netherlands has a unique combination of high-volume traffic and a large number of level crossings per kilometre of its railway network. On average, each section of track in the Netherlands is travelled over 140 times each day. The Netherlands tops the list in this regard; only Switzerland runs trains at a comparable density on its lines. Moreover, the Dutch network has many level crossings: there is a level crossing every 1.3 kilometres on average.[13] There are only five European countries with more level crossings per kilometre than the Netherlands: Norway, Austria, Czech Republic, Sweden and Hungary. However, track use is much less intensive in those countries.

Several countries have better level crossing safety than the Netherlands

We can compare level crossing safety based on the figures the European countries supply to the European Union Agency for Railways. This is normally expressed in the number of casualties per million kilometres travelled by train. To facilitate a more intuitive comparison in this report, the number of level crossing casualties for each country has been converted into the total kilometres that Dutch trains travelled.[14] In other words: how many level crossing casualties would there be in a given year, if we suppose that there was as much train traffic in other countries as there is in the Netherlands? Based on these statistics, in position 13 (of 28) the Netherlands is in the middle bracket in Europe in terms of level crossing safety.

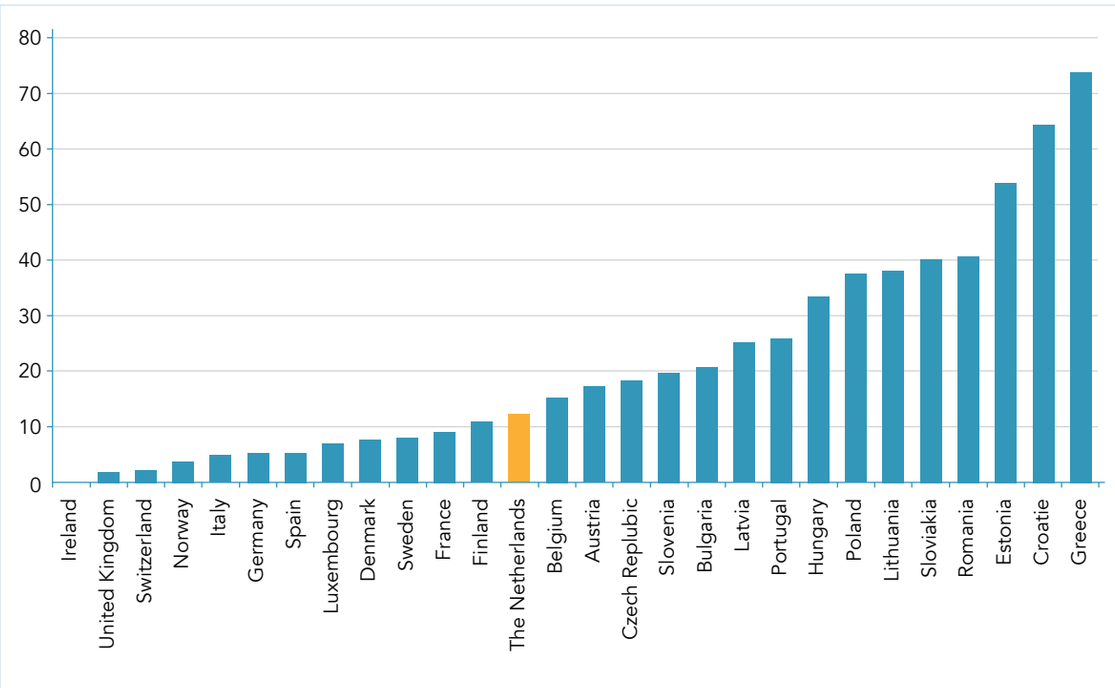

Figure 10: Number of level crossing fatalities if the train traffic in other countries was at the same intensity as it is in the Netherlands (Dutch casualty equivalent).

13 The information value of the average number of level crossings per kilometre of track is limited: some railways (such as high-speed lines, lines that have been constructed since the 1980s and four-track railways) do not include any level crossings at all. This means that there is a higher than average number of level crossings on the other railways. This type of distortion can be found in every country but not to the same extent.

14 Percentage-wise the figures for the various countries remain exactly the same here, but the numbers themselves are easier to compare with each other.

Note however that while these figures do take train intensity into account, they disregard road traffic intensity. Given that a level crossing is an intersection between a railway and a road, it is important that road traffic is also taken into consideration.

In a densely populated country like the Netherlands, a level crossing is used by road traffic more frequently on average than in a less densely populated country. Because every crossing by road traffic carries a risk of an accident, this could result in more accidents. Unfortunately, there are no European or Dutch figures for road traffic intensity on level crossings. The statistics above have been adjusted for population density to allow for a more realistic safety comparison.[15] In doing so, the Dutch Safety Board assumes that there is a close relationship between population density and road traffic intensity.

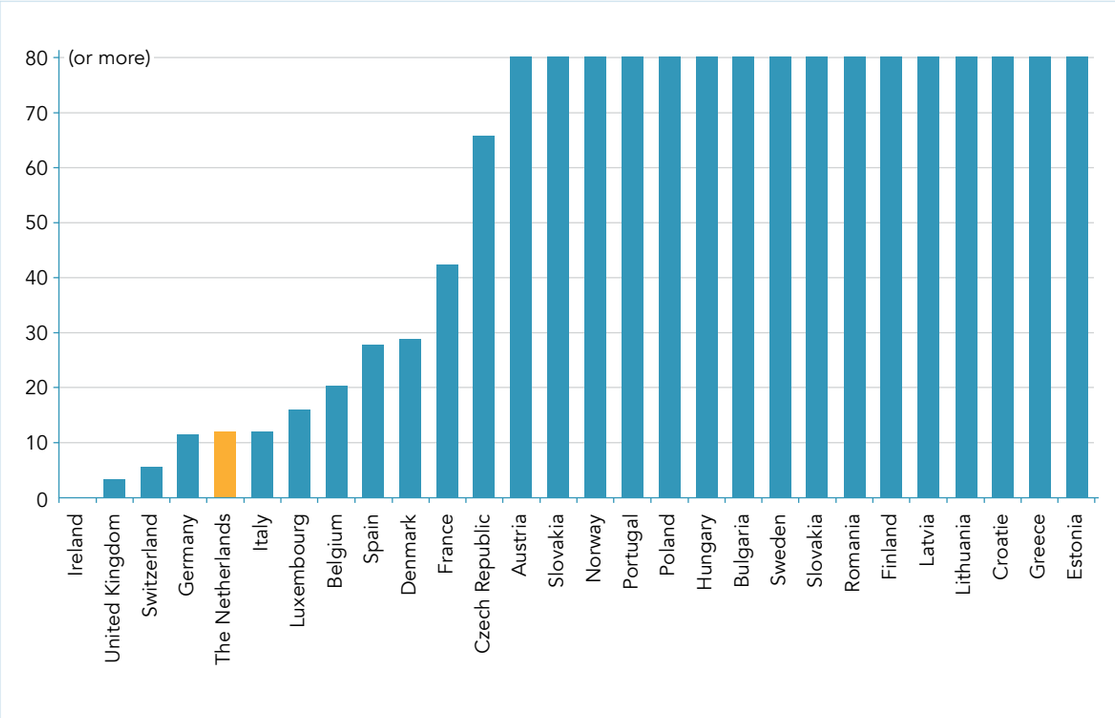

Figure 11: Number of level crossing fatalities if train traffic in other countries were of the same intensity as it is in the Netherlands and the population density were the same.[16]

The Netherlands ends up in a better position when the figures are adjusted for population density. The United Kingdom and Switzerland in particular show that there is probably still scope for further improving level crossing safety in the Netherlands.[17]

Paragraph 3.2 includes a box showing things that are arranged differently in these countries.

15 Population density is expressed as the average number of inhabitants per square kilometre of land area.
16 Source: European Union Agency for Railways (casualties and train kilometres) and Eurostat (population density).
17 Because of the much less intensive use of the railway network in Ireland, this country appears to be unsuitable to compare the Dutch situation to.

2.4 Subconclusions

Safety gains achieved, but room for improvement
Level crossing safety in the Netherlands improved significantly between 2000 and 2017. The safety gains, expressed in the number of casualties due to level crossing accidents, were mainly achieved in a period of targeted improvement policy in the first couple of years of this century.

The Dutch railway network is unique in Europe, with its high volume of traffic and many level crossings. There likely is scope for further improvement, and it would seem that the United Kingdom and Switzerland in particular could serve as useful examples.

Unprotected level crossings are the most risky, but most casualties occur at protected level crossings
Most level crossing collisions occur at protected level crossings. This is also where most of the serious injuries or fatalities occur, among slow traffic in particular.

In absolute terms, the number of accidents at unprotected level crossings is clearly lower, but the number is high in relation to the number of level crossings.

3 LEGAL FRAMEWORK

This chapter describes the statutory requirements applicable to level crossing safety, and the associated allocation of responsibilities.

3.1 Interaction of factors in rail and road traffic

3.1.1 Different safety philosophies for rail traffic and road traffic

Trains are almost entirely incapable of dealing effectively with a sudden event. They cannot swerve and their braking distance can be up to one kilometre. The safety philosophy for railways is entirely focused, therefore, on the train literally having a clear track. The timetable and rail traffic control determine which trains are allowed to run where and protection systems ensure that mistakes by a traffic controllers or train drivers do not result in accidents. The maximum speed on the track is determined by the infrastructure manager and is monitored by protection systems.

This is totally different from the philosophy for road safety, where the road users themselves determine who can drive where at any time; this system depends on the highway code and mutual contact to keep the traffic situation manageable. In contrast to the railway system, mistakes by road users are not compensated by protection systems to any great extent, but, other road users can usually avoid an accident or mitigate its severity by swerving or braking.

These two safety philosophies come together at a level crossing; here too the train always needs to get a clear track and the road user has to adapt to the traffic situation: if a train is approaching the road user must clear the intersection.

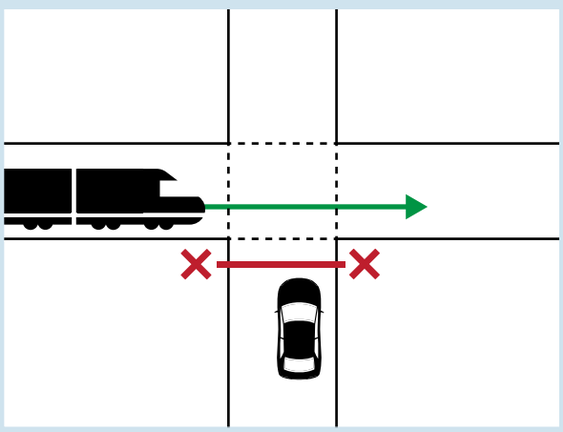

Figure 12: Trains always have priority at a level crossing.

3.1.2 Level crossing safety depends on interaction between four factors

The term level crossing safety in this report means: the set of factors that lead to trains being able to pass safely and road users being able to cross safely. This concerns the following four factors:

- responsible use of railways and roads on the one hand, and
- safe road and rail infrastructures on the other.

To give a train priority, road users must be aware that they are approaching a level crossing, check if a train is approaching and, if so, wait until the train has passed. If the road user is already on the level crossing, he needs to clear it completely. In principle, the train driver will also look whether the level crossing is clear but, unless the train speed is very low or the distance very high, he will not be able to avoid a collision.

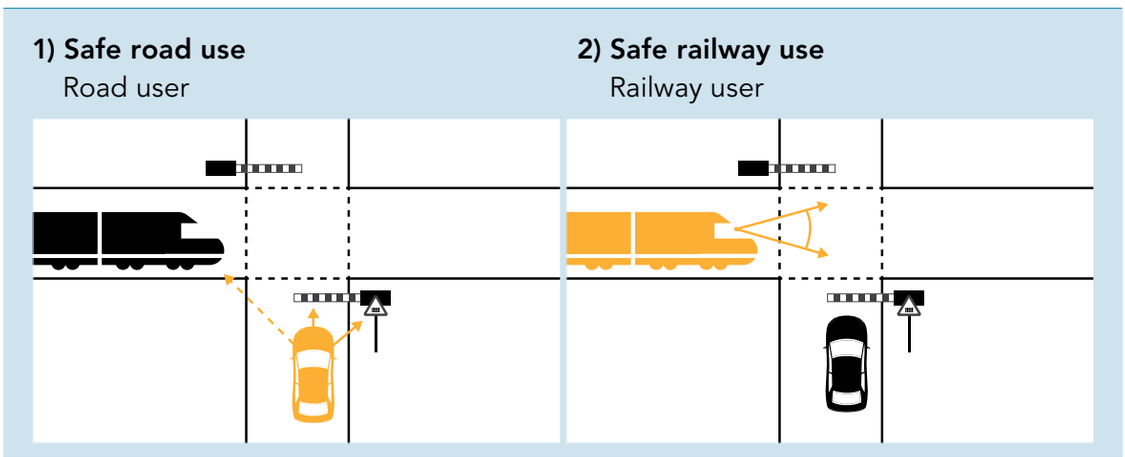

Figure 13: The two behavioural factors in level crossing safety.

To enable the road as good as possible to give priority to the train, the level crossing must be properly protected and the road laid out as well as possible, both on and near the level crossing. In short, both the railway infrastructure and the road infrastructure must be safe. The next paragraph discusses these factors in more detail, focusing on which rules apply and who is responsible for them.

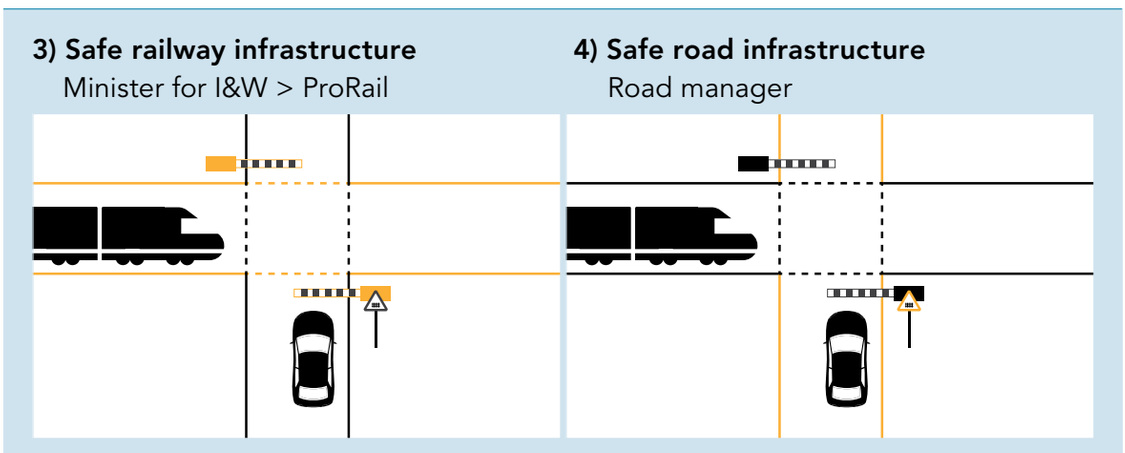

Figure 14: The two infrastructure factors in level crossing safety.

3.2 Each factor has its own legislation and responsibilities

Applicable legislation

For safety on level crossings, two legal regimes are relevant. The regime on the railway side is the European Railway Safety Directive, the Dutch Railways Act and corresponding decisions and regulations. On the road side, the Roads Act and the Road Traffic Act (*Wegenverkeerswet*) with the Dutch Traffic Code, Road Traffic and Traffic Signals Regulations (*Reglement Verkeersregels en Verkeerstekens*) and the Road Traffic (Administrative Provisions) Decree (*Besluit administratieve bepalingen wegverkeer*) apply.

Road use

Level crossings are used by drivers of cars and trucks, by moped and bicycles riders, and drivers of other vehicles, by horse riders and herds. Also pedestrians can use a level crossing, as hiker or as a train passenger

The law stipulates that road users must take care when approaching and crossing a level crossing, including by driving at a moderate speed and by giving way to trains. Road users must also ascertain that they will not have to stop on the level crossing and can fully clear it.[18, 19] The Minister of Infrastructure and Water Management is responsible for this legislation.

Railway use

The railway network is used by train operators to transport[20] passengers or freight. The majority of the train traffic by far involves public passenger transport. The rail companies that provide this type of transport have obtained the exclusive right to do so (in the form of a concession) from the government: the Minister of Infrastructure and Water Management for the so-called main railway network and the relevant provincial authorities for regional lines. A concession includes the requirements for train frequencies and maximum journey times. The concession therefore has an effect on the frequency and speed at which trains pass level crossings; however, the contracting authority and the operator that obtains the concession have no specific responsibility for the management of level crossing safety.[21]

Railway infrastructure

Unclear responsibilities with regard to level crossing safety

The Railways Act vests responsibility for the construction and management of the main railway network with the Minister of Infrastructure and Water Management.[22] The Minister has, therefore, according to the Railway Act[23], awarded the concession for implementing the management of railway infrastructure to ProRail.[24] This includes ensuring the quality,

18 Article 19 of the Vienna Convention on Road Traffic, Vienna 08 November 1968.
19 Article 15 of the Road Traffic and Traffic Signals Regulations 1990 (RVV 1990).
20 The formal name is railway undertaking.
21 The Ministry of Infrastructure and Water Management uses the principle that changes that affect level crossing safety in a negative way, the party that initiates the change must arrange for compensating measures.
22 Article 5 Railway Act.
23 Article 16 Railway Act.
24 In 2017 the then State Secretary for Infrastructure and the Environment decided that ProRail should fall under the Ministry as a non-departmental public body (NDPB). When this change will actually take effect and its consequences on ProRail's mandate are not yet clear. Refer to parliamentary document 29 984, nr. 768.

reliability and availability of the track, as well as the allocation of capacity and rail traffic control.

As a component of its responsibility for quality, ProRail must monitor the safety of the railway network.[25] In this regard, the concession explicitly mentions the safety of level crossing users as a focus area but does not link any concrete requirements to the objective. As a result, ProRail's precise obligations when it comes to level crossing safety are not clear.

Furthermore, the concession stipulates that the Minister, in addition to the existing rules, can set out a temporary programme for railway safety and decide in conjunction with ProRail the extent to which this programme applies to ProRail.[26] What is part of ProRail's regular tasks and what can be considered to be additional remains unsaid.

The responses to a draft version of this report also indicated that the main players have different opinions on this. The Ministry stated that ProRail is responsible for the safety of the rail network based on the EU Railway Safety Directive and that the temporary programmes for level crossing projects are construction projects which makes these projects part of ProRail's normal task package. ProRail indicated that improvements to level crossings often entail changing their function. Because a separate budget must be requested from the Ministry for this, it would therefore fall outside the normal task package.

Railway traffic must become safer

The European Railway Safety Directive stipulates that railway safety must at least remain at the same level and be constantly improved where possible. In accordance with the Directive, the main effort here is in the prevention of serious accidents.[27]

Rules do exist for the visibility of level crossings but not for the level of protection

Railway legislation sets a number of requirements for the visibility and recognisability of level crossings. All public level crossings must have St Andrew's crosses, information signs and red and white warning railings.[28, 29, 30] In addition to this, there are statutory regulations for the dimensions of the area around a level crossing within which there must be no objects taller than one metre, to ensure that road users have a clear view of approaching trains.[31]

25 Section 17 of the Railways Act.
26 Ministry of Infrastructure and the Environment. Article 37 of the Management Concession for 2015–2025.
27 Article of 4 of Directive 2016/798/EC.
28 Articles 2 and 3 of the Network Infrastructure Regulations (*Regeling hoofdspoorweginfrastructuur*). The red and white warning railings are intended to improve the visibility and recognisability of the level crossing and provide an indication of the width of the level crossing surface.
29 The red an white striped railings are meant to improve the visibility and recognisability of the level crossing, and they provide an indication of the width of the level crossing. The statutory requirements to not indicate what the aim, the contents or the design of the information signs.
30 These measures are not statutorily prescribed for private level crossings, but in practice they always have St Andrew's crosses if there are no barriers that can close the crossing.
31 The prescribed dimensions for that area, which is rhombic, are different for main railways and special railways and for protected and unprotected level crossings.

Figure 15: Minimum level of protection required for public level crossings in the Netherlands. (Photo: Dutch Safety Board)

The legislation includes a summary of protection measures that can be applied (red and white flashing lights, for instance) but there are no statutory provisions on when a level crossing is permitted and what kind of protection measures must be fitted. Nor is there a provision on how a protection system should be designed with a view to unambiguous recognisability for the road user.[32]

Under the previous Railways Act, that was in use until 2005, the Minister was authorised to decide the protection level of a level crossing,[33] but this provision has been removed from the current Railways Act. Finally, there are no statutory regulations for the procedure when making changes to level crossings (better protection, removal or conversion to a grade-separated crossing).

Road infrastructure

Roads Act does not contain provisions on roads near level crossings

Most roads that cross a railway line are local public roads that are managed by a municipality or water board. The road manager is responsible for the types of traffic that the road is open to. The Roads Act, which applies to public roads, requires the road manager to properly maintain the road. However, this specifically concerns the condition and availability of the road for road traffic, and only indirectly the safety of the road users. The Roads Act does not contain any provisions for safe access to level crossings. There is no statutory standard for a proper and safe road over a level crossing. Both

32 For other road and traffic signs, this is prescribed in the Road Traffic and Traffic Signals Regulations.
33 Article 20, Regulations on the service on main and local railways (RDHL).

ProRail and CROW[34] do have guidelines on the road layout at level crossings. The application of those guidelines is usual, not compulsory.

Inspiration from other countries

Some European countries could be an inspiration to the Netherlands. The Safety Board has examined, in broad outline, how level crossing safety is implemented in Germany, the United Kingdom and Switzerland: three countries with a higher level of safety than the Netherlands. The most striking differences are summarised in brief here. The extent to which the differences mentioned explain the difference in safety performance cannot be stated with certainty based on the information to hand.[35]

Clear distribution of roles

The improvements to existing level crossings formally regulates the extent to which the road manager must contribute funding. The three countries use different basic principles: in Germany, the Ministry, rail network manager and road manager each pay one third; in Switzerland, the rail network manager and road manager pay pro rata the volume of their traffic; and in the United Kingdom the rail network manager generally pays, while a road manager or other party may contribute if it is beneficial to the modification. If the managers involved cannot reach a mutual agreement, the (federal) state in all three of those countries can impose a solution by means of an assignment.

Prescribed level of safety

Unlike the Netherlands, the three countries have also laid down the required level of safety. In many situations, this depends on the characteristics of the railway traffic and road traffic.

- *Unprotected level crossings* are subject to all kinds of restrictions, such as maximum train speeds (15–80 km/h), limited numbers of road users per day, or on single track lines only.
- *Level crossings with half barriers* are being or have been gradually replaced in these countries by level crossings with full barriers, which completely close the road. They are used to a significant extent in all three countries.
- In the case of *level crossings with full barriers*, there is a check to see that the level crossing is clear before a train passes (Germany and the United Kingdom). In Switzerland, this only happens where train speeds are high or the road situation is such that problems clearing the level crossing can be expected.

34 CROW is the organisation that, among other things, formulates and publishes guidelines for road design.
35 Please refer to Annex H for a more detailed summary.

A disadvantage of level crossings with full barriers that they have to close earlier than level crossings with half barriers as are customary in the Netherlands. They are closed approximately 1 to 2 minutes longer prior to a train passage. On the other hand, a level crossing with half barriers makes entering a closed level crossing difficult (both by mistake and in violation) while there is time to stop the train or to escape if there are clearance problems.

The Safety Board finds it remarkable that in a few years time almost all level crossings in the passenger network in the Netherlands will have been equipped with automatic half barriers while this type of protection is actually being replaced by level crossings with barriers that close the entire road in other countries that are believed to be safer.

3.3 Subconclusions

Responsibility for level crossing safety: shared, with an important role for the Minister of Infrastructure and Water Management
Level crossing safety is determined by four factors: the way in which the road and the railway are used and the layout of the road and the railway. Because trains have priority and cannot brake in time, a level crossing must be set up so that a road user can identify the level crossing and the approaching train. The road user must be able to either stop short before entering the crossing, or clear the level crossing in good time.

While no single actor is responsible for all four factors of level crossing safety, of the actors involved the Minister of Infrastructure and Water Management bears most responsibility. He is responsible both for the rules for responsible use of the railway network and for a safe railway infrastructure, which includes level crossings. The Minister has delegated this responsibility to ProRail in the form of a concession.

The Minister is also responsible for the requirements imposed on roads, but not for the way in which this is implemented on specific roads. That responsibility lies with the road manager, usually a municipality.

Finally, road users have their own individual responsibility for giving way to trains. The Minister is not responsible for the behaviour of road users but does lay down the highway code.

Ambiguous division of roles between the Minister and ProRail
As the railway manager, ProRail must monitor safety of the network, but it is not clear to what extent it is also responsible for improving level crossing safety as part of its regular task.

Limited requirements for level crossings
The requirements that have been set for level crossings are limited. Railway legislation includes some regulations on the visibility and recognisability of level crossings, but there are no rules prescribing specific types of level crossings for specific situations or whether a level crossing is permitted at all. Although safe road infrastructure is a part of level crossing safety, the Roads Act does not set any requirements for the layout of roads on and at level crossings.

Although there are differences between the Netherlands and other countries, and the relationship with (avoided) accidents is difficult to quantify, more aspects are regulated in other countries than in the Netherlands. In addition, the bar is set higher than is customary in the Netherlands.

Factors	Responsible party	Description
Safe railway infrastructure	Minister of Infrastructure and Water Management	Responsible for the Railways Act and grants a network management concession to ProRail.
	ProRail	Manages the railway network for the Ministry.
Safe road infrastructure	Minister of Infrastructure and Water Management	Responsible for the Roads Act.
	Road manager	Specifies the road layout.
Safe railway use	Minister of Infrastructure and Water Management / provinces	Responsible for granting transport concession.
	Train driver	In practice, cannot stop in time.
Safe road use	Minister of Infrastructure and Water Management	Responsible for traffic regulations.
	Individual road user	Must give trains free passage.

Table 1: The four factors of level crossing safety and who is responsible for them

4 CURRENT APPROACH

This chapter describes how the parties involved are working to improve level crossing safety.

4.1 Four options for improving level crossing safety

Measures for improving level crossing safety can be split into two groups: one group focuses on improving level crossings which will continue to exist (for the time being), the other group on removing level crossings. There are four options in all:

A. If the level crossing remains in existence:

1. it can be better protected: by installing level crossing barriers for instance.
2. Changes can be made to the situation at or around the level crossing, by redesigning the road section before or after the level crossing for a better overview, for instance, or by closing it to certain types of road traffic.

B. If the level crossing is removed there is the option of

1. permanent removal,[36] or
2. removal with a replacement crossing facility (a tunnel or viaduct for example).

36 One option to compensate for the removal of a level crossing is to divert the road to another (better protected) level crossing or grade separated crossing.

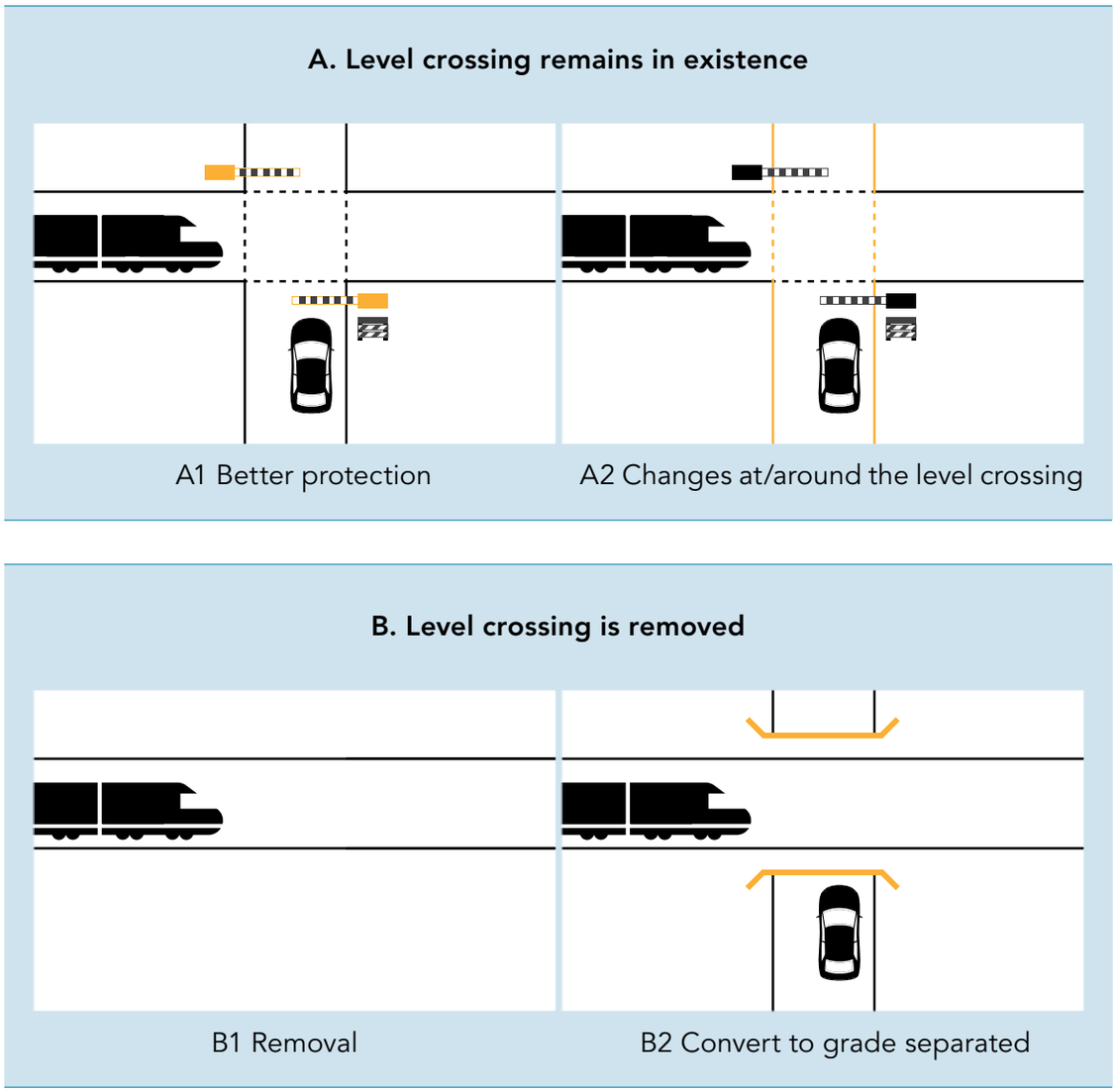

Figure 16: The four options for improving level crossing safety.

4.2 Policy: no objective, only principles do exist

The Ministry has described the rail safety policy in three framework memorandums (from 1999, 2004 and 2010). In 2016, the Rail Safety Policy Incentive actualised the 2016 framework policy.

Objective for level crossing safety is blurred

In the first decade of this century, the Ministry had a concrete safety objective: by 2010 the annual number of level crossing fatalities should be halved to 24 (relative to 1985).[37, 38] This objective was already achieved in 2005 and level crossing safety continued to improve afterwards.

The safety objectives were toned down in 2010: the aim was to realise further improvements in safety.[39] A number of concrete indicators were specified however, including the number of level crossing accidents and the number of fatalities as a result of such accidents. In the Rail Safety Policy Incentive in 2016, those indicators also disappeared as an instrument to influence level crossing safety. There was still mention of obligations to continue improving under EU law.[40] However, no indication was given of the required improvement or the time scale on which this has to be achieved.

The Ministry's reason for scrapping concrete objectives was that it was becoming increasingly difficult to demonstrably achieve further appreciable reductions in the accident statistics – in terms of the number of casualties – because the safety performance in the Netherlands was already quite good. Also the aim of 'permanent improvement' as a norm was called into question because the relevant activities were actually motivated by viability and affordability concerns.[41]

Since 2016, the Dutch level crossing policy no longer has any specific objectives for improving level crossing safety. The Ministry strives to lower the total risk and in the Rail Safety Policy Incentive, the Ministry indicates that further improvement of the level of safety on the railways requires flexibility. This is why the focus shifts from direction based on safety performance indicators (such as the number of level crossing accidents per year) to direction based on risk factors. These risk factors must be analysed and interpreted in the annual report by the Human Environment and Transport Inspectorate (ILT) and serve as input for the relevant policy.[42] However, the ILT's 2016 Annual Report on Railway Safety, published in 2017, does not however provide any insight whatsoever into factors that play a role in level crossing accidents.[43]

37 House of Representatives of the States General, 1999. *Memorandum Concerning Rail Safety*, p.13. Parliamentary Paper 26699, No. 2.
38 Ministry of Transport, Public Works and Water Management, 2004. *Safety on the rails: second framework memorandum concerning the safety of rail transport in the Netherlands*, p. 65.
39 Ministry of Transport, Public Works and Water Management, 2010. *Transporting safely, working safely, living safely with the railways (Veilig vervoeren, veilig werken, veilig leven met spoor): Third Rail Safety Framework Memorandum*, p. 43.
40 Ministry of Infrastructure and the Environment, 2016. Rail Traffic Policy Incentive (*Beleidsimpuls Railveiligheid*).
41 Lower House of Dutch Parliament, session year 2015/2016, 29 983, No. 200 (08 December 2015).
42 Ministry of Infrastructure and the Environment, 2016. *Rail Traffic Policy Incentive*, pp 2–3.
43 The Human Environment and Transport Inspectorate, 2017. *Annual Report on Railway Safety: How Safe are the Railways in 2016? (Jaarverslag spoorveiligheid: hoe veilig is het spoor in 2016?)*

Three basic principles

The Rail Safety Policy Incentive from 2016 and a letter sent to the House of Representatives in March 2017 form the basis for the Ministry of Infrastructure and Water Management's current level crossing policy.[44, 45] The policy comprises the following basic principles:

1. 'no, unless' principle: new level crossings are not normally allowed to be constructed. Level crossings and their use may only be changed if it can be demonstrated that this does not compromise safety;
2. there will be a new procedure to consider the interests of those participating in leisure activities when changes are made to a level crossing;
3. the two level crossing programmes are being continued; they are the National Level Crossing Improvement Programme (LVO) for protected level crossings and the NABO[46] programme for unprotected level crossings. Measures will be taken at locations where the risk is highest and the costs are proportionate to the safety gains. For this risk based approach, the risk profiles of level crossings will be actualised.

The costs of improving level crossing safety were met by central government until 2010. Since 2012, the Ministry of Infrastructure and Water Management requires that fifty per cent of the costs for measures of the LVO or NABO programme be met by regional or local authorities. This is meant to increase the involvement of the road authorities.

The three basic principles will be explained below in further detail.

4.3 Policy implementation

No-unless principle

The no-unless principle means that the construction of new level crossings or more intensive use of existing ones by rail or road traffic will only be permitted if this will not increase the safety risks.

If, for example, on a track section trains will operate more frequency or at higher speed, or if a spatial development results in a higher volume of road traffic at a level crossing, the initiator of such a change will have to conduct a risk analysis. If necessary, level crossings will be improved or removed.[47] These measures are paid for from the budget of the initiator concerned. Approximately ten level crossings per year have been removed in this way in recent years.

The main objective of the no-unless principle is that the level of safety is not degraded inadvertently. It strikes the Dutch Safety Board that in the Rail Policy Safety Incentive, the no-unless principle is more limited and cautious than was previously formulated. For example, it no longer states that, in principle, no new level crossings will be constructed.

44 Ministry of Infrastructure and the Environment, 2016. *Rail Traffic Policy Incentive*.
45 Lower House of Dutch Parliament, session year 2016/2017, 29 983, No. 211.
46 NABO is short for Not Actively Protected Level Crossing (*Niet-Actief Beveiligde Overweg*).
47 ProRail has indicated that in case of spatial developments, the relevant initiator (usually a municipality) does not always feel responsible for taking such compensating measures.

In the letter sent to the House of Representatives in 2017, the 'prohibition' of new level crossings is again included, but the influence of new developments on the rail and the road is no longer mentioned under the no-unless principle, but under the principle that the 'causer pays'.[48] Given the importance of the principle in the level crossing safety policy, the Safety Board is concerned about the frequent change in the meaning of the principle. The Letter to Parliament in 2017 specifically mentions the 'prohibition' of new level crossings but the effect of developments on the road and railways is not articulated under the no-unless principle, but under the 'causer pays' principle.[49] Given the importance of the no-unless principle in level crossing safety policy, the Safety Board is concerned about the constantly changing meaning of the principle.

According to the Letter to Parliament in March 2017, road managers also have a role if developments in the vicinity lead to a higher risk on a level crossing. In the event of such developments, road managers are given a role in the risk assessment of level crossings and the funding of measures. The State Secretary is still in discussion with road managers on suitable instruments to guarantee this basic principle, in the new Environmental Management Act for example.

This innovation stems from the investigation by the Safety Board into a collision on a level crossing at Dalfsen, among other things. Based on that investigation, as well as the subject investigation, the Safety Board believes that road managers should also have a structural role in level crossing safety; not only when there are developments in the vicinity of a level crossing. After all, factors other than such developments can require modification to the level crossing; examples include gradual growth in road traffic, new possibilities and insights in the field of level crossing safety, the changing behaviour of road users or a changed degree of society's acceptance of risk.

Taking recreational interests into consideration when making changes to level crossings

The removal or selective closure[50] of a level crossing can have consequences for those who use them for recreational purposes. Therefore, various recreational interest groups have united in the Recreation and Infrastructure Advisory Group (*Adviesgroep Infrastructuur en Recreatie*).[51] The Ministry of Infrastructure and the Environment and ProRail made the following procedural agreements with this advisory group in 2016:[52]

- The Advisory Group informs ProRail of existing and new recreational routes on which level crossings are situated. In addition, the Advisory Group encourages the greatest possible use of protected level crossings on recreational routes.

48 *Kamerstukken II* 2016/17, 29 893, nr. 211
49 *Parliamentary Papers II*, 2016/17, 29 893, No. 211
50 The selective closure of a level crossing means that only certain categories of road users (e.g. pedestrians and cyclists) can still continue to use it.
51 The following parties are represented in the Advisory Group (previously: Infrastructure Barrier Formation Steering Group (*Stuurgroep infrastructurele barrièrewerking*)): the Dutch Automobile Association (*ANWB*), the Dutch Cyclists' Federation (*de Fietsersbond*), the National Cycling Forum Foundation (*Stichting Landelijk Fietsplatform*), the Dutch Olympic Committee*Dutch Sports Federation (*NOC*NSF*) and the Hiking Network Foundation (*Stichting Wandelnet*).
52 Framework of agreements: transparent process for balancing safety and recreational interests when changes are made to level crossings, 09 November 2016.

- The Advisory Group is to be actively involved in the NABO programme (explained below).
- When proposing to close a level crossing, ProRail requests advice from the Advisory Group and the Group assesses the consequences of the proposed changes for recreational use of the level crossing. If the Advisory Group's recommendation is negative, ProRail submits a risk analysis to the ILT. Depending on the opinion of the ILT, ProRail may decide to ignore the Advisory Group's negative recommendation.

National Level Crossing Improvement Programme (LVO) for protected level crossings

When evaluating the Second Rail Safety Framework Memorandum in 2010, ProRail concluded that the 'easy pickings' had been harvested and at the time no other cost-effective measures were possible to further improve level crossing safety. The year 2000 objective to reduce the number of level crossing fatalities to a maximum of 24 per year had already been achieved in 2005. The Level Crossing Safety Improvement Programme (*Programma Verbeteren Veiligheid Overwegen*) came to an end in 2010 and the Ministry did not launch any new programmes for level crossings.

That changed in 2012. In October 2012 the Rutte-II government published the Build Bridges (*Bruggen slaan*) coalition agreement. It contained the following pledge: 'there will be an improvement programme to reduce the number of level crossing incidents'.[53] This programme was developed and launched in 2013 under the name National Level Crossing Improvement Programme (LVO). Its objective is not only to reduce the number of level crossing incidents and improve safety on the railways, but also to foster the smooth flow of road and rail traffic.[54] The coalition agreement and the LVO did not indicate to what extent and at what time scale the level crossing incidents should be reduced. There is no concrete objective for the reduction of the number of accidents or the number of casualties that the LVO programme should realise.[55]

In practice, the LVO only focuses on protected level crossings and provides two kinds of measures: generic measures, which can be used on a large number of level crossings, and specific measures, that focus on tackling a specific level crossing.

53 Building Bridges (*Bruggen slaan*), Coalition Agreement VVD – PvdA, 29 October 2012.

54 The reason given for including the 'smooth flow of road traffic' component in the LVO differs from document to document. For example, one LVO document states that the objective is to encourage road authorities to contribute ideas and provide funds when level crossings are improved (source: Assessment Framework for the National Level Crossing Improvement Programme (*Afwegingskader Landelijk Verbeterprogramma Overwegen*) final version (2.0), 18 September 2013, Movares; Goudappel Coffeng; Procap on behalf of the Ministry of Infrastructure and the Environment). In response to questions from the Dutch Safety Board, civil servants at the Ministry of Infrastructure and Water Management indicated that a poor traffic flow provokes unsafe behaviour and, as such, is a factor relevant to level crossing safety.

55 Since 2016, the Ministry uses an internal objective of a 15% improvements in 'LVO points' for 140 level crossings with the greatest potential for improvement, which should be achieved by 2028. This objective has been decided upon after the previously used internal objective of 20-25% reduction turned out not to be achievable. Both objectives have not been published. The Safety Baord does not know how these 15% (that are partly for safety and partly forsmoother traffic flow) for 140 level crossings relate to the safety gains for all level crossings in passenger lines.

Generic measures

ProRail is developing various measures to reduce accidents on protected level crossings.[56] These measures, which are explained in more detail in Appendix G, can be divided into the following three categories:

- *Preventing a collision with a slow road user*. This concerns an additional warning light that will indicate some time before the level crossing is activated to indicate that a train is approaching.
- *Preventing a road user crossing while the protection is in operation*. This concerns reducing the waiting time at level crossings, improving the recognisability of the level crossing and tightening up supervision and enforcement.
- *Preventing a collision with a stranded road user*. This concerns changes to the level crossing surface to prevent vehicles that are off course becoming trapped.

One portion of these measures is currently being introduced: however, for the majority it is not yet clear if they ever will and, if so, at how many level crossings. Mid-2018, the Ministry has budget allocated to decrease the waiting time for road traffic at approximately 200 level crossings. Before budget is allocated to other measures, it must first be demonstrated that these are cost effective.

In addition to the measures mentioned above, ProRail has started the following measures after a train collided with a man lift near Dalfsen in 2016:[57]

- *Support for exceptional crossings of level crossings*. This concerns two procedures for assisting when crossing a level crossing: one is for exceptionally large trucks (exceptional transport), the other for large groups of people or animals and for other slow vehicles.
- *Preventing a collision with a stranded road user*. ProRail examines possibilities for a technical system (obstacle detection) to brake a train if the level crossing is not clear, and ProRail is in the process of the application of a sticker with the contact details of the Railway Control Room (*Meldkamer Spoor*) so that a stranded vehicle can be reported.

These measures are not part of the LVO, but they are generic measures.

Specific measures

In addition to the generic measures, the LVO also provides for specific measures (custom solutions) for level crossings with a high improvement potential in terms of traffic flow and safety. Many of these level crossings are situated in busy urban areas. Local authorities can nominate this type of level crossing for improvement. Once the improvement plans have been worked out with the rail network manager, the State Secretary for Infrastructure and Water Management decides on the Dutch State's contribution, to a maximum of fifty percent. To do this, the State Secretary will assess the cost-effectiveness of the proposal: over-eagerness to opt for a tunnel or viaduct will not be accepted within the LVO.

56 ProRail had researched a number of these measures even before the start of the LVO in 2012.
57 In response to the Dutch Safety Board's recommendation following a level crossing accident in Dalfsen.

Budget limits

Although the programme runs until 2028, the 200 million euro budget has already been fully allocated.[58] Approximately 100 million euros will be allocated to specific measures, to which regional governments will contribute another 100 million euros. This will be used to tackle 25 level crossings. Five will be replaced by tunnels; measures such as redesigning the level crossing or the connecting roads will be implemented for the others.

Approximately sixty million euros is being used for generic measures, including shortening waiting times at level crossings, improving their recognisability and improving their surfaces to prevent stranding. Approximately 30 million euros is being used to cover the costs of the LVO programme itself and for maintenance cost. Ten million euros was transferred to the NABO programme.

58 Because of price indexing, slightly different numbers are also published; the difference is approximately 3%. The Dutch Safety Board has rounded off the figures mentioned to whole tens.

Illustration of high costs: conversion to grade-separated crossing in urban area

There is a level crossing on the Vierpaardjes road in Venlo. The road crosses four tracks over a distance of approximately 40 metres. There is space for road users to wait between the railway lines. The road users find the level crossing to be confusing. There was a collision between a car and a local train at the start of 2017. In addition to the safety issue, the level crossing is attracting local attention primarily because it is closed so often and for so long. For years, local residents have been pleading for a tunnel to be constructed. The municipality had been asking for state funding for this project for a long time, and was given that opportunity within the framework of the LVO. In February 2017 the Dutch State signed the administrative agreement for co-funding. The province and the Venlo municipality are each paying 13.5 million euros towards the tunnel project, which is estimated to cost approximately 45 million euros in total. The Dutch State is contributing 16 million euros from the LVO 'specific measures' sub-programme[59] The total budget for this sub-programme, which is intended to tackle specific problematic level crossings, is approximately 100 million euros. This example shows that tackling this single level crossing accounts for a considerable portion of the total budget.

Figure 17: The Vierpaardjes level crossing in Venlo will be replaced by a tunnel. (Photo: Google Maps)

NABO programme for unprotected level crossings

The NABO programme came about as a response to two accidents on the same unprotected level crossing in Winsum (see box). Unlike the LVO, the NABO programme has a concrete objective: by 2028 all 127 public, unprotected level crossings in the passenger network will be protected, removed or no longer publicly accessible. The budget of 35 million euros[60] has been tailored to this objective[61]. The Ministry is making

59 In total the contribution is 18 million euro's.
60 In 2018 there is a 39 million euro budget, since the starting budget of 35 million euro has been increased by almost 4 million euro budget in order to tackle unprotected crossings at stations.
61 Broadly: with fifty per cent co-funding there is a total of (35 + 35 +4) 74 million euros available, this is an average of more than half a million euros per level crossing.

the budget available on condition that the approach is cost-effective. Since there are no standards for choosing between removal or protection, the decision is taken in consultation with the parties involved, such as ProRail, the road manager, local residents, recreational umbrella organisations and the Ministry of Infrastructure and Water Management. In addition, the Ministry has stipulated that level crossing issues are tackled within an area-specific approach: in other words, any proposed changes to a level crossing should be considered within the context of the overall road network of which it is part. The local authority will also have to contribute 50% towards the costs, just as in the LVO programme.

Emergence of the NABO programme: accidents must happen first

An internal programme to improve safety at unprotected level crossings was set up within ProRail in 2012. The objective of this so-called NABO action plan was to have no more public unprotected level crossings within ten years. ProRail's expectation was that this could reduce the annual number of fatalities by approximately two.

But the project appears to have been halted even before the project organisation was able to implement the plan. The internal body that manages the ProRail portfolio, decided not to allocate a budget to the action plan. Shortly thereafter, at the start of April 2014, a fatal accident occurred on Voslaan in Winsum. The halting of the programme was brought to the attention of the ProRail management internally, which once again confirmed its earlier decision to implement the action plan and at the same time acknowledged there were no financial resources for this.[62]

At the request of the Ministry, this letter was never formally sent, but ProRail and the Ministry did enter into mutual discussions. However, this did not lead to a budget nor to the integration of the NABO plan into the LVO. In the meantime, ProRail stood by its policy for improving safety at unprotected level crossings.

Figure 18: The Voslaan level crossing (that has been closed) in Winsum. (Photo: RTV Noord)

62 Sources: ProRail factual report (Collision between a train and passenger car at level crossing 3.188 in Winsum dated 2 April 2014), ProRail internal memo (Reconsideration of the halting of the NABO Action Plan, 8 April 2014), ProRail internal document (Handling proposal for the Management Team: Reconsideration of decision to halt the Not Actively Protected Level Crossings Action Plan (NABO), date of meeting 15 April 2014, and final minutes of the ProRail Management Team Meeting (15 April 2014).

Due to the lack of a budget, this resulted in ProRail seeking custom solutions in consultation with local road authorities. These solutions included removing level crossings combined with the construction of underpasses or bridges elsewhere and/or diverting traffic, with financial support from local and regional authorities.

A second fatal accident occurred at the level crossing on Voslaan in October 2014. Following Parliamentary questions, the State Secretary decided to release 10 million euros from the LVO budget after all, to tackle unprotected level crossings. There was yet another accident at the level crossing on Voslaan in November 2016. In response to this event, the State Secretary decided to increase the budget by another 25 million euros.

Within the framework of the NABO programme, ProRail commissioned a study into various innovative cost-effective improvement measures which revealed, in particular, a cheaper type of protection system as a promising alternative.[63] Another study is focusing on the possibilities for a less expensive underpass for pedestrians and cyclists. Whether both of these measures will be introduced, and if so on what scale and when, is not clear.

ProRail expects that the vast majority of the 127 public unprotected level crossings will have been tackled by no later than 2022.[64] It expects that approximately one-third of the unprotected level crossings will remain in existence, but will be better protected.[65] The remaining two-thirds of the unprotected level crossings will disappear, mainly through removal and by converting a number of level crossings into grade-separated facilities.

Level crossing remains in existence	Protection No longer publicly accessible	42 5	33% 4%
Level crossing is to be removed	Removal Convert to grade separated	60 20	47% 16%
	Total	**127**	**100%**

Table 2: Way in which ProRail expects to tackle public unprotected level crossings.

63 Changing the system used to detect an approaching train could probably reduce the costs of installing a protection system from approximately 0.8 million to 0.5 million euros.
64 This concerns 117 publicly accessible unprotected level crossings and 10 unprotected foot crossings at stations.
65 According to ProRail, only installations with lights/bells and barriers (AHOB) will be considered.

4.4 Improved level crossing safety as a voluntary and lengthy process

In practice, the improvement of level crossing safety sometimes proves to be a lengthy and difficult process. In case of the level crossings in Winsum, Harlingen and Wouw it took an accident to trigger consultation between ProRail and the relevant (private or public) road manager and to start developing measures.[66] In some cases the process to reach an agreement on the concrete measures to be taken and on the financing arrangements proved to be so complicated that the projects concerned had still not been completed when another accident occurred at the same level crossing. A similar second or even third accident resulted in parties being able to reach agreement, although this was usually only a temporary or provisional solution (see the box below).

New access road with financial risk

In March 2017 a car was involved in a collision on a level crossing in Harlingen; both occupants of the car were killed. The level crossing, which has since been removed, was a private level crossing with a public character, giving access to a single farm. As a result of a previous accident, the residents of the farm had taken the initiative and had been in discussion with ProRail since early 2017 on ideas for a new access road. However, the proposed new road ran across leased land and had to cross a small canal. Removing the level crossing and constructing the by-pass road involved a significant sum of money. The residents generously took the initiative to improve the situation: after the second accident they pre-financed and commenced the construction of the new road before the steward of the leased land had given formal approval. Central government eventually reimbursed the construction costs of the road; the road owner bears the costs of maintaining the road and the bridge.

Figure 19: The by-pass road that has been constructed in order to be able to close the Oude Trekweg level crossing in Harlingen. The level crossing was situated to the right of the red roof in the picture (Photo: ProRail)

66 Please refer to 1.1 and Annex C for a more detailed description of the accidents.

The Dutch Safety Board has identified the following underlying causes for an improvement process being lengthy and sometimes difficult: a mismatch of interests, the co-funding requirement, and a lack of substantive development course in legislation or policy.

Mismatch of interests

At least three parties are involved in improving level crossing safety: the road manager, the rail network manager and the Ministry, which provides part of the budget. These parties have different preferences for the solutions to be employed (see table).

Party	Preferred measures	Least favourite measure	Motivation
Road manager (municipality)	Grade separation / Improvement	Removal	Accessibility and liveability
Rail network manager (ProRail)	Removal / Grade separation	Improvement	The best level crossing is no level crossing
Central government Ministry of I&W	Improvement / Removal	Grade separation	Cost-effectiveness

Table 3: Preferences for improving the safety of a level crossing vary across parties involved.

Although the table is an over-simplification and these preferences are not expressed in this way in every discussion on a particular level crossing, the table does show that one party's preferred measure frequently is another party's least favourite measure. This is because the parties involved have the following interests:

- *Municipality*: The basic function of a level crossing is to create the opportunity for road users to cross a railway. Local residents and other road users benefit from having as many locations as possible where they can cross the railway. In general, a municipality will therefore prefer a grade-separated or improved level crossing over removal or by-passing.
- *ProRail*: On the other hand, level crossings are not needed for the effective functioning of a railway, and they come with drawbacks such as maintenance costs, faults, delays and accidents. Seen from this perspective, reducing the number of level crossings to an absolute minimum is an attractive proposition for ProRail. However, ProRail cannot remove level crossings independently: this is the road manager's mandate.
- *Ministry*: Since it is the Ministry that provides the maintenance budget for level crossings, it too will prefer to have as few level crossings as possible. At the same time, in many cases funding from the Ministry is needed for safety measures and the Ministry has a responsibility for all level crossings in the Netherlands. This gives rise to the need for cost-effective measures to enable as many level crossings as possible to be tackled for a set amount of money. This explains why investing a relatively large sum in one or a few expensive grade-separated crossings is not the Ministry's preferred choice.

When tackling some level crossings, even more parties with specific interests are involved: for example, if a level crossing has a recreational function or if land will have to be bought for a by-pass road. This will potentially complicate the existing conflicts of interest even further, resulting in a lengthy process, as the box below illustrates.

From protecting a single level crossing to a complex project

There were two fatal accidents at the unprotected level crossing on Voslaan in Winsum in 2014. As a result of these accidents, many people both in and from outside of Winsum failed to understand why no safe solution for that particular level crossing was forthcoming. This was even more the case when in November 2016 there was a third accident at the same level crossing.

In November 2014 the municipality of Winsum was calling on ProRail and the Ministry to improve the safety of all unprotected level crossings in the municipality. While the local residents and the municipality envisaged that this would entail the rapid installation of level crossing barriers, ProRail's preference was to remove the level crossings. The Ministry of Infrastructure and the Environment pressed for an area-specific approach, cost-effective measures and fifty per cent co-funding from the municipality. This set a comprehensive approach in motion covering the entire region. The municipality and ProRail drew up a plan for all 23 level crossings in Winsum, which was presented in February 2015. According to this plan, the Voslaan level crossing would be removed and there would be a new road to another level crossing. The municipality entered into discussions on funding with ProRail, the Ministry and the provincial authorities. Through letters, discussions with those directly involved and public information sessions, the municipality also involved its residents in the project.

Acquiring the land for the new road proved to be difficult: the land owners had doubts about selling or exchanging land and the municipality is tied by statutory procedures (including objection procedures) for changing the land use plan, for the environmental permit and for buying (or, in extremis, expropriating) land. In June 2016, the municipality and the Ministry signed a financing agreement, which provided for a Dutch State contribution of 3.25 million euros to tackle as many level crossings as possible. At that time however, there was still no land available for the road to bypass Voslaan.

Following the third accident, in November 2016, a temporary solution was realised, due in part to social pressure. The level crossing was closed and a temporary bypass road was built on leased land. It was now possible to realise the solution quickly because its temporary nature removed the need for most procedures. At the time of this report however (spring 2018), there is still no definitive solution: by mid-2017 agreement had only been reached with one of the six land owners involved. The municipality expects that it will take at least until 2019 to complete all of the measures for the level crossings project. In the meanwhile, local residents are still wondering why level crossing barriers were not installed immediately at the Voslaan level crossing.

No clarity from statutory regulations

Since neither the municipalities nor the provinces have a statutory task to improve level crossing safety, they will only make the budget available if they agree to the plans. Nor are there any statutory requirements as regards the acceptable level of protection (unprotected, protected by barriers, grade separation) for specific situations. As a result, the parties involved are free to decide whether to accept or reject a particular solution and its financing arrangement. If the parties cannot reach agreement there is no-one to break the deadlock.

This is not a new problem and it was also investigated by the Dutch Transport Safety Board in 2003 (see box).

Dutch Transport Safety Board investigation of level crossing safety

Approximately 15 years ago, the Dutch Transport Safety Board (which became the Dutch Safety Board in 2005) also conducted a thematic investigation into level crossing safety. The immediate cause for this was a collision between a passenger train and a car on a level crossing protected by flashing lights in Voorst on 16 June 2000, in which all five occupants of the car died. The Voorst municipality proved to have been engaged in negotiations with the rail network manager for years over the approach to the level crossings in its territory. However, the negotiations had reached an administrative impasse, mainly because of a difference of opinion on the solution.

This course of events proved to be typical of the administrative context of level crossing improvement projects: the rail network manager and the road managers are mutually dependent, but have considerable differences when it comes to their interests and perceptions of problems. Despite this, there are no administrative rules for improving level crossings nor for the distribution of the associated costs. The Dutch Transport Safety Board further indicated that it would find level crossings of roads and railways would only socially acceptable in the long term if trains were prevented from accessing them until there has been a check that the level crossing is clear.

In its report, which was published at the beginning of 2003, the Dutch Transport Safety Board made the following recommendations to the Ministry of Transport, Public Works and Water Management:

1. Ensure that the level crossings are replaced by grade-separated crossings or by monitored level crossings (where a train only gains access after it has been ascertained that the level crossing is clear). Formulate an action plan for this and link the necessary funding to it.
2. Resolve the administrative and legal stumbling blocks that have been identified, for instance by vesting integral responsibility for level crossing safety with a single body with sufficient financial resources and statutory powers to carry out the task.
3. Develop an Act, or supplement the Railways Act so that the improvement plan can be implemented expeditiously and with wide support from the administrative parties involved. When doing so, provide assurance that administrative impasses can be resolved with a binding judgement.

The response from the Minister of Transport, Public Works and Water Management[67] can be summarised as follows:

- Recommendation 1: The recommendation to only allow controlled level crossings to exist was given shape in the development of the ADOB system.[68] Decision-making on its introduction will be based on two pilots and with due regard for the high investment and maintenance costs involved.
- Recommendations 2 and 3: As of 1 January 2005, both a new Rail Safety Framework Memorandum and a new Railways Act (with a system of decisions, regulations and concessions) have become operational, laying down the responsibilities of and relationships between the parties in the railway sector. The Minister believes amending the railway legislation or introducing a new Act to be inopportune. Within the new legal framework ProRail, as the rail network manager, has been tasked with implementing Dutch State policy with regard to level crossings. ProRail and the road authorities know how to achieve the most suitable measures in almost all cases.

Meanwhile, it has become clear that the Netherlands has two such ADOB level crossings at the moment; one of these will soon be replaced by a tunnel, and ProRail no longer uses these systems in new situations.

Furthermore, the current investigation shows that the cooperation between ProRail and the road authorities still can be a stumbling block: conflicting interests and discussion about solutions and funding still play a role.

Co-funding

The costs involved in improving level crossing safety are usually high in comparison with the budgets available to a municipality. This is why the province sometimes needs to make an additional budget available.

At the same time, in the Dutch Safety Board's investigation several parties emphasised that a (financial) contribution by municipalities also leads to a municipality feeling involved and responsible and that this prevents national solutions being applied heedless of the local situation.

67 Letter of the Minister of Transport and Water Management to the Dutch Transport Safety Board, *Recommendations to the Minister of Transport and Water Management in the 'Voorst level crossing accident report'*, March 2005.

68 ADOB refers to systems with automatic full barriers (*Automatische Dubbele Overwegbomen*). These systems completely close the level crossing to road traffic during a train passage, and check whether the level crossing is clear.

4.5 Anticipated safety gain is unclear

The improvement programmes described (LVO and NABO-programme) relate to public level crossings on railway lines carrying passenger trains. Those level crossings (approximately 1600 in total) are responsible for approximately 96 per cent of all fatalities and serious injuries.

In the NABO project, a reasonably concrete estimate can be made of the safety gain that it can achieve, because almost all 127 unprotected level crossings in this group will either be removed or protected before 2028.[69] The Safety Board considers it realistic that this will prevent the majority of accidents and casualties that are currently occurring on unprotected level crossings. This concerns approximately 16% of all fatalities and serious injuries.

The LVO project on the other hand allows a much more limited estimate of the safety gain that it can achieve. All that is clear at present is that specific measures will be implemented at 25 level crossings in the coming years. In five cases, the level crossing will be replaced by a tunnel. A tunnel may well be an effective way of preventing level crossing accidents but this solution involves only approximately 0.3% of all level crossings. The other 20 cases involve modification to the level crossing and/or the road and the degree of safety improvement expected from those measures is still not clear. In addition, it has now been decided that measures will be taken to shorten the waiting time for road traffic at approximately 200 level crossings. The extent to which this will lead to a reduction in accidents and casualties is not yet clear.

Furthermore, there are other measures in development, as is explained in Appendix G. It is not yet clear however, if, and if so in what time frame and at how many level crossings they will actually be implemented.

69 ProRail has indicated that the majority will already have been tackled before 2022.

4.6 Subconclusions

The Ministry has no concrete objective for level crossing safety
The Ministry of Infrastructure and Water Management has not had a concrete objective and long-term vision for level crossing safety since 2010. That was the year that the level crossing programme at the time came to an end and the earlier safety objective of halving the number of level crossing fatalities had been more than achieved. In the same year, ProRail indicated that, at the time, there were no additional cost-effective ways of further improving level crossing safety.

Nonetheless, the National Level Crossing Improvement Programme (LVO) for protected level crossings commenced in 2012. Since early 2014, ProRail has been calling for the Ministry to also introduce a programme for unprotected level crossings. Finally, the Ministry agreed to make budget available after two accidents on an unprotected level crossing in Winsum, and increased the budget after a third accident on the same level crossing.

Two improvement programmes: LVO and NABO programme
The LVO and NABO programmes run until 2028 and have a funding stream and programme organisation that are separate from ProRail's regular tasks within the framework of the concession. It is not clear why these programmes cannot be part of those regular tasks under the direction from the Ministry of Infrastructure and Water Management.

The LVO programme has a budget of nearly 200 million euros, but no concrete objective for the reduction of accidents or casualties. It focuses solely on safety and traffic flow at protected level crossings. In practice, a large proportion of the budget is being spent on a few grade-separated solutions.

Since early-2018, the NABO programme has a budget of 39 million euros. This programme does have a concrete objective: all 127 public, unprotected level crossings within the passenger network will be protected, removed or no longer publicly accessible by 2028.

The safety gain from the programmes is doubtful
If agreement can be reached with the road managers, the 127 unprotected level crossings will be removed or protected. The fact that this approach will lead to fewer accidents and casualties is evident but this is a limited proportion (approximately 16%) of all level crossings and casualties. We must also consider that co-funding by the road manager cannot be enforced, which casts doubt on the feasibility of these measures.

ProRail is also working on improvement measures for the large group of protected level crossings. In this regard, the actual implementation of improvements is certain for specific measures at 25 level crossings and the shortening of waiting time for road users at approximately 200 level crossings. For the other measures that are under development, it is still not clear if and if so when they will be implemented and at how many level crossings. In addition, the extent to which those measures will lead to a reduction in the number of accidents or casualties is still not clear.

Conflicts of interest and ambiguity of roles not resolved

There is a lack of clear responsibilities for all parties and of a substantive long-term objective for tackling level crossings in the Netherlands. While the road manager has no explicit statutory role in level crossing safety, under current policy it does contribute fifty per cent of the costs where a level crossing is tackled. This can result in lengthy discussions on the solution to be implemented and its funding. Although this problem has been know for a long time, the Ministry of Infrastructure and Water Management has not yet resolved it.

	Unprotected level crossings	Protected level crossings	
Number of level crossings	127	Approx. 1500	
Fatalities per year	Approx. 2	Approx. 9	
Improvement programme	NABO	LVO	
		Specific	Generic
Number of level crossings being tackled	127 (100%)	25 (1,7%)	Depends on measure
Budget	39 million euros	100 million euros	60 million euros
Effect of measures	Certain	Certain (5) Probable (20)	Unknown
Implementation of measures	Plausible	Certain	Unknown

Table 4: Summary of the two improvement programmes

5 LEARNING LESSONS FROM LEVEL CROSSING ACCIDENTS

Following the implementation of the NABO programme, almost all level crossings will be protected level crossings. They are relatively safe and to make further safety gains it is extremely important to know how level crossing accidents come about. This chapter examines the way in which the parties involved learn lessons from the level crossing accidents that occur.

5.1 Accidents investigated mainly by ProRail, and with a focus on the railway aspects

Who are the parties investigating level crossing accidents?
ProRail gathers information in what is known as a factual report for almost all level crossing collisions and a large number of near-collisions. Additionally, ProRail administers a database with abridged information about these accidents.

In addition to ProRail, the ILT is also involved in level crossing accidents, discussing them internally and gathering information. The ILT only visits the scene of the accident in exceptional cases (unusual cause or large number of casualties).

The Ministry of Infrastructure and Water Management does not conduct its own accident investigations but primarily uses the data from ProRail. The Ministry only makes limited use of the ILT as its own, independent source of information. This may change: the Ministry of Infrastructure and Water Management has indicated in the Rail Safety Policy Incentive[70] that the ILT will 'provide insight into underlying risk factors through analysis of accidents and near accidents in its annual reports'. The reason stated is that the statistical key figures which the ILT keeps for European statistics in its role of national safety authority are not a sufficient basis for the policy that is to be conducted. The ILT's Safety in Rail Traffic Annual Report for 2016[71] does not, however, include any analyses of accidents or near-accidents at level crossings.[72]

Train operators very rarely investigate level crossing accidents themselves, if at all; and if they do, they tend to focus on the procedures and the train driver's course of action. Train operators do inform ProRail of hazardous situations (near-collisions) and they feed specific information to ProRail's accident investigations, such as the train driver's statement. As far as is known, road authorities (usually municipalities) do not normally

70 Published in June 2016.
71 Published in October 2017.
72 In the review of the draft report the ILT indicated that problems arise in obtaining the necessary information from the rail companies.

conduct independent investigations of level crossing accidents, although in some cases they are in contact ProRail within the framework of its investigation.

The police also investigate level crossing accidents with the objective of establishing if criminal offences have been committed.

ProRail's knowledge monopoly

Because ProRail is the party most actively involved in investigating level crossing accidents and is also involved in almost all level crossings it has, to a certain extent, a knowledge and information monopoly. A road manager does not have information about causes and underlying factors of an accident and depends on ProRail to gain this knowledge.

Because ProRail does not distribute this information widely of its own volition, the road manager will have to actively approach ProRail for it. In practice this does happen after an accident, but not usually preventively.

Within the framework of the LVO, CROW – the organisation that draws up the guidelines for road design – has come up with the idea to set up an 'incident analysis platform' in which road managers, the rail network manager and other parties cooperate to share lessons learned. However, there was limited interest in this from the road managers and the platform is no longer active at this time.

In Germany for example, there are joint level crossing inspections in which the road manager, the rail network manager, the police, the railway police and the Inspectorate participate. At regular intervals, they determine whether the protection measures in place are still in line with the local situation.

Primary focus on own responsibilities

The accident investigations by ProRail, the ILT and the police do not primarily focus on finding structural options for improvement. On the contrary: in their investigations ProRail and the ILT mainly focus on the extent to which the level crossing complied with the regulations, while the police investigation is usually limited to identifying whether those directly involved have committed criminal offences. In a large majority of cases, the outcome of the investigations is that the level crossing complied with the regulations and that the accident occurred because the road user did not fulfil their obligation to give way to the train.

In their factual reports, ProRail systematically asks the valid and logical question of whether the level crossing (system) complies with the internal guidelines. If the answer is yes, usually the investigation is completed; after all, there was nothing wrong with the level crossing as such. The question of whether, given the accident, the guidelines should be improved is not posed however. And in some of its investigations ProRail does not recommend any follow-up actions, the reason being that the cause falls outside of ProRail's sphere of influence. The following quotes by way of illustration:

'*Given that the accident was not caused by any failure of the railway infrastructure and that, hence, there is no safety gain to be achieved, we recommend no further investigation be conducted.*'

'*ProRail cannot prevent (heavy) road vehicles coming to a halt on a level crossing. The ambition is to reduce the number of level crossings.*'

Since 2012, ProRail did conduct extensive research into how level crossing accidents generally happen, but ProRail the Inspectorate and the police grasp the opportunity to use the accident investigations for improvement options only to a limited extent. The Dutch Safety Board believes that there are three factors that explain this:

- The organisations choose to limit the focus of their investigations to those aspects for which they are primarily responsible. For ProRail that is the management and maintenance of the railway infrastructure, for the ILT it is supervision and enforcement of railway legislation and for the police it is detecting and prosecuting criminal offences.
- The organisations take as their basic view of why level crossing accidents occur, that – apart from the rare failure of the level crossing protection system and/or the train driver – the cause lies in the road user's unlawful or improper behaviour.
- There are stumbling blocks in the mutual exchange of information between the organisations involved. For instance, ProRail has indicated that it is experiencing problems in requesting personal details and statements from those involved and witnesses, as well as requesting the video images from the front cameras on trains.

Such an interpretation of duties fails to produce a systematic and integral analysis of improvement options after an accident - even though many accidents actually reveal a combination of railway and road related factors.

Analysis of level crossing accidents by the Dutch Safety Board

Based on information from ProRail and other sources, the Dutch Safety Board has analysed the accidents from the 2012–2016 period (see Appendix E). This analysis revealed that the way in which the accidents occur depends on the level crossing protection and the type of road user, that causes can be both railway and road related, and that information about the immediate cause is available for most accidents but there is no or hardly any insight into the underlying factors. In particular, there is a lack of insight into why the road user's behaviour fell short.

Level crossings protected by barriers
More than half of all fatalities and serious injuries that occur every year on level crossings involve slow traffic on protected level crossings. Some of the accidents occur near stations. Moped and bicycle riders are involved in accidents with slow traffic as often as pedestrians and mobility scooters. The main causes of accidents are, as far as they are known:

- *Passing closed or closing barriers:*
  in many cases the underlying cause is not known. Sometimes the road user was driving on the wrong side of the road where there was no level crossing barrier. In addition, there are instances where the descending barriers were noticed too late. Haste and impatience also play a role, and many of these accidents also involve what is known as second-train accidents.
- *Being too slow, falling and/or problem with the vehicle:*
  this usually involves older people (sometimes with a rollator). In these cases some victims were unable to find safe haven after ending up between closed level crossing barriers. Other reasons are falling and a mobility scooter breaking down.

Collisions with fast traffic on protected level crossings account for a quarter to one-third of all accidents and casualties on level crossings. A private car or van is usually involved. In collisions with heavier vehicles (such as a truck) the train sometimes derails. The main causes of accidents are, as far as is known:

- Stopping or stranding on the level crossing:
  this usually happens because a vehicle grounds next to the level crossing surface, almost always by turning off too quickly (see section 5.2, the Boxtel accident). Engine problems also occur, as well as being unable to drive on due to, for example, a traffic jam after the level crossing. Finally, the road user could be manoeuvring on the level crossing because the level crossing dimensions are too tight or there is a sharp bend immediately before or after it.
- Passing closed or closing barriers:
  the reason for this is sometimes unknown. In other cases, intentionally (wilfully) ignoring the protection is slightly more common than not noticing the (lowering) barriers in time.
- Being too slow:
  this always involves large or heavy vehicles. Occasionally the re-closing of a level crossing that has just opened precedes the collision.

Unprotected level crossings
Between 5% and 10% of all fatalities and serious injuries on level crossings involve slow traffic on unprotected level crossings on passenger lines. Pedestrians are rarely involved in an accident; almost invariably the victim is someone riding a moped or pushing or riding a bicycle.

Fast traffic on unprotected level crossings also accounts for approximately 10% of all fatalities and serious injuries on level crossings. This usually involves a passenger car, van or minibus and occasionally a truck.[73]

The cause is unknown for approximately 20% of the accidents on unprotected level crossings. In the other accidents, the road user was not looking or was not looking well enough. There are scenarios where the driver was not looking, or was looking too late, but there are also scenarios where the driver was consciously looking but failed to see the train. The underlying factors are often unknown in these cases. In many cases the driver was from the area, but in several cases they were not familiar with the level crossing.

Limited attention to broadening lessons learned
From the analysis that the Dutch Safety Board carried out on ProRail's investigation reports, it follows that after some of the level crossing accidents changes have been made to the level crossing or its surroundings in consultation with the road manager. Those improvements focus strongly on taking away undesired situation at or around the level crossing where the accident occurred. The question of whether the problem involved could also be an issue on other level crossings in the Netherlands is not addressed systematically. As a result, accidents could continue to occur (see box).

73 The accident in Winsum (see paragraph 1.1) resulted in the total derailment of a train and was responsible for almost all minor injuries in this accident category during the 2012–2016 period.

Accident in Wouw (2017): Road layout leads to manoeuvring on level crossing[74]
A truck driver was manoeuvring with his low loader on a level crossing in Wouw[75] because he wanted to turn right just after the level crossing. He could not take the bend in one go because of a lamp post and chose to manoeuvre backwards and forwards. During that manoeuvre, the level crossing protection system came into operation due to an approaching passenger train. The driver no longer had time to get the vehicle clear of the level crossing; the train crashed into it and partly derailed. The driver had left the vehicle in time; the train driver and some of the train's passengers suffered minor injuries.

Figure 20: Wouw level crossing (the truck was attempting to turn right after the level crossing). (Photo: Police)

74 Sources: ProRail's accident database and factual reports, ILT and NS Reizigers accident databases and various media websites, interviews of those involved.
75 This accident is also described in paragraph 1.1 and Appendix C.

Previous, similar incidents

2012: A low loader drove through a level crossing barrier on a level crossing in Utrecht, breaking it, when the level crossing closed during a manoeuvre to take the bend after the level crossing. The driver stated that he had had to engage the drive on his back wheels, which made his vehicle slower than is the case with normal steering. He further stated that he had been involved in a similar accident at that location before but no damage occurred on that occasion.[76]

2014: There was a level crossing collision in Ruurlo when a truck was stationary on the track while attempting to take a sharp bend. This manoeuvre was needed to drive into a road just after the level crossing. When the level crossing protection system came into operation, the driver no longer had time to clear the tracks with his truck. Several train passengers suffered minor injuries. In its factual report, ProRail stated that they could see no reason for a follow-up investigation because the level crossing satisfied the requirements and the accident was caused by the road user's behaviour.[77]

2015: A truck driver drove through and destroyed a level crossing barrier in Leerdam. The driver stated that he was unable to cross the level crossing in one go due to the local situation and had to reverse once. The level crossing closed for an approaching train during this manoeuvre. The driver chose to crash through the level crossing protection system and signs to avoid a collision.[78]

With hindsight, the collision in Wouw could easily have been prevented by moving the street furniture and widening the bend. These changes were made after the accident. However, none of the parties checked if similar accident scenarios were possible (and easily preventable as well) on other level crossings in the Netherlands.

76 Source: ProRail factual report.
77 Sources: ProRail's accident database and factual report, ILT accident database, Ruurlo Vandaag media website, police website.
78 ProRail factual report.

5.2 Understanding road users' behaviour is needed for safety to be improved

Not being understanding of, but understanding reckless behaviour ProRail, the Ministry of Infrastructure and Water Management and the ILT are regularly spreading the view that level crossing accidents occur because of the 'recklessness' of road users. The Chairman of ProRail's Supervisory Board said in *De Telegraaf* newspaper on 24 November 2016: 'Many accidents occur on level crossings with barriers as a result of road users behaving recklessly'.[79] In the current policy document the Ministry says: 'The cause of accidents on level crossings can, in many cases, be blamed on the risky behaviour of road users, such as crossing when a train is approaching or slaloming between closed barriers.'[80] And finally, the Inspectorate reports that 'accidents are the consequence of, among other things, unsafe behaviour, such as intentionally passing closed barriers. Ten serious injuries were caused by reckless behaviour in 2015.'[81]

For all level crossing accidents on passenger lines in the 2012–2016 period, the Dutch Safety Board investigated the extent to which the level crossing protection system which had been activated was intentionally (wilfully) ignored. The conclusion is that a quarter of all level crossing accidents (23 per cent) and less than half of all fatalities and serious injuries (40 per cent) can be blamed on intentionally ignoring an activated level crossing protection system. In a majority of accidents, there is no question of intentional risky behaviour.[82]

Although this picture of reckless behaviour presents the correct picture of a quarter of the accidents, the Dutch Safety Board believes that the labels 'recklessness' or 'risky behaviour' are not always used appropriately and that this can hamper the improvement of level crossing safety. By emphasising recklessness there is a danger of losing the understanding that a significant proportion of level crossing accidents occur without there being a conscious choice to behave dangerously.

The two boxes below provide examples of accidents where risky behaviour was not a factor.[83]

79 *De Telegraaf*, 24 November 2016.
80 Rail Traffic Policy Incentive, Ministry of Infrastructure and the Environment, June 2016.
81 ILT, Annual Report on Railway Safety 2015, The Hague, 2016.
82 Approximately 20% of the accidents and 30% of the fatalities and serious injuries were the result of intentionally passing closed or lowering level crossing barriers. Sixty per cent of the accidents and 45% of the fatalities and serious injuries had a different cause. The cause of the remaining 20% of the accidents and 25% of the fatalities and serious injuries is not known. These percentages are evenly distributed across the intentional and unintentional categories.
83 In this cases ProRail did not use the label 'behaving recklessly'

Heiloo accident: Elderly person who was crossing too slowly no longer able to find save haven[84]

An elderly woman and her husband arrived at Heiloo station on bicycles and were looking for a safe place to park them. The bicycle parking area on one side of the track appeared to be full so they crossed the level crossing. While crossing, the level crossing barriers closed for an InterCity approaching from Alkmaar. The woman was still standing between the level crossing barriers and tried to turn and walk back but could not get away in time. She was run over by the train and died shortly afterwards.

Figure 21: Level crossing next to Heiloo station. (Photo: Dutch Safety Board)

84 Sources: ProRail's accident database and factual report, ILT and NS Reizigers accident databases and the NH News media website.

Boxtel accident: Stranding next to the crossing surface after turning off too soon[85]
During darkness, a 59-year-old man in a passenger car wanted to turn left after a level crossing in Boxtel but turned off too early. This took him onto the track and he could not get off any more. The driver reported the stranded car to ProRail via the police. The emergency services came to remove the car from the track, but were unable to do so in time. The car was hit but the driver had left the car in time.

Figure 22: Boxtel level crossing (the car was oncoming, it was dark). (Photo: Dutch Safety Board)

The terms 'reckless' and 'risky' are also, in a certain sense, suggestive. The Dutch Safety Board is concerned that this choice of words 'explains away' the accident, suggesting that it would not have happened if the user had not behaved improperly. However, to improve safety is necessary to understand why the behaviour occurred and to take measures to anticipate this. Understanding the behaviour should be separate from the question of whether or not the behaviour is prohibited.

Just as with other level crossing accidents, that usually occur due to a miscalculation, a miscalculation is also usually involved in those accidents that do occur as a result of risky behaviour. After all, here too the level crossing user usually supposes that he or she – despite ignoring warning signs – can safely reach the other side.

The box below gives an example of an accident where this type of miscalculation played a role in the intentional ignoring of level crossing barriers.

85 Sources: ProRail, ILT and NS Reizigers accident databases, *Brabants Dagblad* media website.

Ravenstein accident: Trying to catch a train, run over by another one[86]
One evening, a 32 year-old man was trying to catch the train to Oss, which was standing at the platform on the other side of the tracks. The next train would not depart for another 30 minutes. The man climbed over the closed level crossing barriers with perpendicular fencing. They were still closed for the passage of an InterCity from the opposite direction. The man was hit by this InterCity while crossing the tracks and died as a result.

Figure 23: Foot crossing at Ravenstein station. (Photo: Dutch Safety Board)

Different views
The Dutch Safety Board notes that within ProRail there are different views on the extent to which the behaviour of road users influences level crossing accidents.

On the one hand, in its recent accident investigations ProRail often reaches the conclusion that improper behaviour by the road user involved played a role in bringing about the accident and that it has no influence on this behaviour. At the same time, ProRail takes a wide range of measures, in a general sense, which do aim to influence the behaviour of road users. ProRail runs publicity campaigns, employs special enforcement officers and in some cases files criminal complaints, to counter intentionally risky behaviour. Within the framework of the LVO, ProRail is conducting extensive research into generic solutions to counter unintentionally risky behaviour (see paragraph 4.3).

86 Sources: ProRail's accident database and factual report, NS Reizigers accident database and various media websites.

The Dutch Safety Board believes it is important that ProRail, in its accident analyses, also expressly endeavours to understand the behaviour of the road user instead of merely mentioning it or condemning it. Whilst it is true that ProRail is not responsible for the behaviour of road users it can, as part of its responsibility for level crossing safety, count *knowledge* of the behaviour of road users as part of its responsibilities. In addition, given ProRail's knowledge monopoly described above, under the current system it is also the only, logical party where this type of knowledge is accumulated.

5.3 Subconclusions

ProRail's knowledge monopoly
ProRail is the only party that investigates almost all collisions and near collisions on level crossings. As a result, knowledge about level crossing accidents is concentrated at ProRail. Other parties, such as road authorities, train operators, road haulage companies and the ILT, do very little research of their own and are not actively involved in learning lessons from level crossing accidents. The Ministry of Infrastructure and Water Management has announced that the ILT is going to provide greater insight into the underlying factors in level crossing accidents, but this is yet to materialise.

Limited attention to broadening lessons learned
ProRail does not structurally investigate the extent to which situational factors that played a role in a specific level crossing accident could also be an issue at other level crossings. As a result, potential safety improvements are not implemented.

The investigation of level crossing accidents only focuses on opportunities for improvement to a limited extent
Usually, accident investigations by ProRail, the police and the ILT mainly focus on the question of whether the level crossing satisfied the regulations and whether criminal offences were committed. The usual outcome of the investigation is that the level crossing satisfied the regulations and the accident occurred because the road user failed to give way to the train. Often, there is no further investigation into the circumstances under which the road user stranded on the level crossing or into their reasons for entering the level crossing even though a train was approaching. However, insight into this is required to be able to influence the behaviour of road users.

Inappropriate use of label 'recklessness' can hamper learning lessons
ProRail, the Ministry of Infrastructure and Water Management and the ILT regularly state that the majority of level crossing accidents are caused by the reckless or risky behaviour of road users. This can create the impression that most of those involved intentionally take a risk and that their behaviour cannot or can hardly be influenced. However, the analysis revealed that a majority of accidents involved no intentional risk-taking and that even in those accidents where road users did take an intentional risk, factors are involved that can be influenced to realise further safety improvements.

6 CONCLUSIONS

The Dutch Safety Board started its investigation after three serious level crossing accidents. These accidents led to the Dutch Safety Board raising questions on the level of safety of level crossings, on the existence of a vision on level crossing safety and on learning lessons from accidents at level crossings. The investigation has revealed that while attention is devoted to level crossing safety, there is room for improvement in all three points for concern.

1. Safety on level crossings has improved significantly in recent decades. There is still room for improvement.

Level crossing safety improved significantly between 2000 and 2017. The number of accidents fell by sixty per cent and the number of fatalities by seventy per cent. The safety improvements were mainly achieved in a period of targeted improvement policy in the first years of this century.

On average, there are thirty accidents each year, in which eleven people die. The majority of these occur on the many protected level crossings and approximately two per year are on a small group of unprotected level crossings.

The Dutch railway system with its high volume of traffic and many level crossings is unique in Europe. Compared with other European countries, it turns out that other countries perform better than the Netherlands, which indicates that there is still room for improvement. The United Kingdom and Switzerland in particular could serve as useful examples.

2. The responsibilities of the road manager and rail network manager are not sufficiently explicit.

A level crossing is where a road crosses a railway. Therefore, both the layout of the level crossing itself and the layout of the roads leading to it are determinative for the safety of the crossing. It is remarkable, therefore, that there are hardly any statutory provisions for this. For instance, there are no rules for the acceptability of and minimum protection for level crossings.

Statutory requirements for level crossings are fragmented: for instance, no single actor is responsible for all aspects of level crossing safety. The Minister of Infrastructure and Water Management does bear most responsibility however. After all, the Minister is responsible for the rail infrastructure, including the level crossings. The Minister has granted a concession to ProRail, who manage the main railway network and also bear responsibility for the safety of level crossings within that network. The Minister of Infrastructure and Water Management does not, however, set any concrete requirements for ProRail with regard to level crossing safety. In practice, separate programmes are set up for level crossing safety, with separate budgets and control mechanisms. This makes the true extent of ProRail's responsibility unclear, but it is clear that the Ministry keeps a certain responsibility.

Level crossing safety is a wider topic than railway management. Nonetheless, a road manager has no explicit statutory role in level crossing safety either; under current policy however the manager does contribute fifty per cent of the costs of tackling a level crossing. Both this policy and the Road Act are the responsibility of the Ministry.

3. Current improvement policy is too voluntary and may only deliver safety improvements to a limited extent.

As long as the number of level crossing casualties does not increase, the Netherlands will be complying with the standard that the EU has set for level crossing safety. The Dutch Safety Board does not believe that this is sufficiently ambitious. The Ministry of Infrastructure and Water Management has not had a concrete, national objective for level crossing safety since 2010. In that year, in which the policy at that time came to an end and the earlier safety objectives had been amply achieved, ProRail noted that at the time there were no further cost-effective measures for improving level crossing safety. Nevertheless, the LVO programme was launched in 2012 and, at the insistence of ProRail and after two accidents at a level crossing in Winsum, the NABO programme commenced in 2014.

Because the probability of an accident at an individual level crossing is fairly small, many level crossings have to be tackled to substantially reduce the number of accidents and casualties. Four types of measures will be implemented within the framework of the two aforementioned programmes (removal or protection of 127 unprotected level crossings, grade separating 5 protected level crossings and other measures on 20 protected level crossings). These measures will probably be effective but since they only involve less than 10% of the total number of level crossings. As a fourth measure, it has been decided that at approximately 200 protected level crossings measures will be taken to reduce waiting times for road traffic. It not clear, however, how far this will reduce the number of accidents.

The effectiveness of the remaining measures, which relate to a greater proportion of the level crossings, is not known; moreover, for some of measures it is not clear whether they will be implemented at all, or when, and at how many level crossings. The Ministry has only released a partial budget for these measures thus far.

4. Level crossing accidents are investigated from a limited perspective, creating an incomplete picture of the causes and leaving opportunities for safety improvements unexploited.

ProRail is not the only party with an interest in safe level crossings, but at the majority of level crossing accidents it is the only party that conducts systematic accident investigations. After an accident, ProRail mainly investigates what happened with less concern for *why* it happened. This means that the investigation and the data that is recorded is usually too limited and one-sided to be able to learn structural lessons. Improvement measures usually relate to the level crossing where the accident occurred but there is no systematic check of whether the same issue exists at other level crossings.

ProRail, the Ministry of Infrastructure and Water Management and the ILT communications often speak of reckless or risky behaviour by road users as the leading cause of level crossing accidents. The Dutch Safety Board concludes, based on its own analysis of ProRail's accident reports, that recklessness or intentional risk-taking is not a factor in about three quarters of all accidents and more than half of all casualties. Furthermore, even in accidents that do involve risk taking, factors are at play that could be influenced to achieve further safety gains. The qualifications 'reckless' or 'risky' behaviour do not explain the road user's motivation for demonstrating this behaviour; such an explanation is, however, needed as a starting point for preventing this type of behaviour.

7 RECOMMENDATIONS

The Dutch Safety Board has formulated the following recommendations.

To the State Secretary for Infrastructure and Water Management:

1. **Within six months, merge the existing level crossing programmes (LVO and NABO) into a single overarching level crossing policy. With this policy, halve the number of level crossing accidents and level crossing fatalities within 10 years and reduce it to zero as quickly as possible.**
   The ultimate objective of the level crossing policy should be that there are no more level crossing accidents and no more level crossing casualties. The Safety Board considers it to be unacceptable that 11 people lose their lives every year on the government's rail network.

2. **Improve level crossing safety by basing the policy on:**
   a. Measures from other countries that have proved to be worthwhile, both in relation to the level crossing protection used, the number of level crossings and the administrative relationships.[87]
   b. An independent and scientifically underpinned analysis of the factors that play a role in level crossing safety and the demonstrable effectiveness of available measures.
   c. Integral accident investigation following an accident, by the rail network manager and road manager together, examining the factors in the accident (including the reason for the behaviour of level crossing users).

3. **Legally stipulate who is responsible for what and bears the costs for level crossing safety.**
   Administrative impasses about the desired solution and the funding for it were also raised by the predecessor to the Safety Board in 2003. The recommendation to resolve these impasses, made at that time to the Minister for Transport, Public Works and Water Management, has not been followed up. The Safety Board believes there is an urgent need for this to be done now, as part of the ongoing modernisation of railway legislation for example.

87 Paragraph 3.2 shows a number of examples of measures from other countries.

APPENDIX A

EXPLANATION OF THE INVESTIGATION

Purpose and research question

In mid-2017, following a brief exploratory assessment, the Dutch Safety Board decided to conduct a thematic investigation into the safety of railway level crossings. The purpose of this investigation is to contribute to improving the safety of level crossings. The investigation aims to answer the research question:

Main question:
Can level crossing accidents be reduced further and if so how?

Procedure

To answer the research question, a summary was compiled of the various types of level crossing in the Netherlands and of the parties that are involved in the management of level crossing safety. In addition, the roles, tasks and responsibilities of these parties were listed.

An overview of level crossing categories (in relation to the ways they are used/managed/protected) was drawn, including data on the number of accidents and casualties occurring annually per category and developments in these numbers in recent decades. Based on an analysis of the approximately 160 level crossing accidents that occurred in the 2012–2016 period, an impression was gained of the state of level crossing safety in the Netherlands, both in terms of how level crossing accidents occur and how the parties concerned learn lessons from this.

To assess how the Netherlands ranks on level crossing safety at international level, relevant key figures were compared with the figures published by the EU Agency for Railways (formerly ERA). These figures cover 28 countries: the 26 EU Member States in which there is train traffic plus two other European countries (Switzerland and Norway) that are not EU members but are included in the European statistics. In addition, the national safety authorities in these countries were asked to complete a questionnaire so as to gain insight into how level crossing safety is managed in other countries, both on a number of technical aspects and on an administrative level. Nine safety authorities responded to this.

For three European countries (Germany, United Kingdom and Switzerland) the Safety Board has formed a broad outline impression of how level crossing safety is implemented there both technically and administratively. The Safety Board has based this on written

sources on the legislation and its application[88], a quantitative impression of level crossing situations from Google Street View and track section videos, and the replies that safely bodies in Germany and the United Kingdom provided to the aforementioned questionnaire.

In addition to this, the Dutch Safety Board asked the Ministry of Infrastructure and Water Management and ProRail what additional measures have been implemented (or are planned) to further reduce accidents on railway level crossings. They also identified if there were any operational, administrative, social and/or other types of stumbling blocks, and if so which, that could stand in the way of such improvement efforts.

The Dutch Safety Board used this information to form an opinion on the extent to which these additional measures can be expected to diminish various categories of accident scenarios and the extent to which more can be done to reduce accidents further or more quickly.

Gathering information
A wide variety of information was used in the investigation:

- photographic material. This is material from the Dutch Safety Board itself (created at the scenes of accidents) as well as from the firms involved, the police, media, local residents and other witnesses;
- correspondence between the actors involved;
- risk analyses conducted by firms and other business documents, such as internal standards, guidelines, methods and their own investigations of level crossing accidents;
- documents drawn up by various firms and bodies involved at the request of the Safety Board, with responses to questions asked by the Safety Board;
- public sources such as news reports, articles in trade journals and scientific literature;
- official reports on technical investigations and hearings conducted by the police;
- interviews: within the framework of this investigation, sixteen interviews were conducted with both those involved in accidents and representatives of parties involved in improving level crossing safety at an administrative level. The purpose of the interviews was partly to gather information and partly for the parties to reflect on the way in which level crossing safety is organised. The semi-structured interviews were recorded in a report that the interviewees could check for accuracy and sign as agreed. This included the following types of parties:

88 *For the United Kingdom:*
Level Crossings Act 1983
Level Crossings: a guide for managers, designers and operators, Railway Safety Publication 7, Office of Rail Regulation, December 2011.
For Germany:
Eisenbahnkreuzungsgesetz
Eisenbahn-Bau- und Betriebsordnung
For Switzerland:
Eisenbahngesetz (742.101)
Verordnung über Bau und Betrieb der Eisenbahnen (742.141.1)
Ausführungsbestimmungen zur Eisenbahnverordnung (SR 742.141.1)

- those involved in accidents
- public and private road authorities
- the rail network manager (ProRail)
- the Ministry of Infrastructure and Water Management
- othe Human Environment and Transport Inspectorate (ILT)
- a province
- several municipalities
- train operators.

Reference framework

The Dutch Safety Board tested the findings of its investigations against a reference framework in which it formulates, in broad outline, the system-level measures it expects from the parties involved[89], specifically in this case the rail network manager, road authorities and central government, to achieve the desired level of safety. Identifying deviations from this reference framework allows the Safety Board to make clear where it believes safety improvements can be made.

In addition to current laws and regulations and directives (see Chapter 3), the reference framework for level crossing safety comprises the following components: a reference framework for risk management, a reference framework for the joint monitoring of safety and a reference framework for safety-oriented public supervision. These various components are described below.

Risk management

A systematic approach to risk management focuses on the timely recognition and reduction of risks: in other words, identifying the accident mechanisms that exist, the probability of an accident occurring in this way and its possible consequences, as well as the measures that can reasonably be taken to counter those risks. Where necessary, this is done in consultation with other parties.

Joint monitoring of safety

The parties that are involved in managing the risks associated with level crossings work together in mutual dependence. In addition to the responsibility for safety on 'their' part of the level crossing, the rail network manager and the road manager are responsible for managing the safety of the level crossing as a whole. This means they should work together to manage the safety risks where their individual safety management systems do not suffice.

89 The Safety Board is employing what is known as a 'system approach' in this investigation. This assumes that (fostering) railway safety can be described as a system in which there is an interplay between various individuals, organisations and technical systems. The actors in this system all have different objectives, various degrees of influence on the accident risk and different capacities to act. In the case of level crossing safety, the actors all have a role to play in facilitating a safe crossing. An accident shows that the interplay of the various actors involved was unsuccessful in achieving a safe crossing in that specific case.

Safety-oriented public supervision
Central government, as guardian of the public interest, should ensure that the cooperation results in safety of the system as a whole being guaranteed. This is given substance by, among other things, appointing the Human Environment and Transport Inspectorate (ILT) as the supervising body. The Safety Board uses the following principles when assessing supervision:

- The road manager and rail network manager have primary responsibility for level crossing safety. The Inspectorate ensures that they fulfil these responsibilities but does not take them over.
- Effective supervision requires that the Inspectorate has suitable knowledge and the personnel and financial resources that are needed to guarantee the intended level of safety.
- The Inspectorate is familiar with developments at the parties and in the sectors it supervises. The Inspectorate warns of risks, places them on the agenda, shares knowledge and actively provides feedback to management, politicians and society at large.
- Where possible, findings are disseminated as widely as possible so that all interested parties are familiar with the state of safety. This allows other parties to contribute towards safety improvements.

Reports
This report is the result of the investigation. It presents the main findings of the investigation and is not a complete summary of all information collected and analyses conducted during the investigation.

Guidance committee

The Dutch Safety Board established a guidance committee for the purpose of this investigation. The committee comprised external members with expertise relevant to the investigation and was chaired by a member of the Safety Board. The external members sat on the guidance committee in a personal capacity. The committee convened on three occasions during the investigation to share information on the purpose and results of the investigation with the members of the Safety Board and the project team. The committee acted in an advisory capacity during the investigation. The Safety Board bears final responsibility for the report and the recommendations.

The guidance committee comprised the following people:

Prof. M.B.A. van Asselt (chair)	Member of the Dutch Safety Board
W.J. Kuijken	Delta Programme Commissioner; former Secretary General, Ministry of Transport, Public Works and Water Management
B.P. Smolders MBA	former Director of Asset Management and Project Management, ProRail
S. Thijsen BNT	Director of the Netherlands National Forest Service (Staatsbosbeheer)
Prof. G.P. van Wee	Professor of Transport Policy; TU Delft
G.H.N.L. van Woerkom	former Director of the Dutch Automobile Association (ANWB)

Project team

The project team comprised the following people:

Dr E.K. Verolme MBA	Investigation Manager (until 1 Dec 2017)
G.W. Medendorp	Investigation Manager (from 1 Dec 2017)
P.M. van der Eerden LLM	Project Manager (until 15 Oct 2017)
Dr J. van den Top	Project Manager (from 15 Oct 2017)
Dr E.M. de Croon	Investigation and Development Consultant (until 1 Jan 2018)
M.H. Verschoor	Investigation and Development Consultant (from 1 Jan 2018)
A. Sloetjes	Investigator
A.J. Tromp	Investigator

The Dutch Safety Board wishes to thank A. Wedzinga for his contribution to summarising the statutory requirements for level crossing safety.

APPENDIX B

RESPONSES TO THE DRAFT REPORT

In accordance with the Dutch Safety Board Act a draft version of this report was submitted to all parties involved for review. The following parties have been requested to check the report for any factual inaccuracies and ambiguities:

- Ministry of Infrastructure and Water Management
- Rail network managers: ProRail and the Heritage Railway Lines association
- Road managers involved in level crossing accidents at Winsum, Harlingen and Wouw

As far as they deemed this necessary, these parties have responded to the draft version of the report. The responses that were received were handled in the following manner:

- The Safety Board has incorporated corrections of factual inaccuracies, additional details and editorial comments in the report, where relevant. The relevant passages were amended in the final report. These responses have not been included separately.
- Where the Safety Board has not adopted responses, the reason for this decision by is explained. These responses and the explanation of them are set out in a table that can be found on the Dutch Safety Board's website (www.onderzoeksraad.nl).

LEVEL CROSSING ACCIDENTS IN WINSUM, HARLINGEN AND WOUW

C.1 Introduction

There were three serious level crossing accidents at the end of 2016 and beginning of 2017 in Winsum, Harlingen and Wouw respectively. These accidents were the reason for this investigation.

C.2 Level crossing accident in Winsum

On 18 November 2016, a passenger train collided with a truck on the unprotected level crossing on Voslaan in Winsum. Eighteen of the train's occupants were injured and the truck and the train were severely damaged. The train derailed and ended up hanging at an angle above a ditch.

Figure 24: The consequences of the collision in Winsum on 18 November 2016. (Photo: Dutch Safety Board)

There had already been two fatal accidents on the same level crossing in 2014. Partly in response to those two previous accidents, consultations were held between the rail network manager (ProRail) and the road manager (Winsum Municipality) to improve the situation at the level crossing. This improvement project had not been completed in the autumn of 2016, when the accident involving the truck occurred. As a result of the collision with the truck, tackling the level crossing in Voslaan was accelerated. Within a couple of weeks a by-bass road was constructed on leased land as a temporary solution and the level crossing was then closed. The parties had still not reached agreement on the definitive solution at the start of 2018.

C.3 Level crossing accident in Harlingen

On 27 March 2017, a train on the level crossing on Oude Trekweg in Harlingen collided with a passenger car. The car's occupants, a father and his son, were killed in the collision. They had been visiting an event at a farm which was visited by approximately 300 visitors over a number of days.

The level crossing gave access to a single farm and was immediately next to the farmyard. It was a private level crossing with a public character where flashing lights warned of approaching trains.[90] There were no bells or barriers.

Figure 25: Former level crossing on Oude Trekweg in Harlingen where collisions occurred on 8 February 2017 and 27 March 2017. (Photo: Movares)

There had been various near-accidents on the level crossing concerned in the past. Approximately seven weeks before the fatal accident, there had been a collision with a passenger car in which the car driver was injured. In response to this first accident, the occupants of the farm and ProRail commenced consultations on replacing the level crossing

90 It was what is known as a WILO; short for *Waarschuwingsinstallatie Landelijke Overweg* (rural level crossing warning system).

with a new by-pass road to a nearby level crossing which is protected by barriers. This process was accelerated as a result of the second accident. Approximately six months after the second accident, the alternate access road was taken into use and the original level crossing was removed. The farm occupants pre-financed and commenced the construction of the new road before the steward of the leased land had given formal approval.

C.4 Level crossing accident in Wouw

On 28 April 2017 a passenger train and a truck collided on the level crossing on Plantagebaan in Wouw. A number of the train's occupants suffered minor injuries; the train and the truck were severely damaged. The front part of the train derailed and landed close to the adjacent track. As a result of this, the accident could have resulted in a collision with an oncoming train.

The level crossing was equipped with barriers, bells and flashing lights.[91] The accident happened because the driver of the truck, which was approximately 25 metres long, could not take the bend to an access road running parallel to the track in one go due to a lamp post on the inside of the bend. Consequently the driver felt obliged to manoeuvre on the level crossing. Because of the nature of the business (buying and selling heavy machinery and trucks for construction, earth moving, forestry, etc.) this was a regular occurrence with exceptionally large and heavy trucks having to drive into or out of the side street.

The road situation was changed in response to this accident; the road manager moved the lamp post concerned and reinforced the verges.

Figure 26: Consequences of the collision in Wouw on 28 April 2017. (Photo: Police)

91 The level crossing was of a category known as AHOB, which is short for *Automatische Halve Overwegbomen* (Automatic Half Barriers).

APPENDIX D

EUROPEAN COMPARISON OF LEVEL CROSSING SAFETY

The table below includes characteristics that are relevant for the comparison of level crossing safety for 28 European countries in Chapter 2. The source data is from several publications of the European Union Agency for Railways and from Eurostat. Values in black are source data, those in blue are data calculated by the Dutch Safety Board based on the source data. The level crossing accidents per year, indicated by (+) are so-called significant accidents. These are accidents which result in at least one seriously injured person, considerable damage or extensive disruption of the railway traffic.

Country	Kms of track	Number of l. crossings (2014)	Level crossings per km	Million train km (2014)	Train passages/ year (2014)	L. crossing accidents/ year	Casualties/ year
Austria	5.223	4.509	0,86	152	29.179	40	17,2
Belgium	3.631	1.818	0,50	97	26.615	16,6	9,8
Bulgaria	3.897	774	0,20	29	7.390	13	4
Switzerland	3.750	1.625	0,43	189	50.475	10	2,8
Czech Republic	9.458	8.001	0,85	160	16.929	39,6	19,2
Germany	33.483	13.983	0,42	1043	31.157	98,4	36,2
Denmark	2.446	1.338	0,55	63	25.869	3,8	3,2
Estonia	918	326	0,36	7	8.159	4,6	2,6
Greece	2.238	1.453	0,65	11	5.136	7,8	6
Spain	15.183	3.304	0,22	204	13.452	12,2	6,8
Finland	5.944	3.384	0,57	50	8.358	6,8	3,6
France	36.831	15.943	0,43	490	13.301	42,4	29,4
Croatia	2.604	1.241	0,48	21	8.040	13,2	9,8
Hungary	7.706	6.041	0,78	101	13.119	31,4	23,8
Ireland	1.683	978	0,58	18	10.856	0,4	0
Italy	15.990	5.010	0,31	331	20.675	21,4	10,6
Lithuania	1.767	545	0,31	14	8.091	4	3,6
Luxembourg	275	127	0,46	9	32.775	0,4	0,4
Latvia	1.860	659	0,35	19	10.231	4,8	3
The Netherlands	**3.061**	**2.282**	**0,75**	**156**	**50.809**	**21,2**	**12,2**
Norway	3.973	3.566	0,90	49	12.426	2,6	1,2
Poland	19.265	13.447	0,70	213	11.078	137	54,2
Portugal	2.546	856	0,34	37	14.355	9	6,4
Romania	17.028	5.225	0,31	90	5.314	45	25,4
Sweden	9.689	7.892	0,81	148	15.317	11,4	7,6
Slovenia	1.209	787	0,65	21	16.974	9	2,6
Slovakia	3.627	2.131	0,59	47	12.958	21,6	12,4
Utd Kingdom	16.086	6.142	0,38	546	33.947	10	6,6

Million train km/year (avg. 2011-2015)	Accident/ million train km (avg. 2011-2015)	Cas./million train km (avg. 2011-2015)	NL casualty equivalent	Population densitity (inhab./km²)	NL casualty equiv./ population dens.	Code
152	0,26	0,11	17	103	84	AT
98	0,17	0,10	15	367	21	BE
29	0,44	0,14	21	67	155	BG
186	0,05	0,02	2	201	6	CH
160	0,25	0,12	18	136	67	CZ
1042	0,09	0,03	5	227	12	DE
64	0,06	0,05	8	131	29	DK
7	0,65	0,37	56	30	915	EE
12	0,68	0,52	79	83	472	EL
197	0,06	0,03	5	93	28	ES
50	0,14	0,07	11	18	305	FI
499	0,08	0,06	9	104	43	FR
23	0,57	0,42	64	75	426	HR
110	0,29	0,22	33	107	154	HU
18	0,02	0,00	0	68	0	IE
327	0,07	0,03	5	201	12	IT
15	0,28	0,25	38	48	395	LT
9	0,04	0,04	7	208	16	LU
19	0,26	0,16	25	33	377	LV
152	**0,14**	**0,08**	**12**	**498**	**12**	**NL**
48	0,05	0,02	4	17	113	NO
221	0,62	0,24	37	124	149	PL
37	0,24	0,17	26	114	115	PT
96	0,47	0,26	40	89	226	RO
145	0,08	0,05	8	23	170	SE
20	0,44	0,13	19	102	94	SI
47	0,46	0,26	40	110	181	SK
543	0,02	0,01	2	264	3	UK

Table 5: Characteristics of level crossing safety in 28 European countries.

ANALYSIS OF ACCIDENTS 2012–2016

The Dutch Safety Board has analysed a large number of level crossing accidents. Initially, we considered the period from 2005 to mid-2017 to gain a first impression of the numbers and nature of the accidents. To include the influence of improvement measures implemented since 2005, we chose to perform the definitive analysis on the latest five complete years for which data were available during the investigation: 2012 to 2016 inclusive. Level crossings exclusively for official use by authorised personnel and level crossings on disaster relief roads have not been included. Those on freight lines and special railways are discussed in Appendix F.

For this period, the accidents on passenger lines have been broken down by type of protection and nature of the road traffic (figure 1). For unprotected level crossings, an additional subdivision was created into public and privately accessible level crossings.

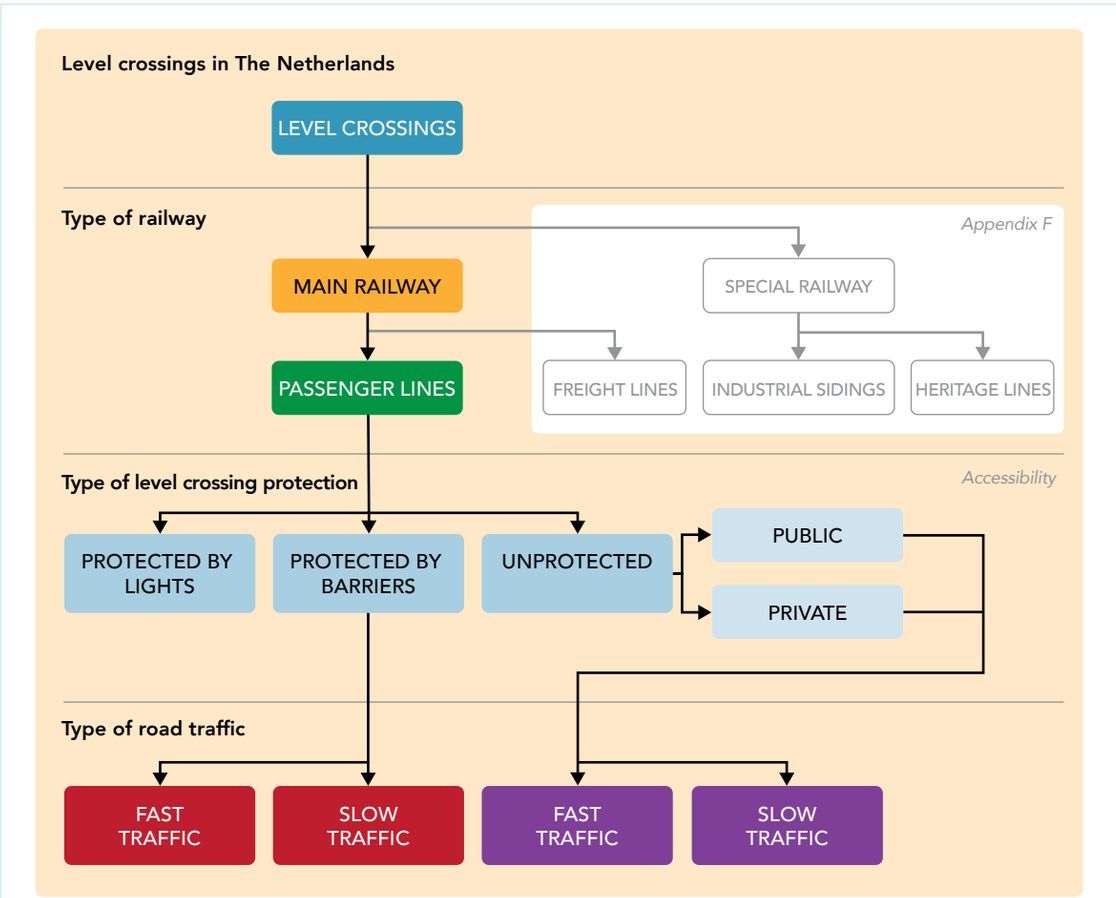

Figure 27: Classification of level crossings by type of railway line, protection, accessibility and the type of road traffic involved in the accident.

E.1 Procedure

E.1.1 Relevant facts for accidents on the main railway network

Information from ProRail, among others, was used in investigating the relevant facts for the accidents on the main railway network. For instance, information which ProRail has distilled from its accidents database and provided to the Dutch Safety Board as an Excel file was used. The factual reports on level crossing accidents compiled by ProRail were also used. In addition, the level crossings and their surroundings were 'examined' using Google Maps' Street View function (where this involved recent material). Finally, media reports were used in a number of cases. Where information was contradictory, we attempted to determine the most reliable source.

In this way, the direct and underlying causes were determined per accident, if they were believed to be sufficiently plausible. If descriptions of the accidents were contradictory or contained ambiguities, the cause was designated 'unknown'. The results are not 100% reliable as a result of this procedure; the Dutch Safety Board could, in principle, have incorrectly designated a cause as 'unknown' or designated an incorrect cause. However, this procedure is considered to be sufficiently accurate for the main objective of the analysis, which is to gain an impression of the types of accidents that occur on the various types of level crossing and the variety of direct and underlying causes.

E.1.2 Number of level crossings and casualties on the main railway network

The Dutch Safety Board used data about numbers of level crossings and casualties on the main railway network in the analysis.

The Dutch Safety Board copied the numbers of casualties one-to-one from the file provided by ProRail. The casualties are divided into two categories for the analysis:

1. casualties with minor injuries;
2. fatalities and serious injuries.

The numbers of level crossings used for reference in the analysis are from ProRail and relate to the situation in mid-2017.[92] The accidents concern the 2012–2016 period and some of the level crossings where accidents occurred have been removed or modified during this period. As a result, the comparison between the percentage of level crossings (from the total number of level crossings) and the percentage of accidents (from the total number of accidents) is not entirely accurate. However, because the error mentioned exists in every level crossing category and in the total number of level crossings, its effect is largely negated.

92 The number of level crossings on freight lines was corrected during the investigation based on new information; the numbers used here include these additional thirty level crossings on freight lines.

E.1.3 Intensity of railway and road traffic

The analysis does not include any data on the intensity of railway and road traffic using the level crossing. On the one hand, road traffic data are not available for every level crossing, and on the other hand, the amount of traffic on a level crossing is viewed as a given in the analysis. In this way, the analysis provides insight into the current number and types of accidents that occur at specific level crossings. The analysis provides no insight into the probability of an accident each time a level crossing is used by a road user or railway user, because the data required for this are not available.

E.2 Figures for accidents and casualties in 2012–2016

In the period from 2012–2016, a total of 159 accidents occurred on the almost 2400 level crossings on the main railway network, which equates to almost 32 accidents per year. Almost all fatalities and serious injuries (97%) from the level crossing collisions on the main railway network occurred on level crossings on passenger lines; see table 6.

Railway category	Number of level crossings		Accidents per year		Fatalities and serious injuries per year	
Passenger lines	1857	78%	24,8	78%	13,0	97%
Freight lines	518	22%	7,0	22%	0,4	3%
Total for main railway network	**2375**	**100%**	**31,8**	**100%**	**13,4**	**100%**

The number of level crossings relate to the situation in mid-2017, the accidents and casualties concern the 2012–2016 period.

Table 6: Number of level crossing accidents and casualties on the main railway network.

The majority of accidents on level crossings on the passenger lines occurred at level crossings protected by barriers, the most common type of level crossing (at 63%); those accidents accounted for the majority (79%) of all fatalities and serious injuries (see table 7). The number of accidents and casualties on public, unprotected level crossings was, in an absolute sense, significantly lower, but it was relatively high in proportion to the number of level crossings of this type.[93] For instance, 16% of all fatalities or serious injuries occurred on public, unprotected level crossings, which account for only 5% of all level crossings (see table 7).

93 If the number of passages of level crossings by road traffic is included, the over-representation will probably be even higher, because unprotected level crossings handle less traffic than protected level crossings.

Level crossing category	Number of level crossings		Accidents per year		Fatalities and serious injuries per year	
Protected by lights and barriers	1507	63%	20,8	65%	10,6	79%
Only protected by lights	19	1%	0,2	1%	0	0%
Unprotected - public level crossing	117	5%	3,2	10%	2,2	16%
Protected - private level crossing	214	9%	0,6	2%	0,2	2%
Total for passenger lines	**1857**	**78%**	**24,8**	**78%**	**13,0**	**97%**

The number of level crossings relate to the situation in mid-2017, the accidents and casualties concern the 2012–2016 period. The percentages are expressed per column in the total value for the main railway network.

Table 7: Number of level crossings, accidents and casualties on passenger lines.

Paragraphs E.3 and E.4 identify the direct and underlying causes of the accidents. A distinction is made between accidents involving fast traffic[94] and slow traffic,[95] because the accident scenarios and number of casualties differ between these categories. Paragraph E.3 discusses the level crossings protected by barriers and E.4 discusses the unprotected level crossings on passenger lines. In addition to these level crossings, there is one further category of level crossing on passenger lines, namely 'level crossing protected by lights'. There are hardly any of these level crossings left and their share of the accidents is small, which is why they are only discussed in brief here. This is done in E.4, because of their similarities with unprotected level crossings.

E.3 Accidents on level crossings protected by barriers

E.3.1 Accidents involving slow traffic

Every year, an average of ten accidents involving slow traffic take place on level crossings protected by barriers,[96] resulting in seven deaths or serious injuries annually.[97] This category represents one-third of all accidents on level crossings and is responsible for more than half of all fatalities and serious injuries that occur on level crossings annually. Half of the accidents involve a moped or bicycle or a scooter; the other half involve a mobility scooter or pedestrian (with or without a rollator). Almost one-third of the slow traffic accidents occur near stations.[98]

94 Fast traffic is understood to mean: motorbikes, cars and trucks, buses and special vehicles such as tractors or manlifts.
95 Slow traffic is understood to mean: pedestrians, mopeds and bicycles, scooters and mobility scooters.
96 Approximately 90% of the accidents involve level crossings that are also used by motorised traffic. Approximately 10% of the accidents involve foot crossings at stations, which are for the exclusive use of pedestrians.
97 Specifically, 50 accidents and 35 fatalities/serious injuries in the period from 2012–2016.
98 On foot crossings at stations or level crossings within approximately 100 metres distance from and with a view of the platforms and trains in the station.

The causes of the accidents were determined in accordance with the approach described in E.1.1 (see Table 8). The top three direct causes are:

1. going past or under closing or closed barriers (approximately 60% of the accidents);
2. going too slow, falling and/or problem with conveyance (approximately 30%);
3. unknown (approximately 10%).

Protected by barriers, accidents involving slow traffic	% of accidents	% of fatalities or serious injuries
Type of road user	**100%**	**100%**
Pedestrian	42%	49%
Bicycle, moped or scooter	50%	46%
Mobility scooter	6%	3%
Other	2%	3%
Location of level crossing	**100%**	**100%**
Not near station	70%	69%
Near station (<100m)	22%	23%
Foot crossing at station	8%	9%
Second or no second-train accident	**100%**	**100%**
No second-train accident or unknown	80%	77%
Second-train accident	20%	23%
Direct causes	**100%**	**100%**
Passing closing or closed barriers	60%	66%
Too slow, falling, vehicle malfunction, becoming shut in	28%	26%
Other	4%	0%
Unknown	8%	9%

Table 8: Accidents involving slow traffic on level crossings protected by barriers, expressed as a percentage of accidents and fatalities/serious injuries (f/si).

Protected by barriers, accidents involving slow traffic	% of accidents	% of fatalities or serious injuries
Underlying causes for 'Passing closing or closed barriers'	**60%**	**66%**
Intentionally/wilfully ignoring barriers	36%	40%
Not seen	4%	0%
Other	2%	3%
Unknown	18%	23%
Underlying causes for 'Too slow, falling, malfunction'	**28%**	**26%**
Speed too low	16%	11%
Vehicle malfunction	4%	3%
Fell	6%	9%
Other	2%	3%

Table 9: Underlying causes of accidents involving slow traffic.

The underlying causes of passing closed or closing barriers (see table 9) are not always known. In some cases, the road user was driving on the wrong side of the road, where there was no level crossing barrier. In addition, there are instances of descending barriers being observed too late. Haste and impatience also play a role, and many of these accidents involve 'second-train accidents', in which the road user is surprised by a train other than the one they were paying attention to. For instance, the road user might believe that the level crossing is closed for a train that is waiting at the station, while a second train is approaching from the opposite direction; alternatively, the road user might cross after the first train has passed, while the level crossing remains closed for another train. In both cases, the level crossing user crosses a closed level crossing.

Accidents where the road user was 'too slow' usually involve the elderly. In these cases, some victims are unable to find safe haven between the closed level crossing barriers. There are also cases where level crossing users fall or a mobility scooter malfunctions.

E.3.2 Accidents involving fast traffic

Every year, an average of 11 accidents involving fast traffic take place on level crossings protected by barriers on passenger lines, resulting in 3 or 4 fatalities or serious injuries.[99] This category represents one-third and one-fourth, respectively, of all accidents and casualties on level crossings. A passenger car or van is involved in over three quarters of these accidents. The other cases involve heavier vehicles, such as a truck or tractor; in some cases, this results in the train being derailed.[100]

99 Specifically, 54 accidents and 18 fatalities/serious injuries in the period from 2012–2016.
100 The derailment of a train near Dalfsen in February 2016 is an example of this.

The causes of the accidents were determined in accordance with the approach described in E.1.1. The top three direct causes are:

1. stopping or stranding on the level crossing (60% of the accidents);
2. going past, under or through closing or closed barriers (approximately 25%);
3. going too slow (approximately 5%).

Protected by barriers, accidents involving fast traffic	% of accidents	% of fatalities or serious injuries
Type of road user	**100%**	**100%**
Passenger car or van	78%	89%
Truck	15%	6%
Construction vehicle (tractor, manlift, etc.)	7%	6%
Direct causes	**100%**	**100%**
Stranding, stopping or manoeuvring	59%	22%
Passing closing or closed barriers	24%	56%
Too slow in straight crossing	7%	6%
Unknown	7%	11%
Other	2%	6%

Table 10: Accidents involving fast traffic on level crossings protected by barriers, expressed as a percentage of accidents and fatalities/serious injuries (f/si).

Protected by barriers, accidents involving fast traffic	% of accidents	% of fatalities or serious injuries
Underlying causes for 'Stranding, stopping or manoeuvring'	**59%**	**22%**
Grounding next to surface	22%	11%
Vehicle malfunction	11%	0%
Obstacle after level crossing	11%	0%
Performing manoeuvre	9%	6%
Unknown	4%	6%
Other	2%	0%
Underlying causes for 'Passing closing or closed barriers'	**24%**	**56%**
Intentionally/wilfully ignoring barriers	11%	33%
Did not see closed or closing barriers	9%	17%
Unknown	4%	6%

Table 11: Underlying causes of accidents involving fast traffic.

Various underlying causes can be identified for 'stranding, stopping or manoeuvring' on a level crossing (see Table 11). The most common (one-third of the stranding accidents) is grounding next to the surface, almost always when turning off too early (whether or not following instructions from a navigation system).[101] In addition, stranding is caused by a problem with the vehicle (such as the engine stalling), and by being unable to drive on due to a traffic jam immediately after the level crossing. The collision could also be the result of a road user manoeuvring on the level crossing, due to the tight dimensions of a level crossing or the sharp bend before or after.

The reason for 'passing a closing or closed barrier' is unknown in approximately one-sixth of the cases. In those cases where the reason is known, intentionally ignoring the protection is just slightly more common than not noticing the (lowering) barriers in time. All accidents where the road user needs too much time to clear the crossing (during a straight crossing) involve heavy or slow vehicles. Occasionally, the re-closing of a level crossing that has just opened precedes this type of collision.

E.4 Accidents on unprotected level crossings or level crossings protected by lights

E.4.1 Accidents on unprotected level crossings involving slow traffic and fast traffic

There are approximately two accidents each year involving slow traffic on unprotected level crossings on passenger lines, resulting in one fatality or serious injury annually.[102] The level crossings where the accidents occurred were (as far as could be ascertained) intended for the exclusive use of slow traffic and residents. Pedestrians were rarely involved in an accident; almost invariably, the victim was someone riding or pushing a moped or bicycle.

There are approximately two accidents each year involving fast traffic on unprotected level crossings on passenger lines, resulting in one or two fatalities or serious injuries annually.[103] Most of the fast traffic accidents on unprotected level crossings on passenger lines involved a passenger car, van or minibus; approximately one-fifth of the cases involved a truck. One of the accidents involving a truck[104] resulted in the complete derailment of a train. This made the accident responsible for almost all of the minor injuries in this accident category in the period from 2012–2016.

The causes of these accidents on unprotected level crossings were determined in accordance with the approach described in E.1.1 (see table 12). The cause of approximately 20% of the accidents is unknown, and 10% are the result of stranding, manoeuvring or stopping on (or too close to) the track. In the other cases, the road user did not look or did not look well enough. There are scenarios where the driver was not looking, or was looking too late, but there are also scenarios where the driver was consciously looking,

101 Example: instead of turning into a road immediately after the level crossing, the driver turns right while still on the level crossing and gets a wheel stuck in the track ballast before (or at the moment that) they realise the mistake.
102 Specifically, nine accidents and five fatalities/serious injuries in the period from 2012–2016.
103 Specifically, ten accidents and seven fatalities/serious injuries in the period from 2012–2016.
104 This was the accident at Winsum (see Appendix C.2).

but failed to see the train. In most cases, the driver was from the area,[105] but in several cases, they were not familiar with the level crossing.[106] Underlying factors are not known; some cases involved fog.

Unprotected, accident involving slow traffic or fast traffic	% of accidents	% of fatalities or serious injuries
Type of road user	**100%**	**100%**
Fast traffic: passenger car or van	42%	58%
Fast traffic: truck	11%	0%
Slow traffic: bicycle, moped or scooter	42%	42%
Slow traffic: pedestrian	5%	0%
Derailment or no derailment	**100%**	**100%**
Derailed	11%	0%
Not derailed	89%	100%
Direct causes	**100%**	**100%**
Did not notice level crossing and/or train	68%	92%
Stranding, stopping or manoeuvring	5%	0%
Unsafe positioning	5%	0%
Unknown	21%	8%
Underlying causes for 'Did not notice level crossing and/or train'	**68%**	**92%**
Unknown	63%	83%
Fog	5%	8%

Table 12: Accidents on unprotected level crossings, expressed as a percentage of accidents and fatalities/serious injuries (f/si).

E.4.2 Accidents on level crossings only protected by lights

There are approximately 20 level crossings on railway lines with passenger trains that are only protected by warning lights. There was as single accident, without casualties, on this type of level crossing in the period from 2012–2016[107]. Analysis of this type of accident over a longer period (2005 to mid-2017)[108] shows driving onto the track when a train is approaching as a result of not noticing the level crossing, the flashing light and/or the

105 Defined here as 'living less than 20 kilometres from the level crossing'.
106 In almost two-thirds of the accidents, it is unknown whether the road user was familiar with the level crossing. In almost one-third of the cases, the road user had crossed the level crossing at least once before.
107 The fatal collision in Harlingen on a similar level crossing in 2017 falls outside of the period from 2012–2016 analysed here.
108 This concerns 15 accidents, with 14 fatalities/serious injuries and 34 minor injuries (33 of which were in a derailed train).

train early enough as the most common cause. In terms of cause, these accidents are therefore similar to the accidents on unprotected level crossings (see the box). The accidents mostly involved fast traffic.

Level crossing protection system with only lights
The accident scenarios on level crossings protected by warning lights alone are comparable with those on the unprotected level crossings. British research has likewise revealed that car drivers quite often do not notice the warning lights and any bells and drive onto this kind of level crossing.[109]

There used to be a large number of level crossings in the Netherlands equipped with what is known as Automatic Warning Lights (Automatische Knipperlichtinstallatie, AKI). The majority of them were removed in the period from 2000–2007, or they were equipped with level crossing barriers, which has made a major contribution to the reduction in the number of level crossing casualties in that period.

Currently, a small proportion of the level crossings are still equipped with a lights-only protection system, usually in the form of an Automatic Lights System (*Automatische Lichtinstallatie*, ALI) or a Rural Level Crossing Warning System (*Waarschuwingsinstallatie Landelijke Overweg*, WILO). When compared with earlier Automatic Warning Lights (AKIs), these systems provide a lower level of protection; for instance, they have no bells and only one set of lights is visible in each driving direction, instead of two. In addition, WILOs differ significantly from the usual traffic lights in road traffic; instead of the continuously illuminated red or green light, a WILO has a flashing red or white light. This increases the probability of road users not consciously noticing the warning signs for a WILO, or not understanding, and entering the level crossing while a train is approaching.

E.5 Causes of accidents from 2012–2016

E.5.1 Summary of causes of accidents

The causes in paragraphs E.3 and E.4 are summarised in the tables below. While the percentages in E.3 and E.4 show the percentages within the subsets (protected or unprotected; fast or slow traffic) the percentages here relate to all accidents on passenger lines. The table below shows accident scenarios and underlying causes where the share of either the accidents or the fatalities and serious injuries is 5% or more.

From table 13, it follows that the most common cause of an accident is fast traffic stranding on protected level crossings. In almost half of these cases, the underlying cause is grounding next to the surface.

109 Automatic open level crossings – a review of safety; P.F. Stott, 1987 Stott, 1987

Protection	Road traffic	Direct cause	Underlying cause	%
Barriers	Fast	Stranding	**(All)**	**20%**
			Of which 'intentionally/wilfully'	8%
Barriers	Slow	Passing barriers	**(All)**	**19%**
			Of which 'intentionally/wilfully' Of which 'cause unknown'	11% 6%
Barriers	Slow	Too slow	**(All)**	**9%**
			Of which 'speed too low'	5%
Unprotected	(All)	Did not see train/level crossing	**(All)**	**8%**
			Of which 'cause unknown'	7%
Barriers	Fast	Passing barriers	**(All)**	**8%**

Table 13: Scenario shares of total number of accidents.

Most of the fatalities or serious injuries also occur on level crossings protected by barriers, but this involves slow traffic that passes a closing or closed barrier (table 14). In approximately two-thirds of these cases, the underlying cause is intentionally ignoring the barriers.

Protection	Road traffic	Direct cause	Underlying cause	%
Barriers	Slow	Passing barriers	**(All)**	**34%**
			Of which 'intentionally/wilfully' Of which 'unknown'	21% 12%
Onbeveiligd	(All)	Did not see train/level crossing	**(All)**	**16%**
			Of which 'unknown'	15%
Barriers	Fast	Passing barriers	**(All)**	**15%**
			Of which 'intentionally/wilfully'	9%
Barriers	Slow	Too slow	**(All)**	**13%**
			Of which 'speed too low'	6%
Barriers	Fast	Stranding	**(All)**	**6%**

Table 14: Scenario shares of total number of fatalities/serious injuries.

E.5.2 Proportion of intentionally ignoring activated protection system

For all level crossing accidents on passenger lines in the 2012–2016 period that were taken into consideration, the Dutch Safety Board investigated the extent to which the activated level crossing protection system was intentionally (wilfully) ignored. table 15 reveals the following:

- Approximately 20% of the accidents and 30% of the fatalities and serious injuries were the result of intentionally passing closed or closing level crossing barriers.
- We determined that 60% of the accidents and 45% of the fatalities and serious injuries had a different cause.
- The direct or underlying cause of the remaining approximately 20% of the accidents and approximately 25% of the fatalities and serious injuries is not known.

	Accidents		Fatalities/serious injuries	
Cause	**Number**	**Percentage**	**Number**	**Percentage**
'Unknown' as a separate category				
Intentionally ignoring protection	24	**19%**	20	**31%**
Other cause	77	**62%**	30	**46%**
Unknown	23	**19%**	15	**23%**

Table 15: Intentionally ignoring an activated protection system.

Distributing the accidents and injuries with an unknown cause equally over the 'intentional' and 'unintentional' categories provides a result where approximately a quarter of all level crossing accidents (23%) and less than half of all fatalities and serious injuries (40%) occur because the activated level crossing system is intentionally ignored (table 16).

	Accidents		Fatalities/serious injuries	
Cause	**Number**	**Percentage**	**Number**	**Percentage**
'Unknown' shared pro rata				
Intentionally ignoring protection	29[110]	**23%**	26[111]	**40%**
Other cause	95	**77%**	39	**60%**

Table 16: Intentionally ignoring an activated protection system.

110 24 + (23 x 24 / (77 + 24)) = 29
111 20 + (15 x 20 / (20 + 30)) = 26

E.6 Escalation as a result of derailment

In a few cases, the train derailed after the collision, as illustrated by the accidents at Winsum and Wouw discussed in Appendix C. A heavy vehicle (such as a truck or tractor) was involved in all derailments in the 2012–2016 period. This concerns approximately 5% of all level crossing accidents on passenger lines.

This type of derailment can form a serious threat to the train occupants in two ways:

- The derailed train can end up alongside the track and in the process undergo abrupt speed and/or direction changes, as in the level crossing collision in Dalfsen in 2016, regarding which the Safety Board has previously issued a report.
- In addition, a train that derails on a multi-track railway line can collide with an oncoming train on an adjacent track. Granted, this type of follow-on accident is not a frequent occurrence (for instance, there was no second track at Winsum, and no train approaching from the opposite direction at Wouw), but the consequences of this could have been extremely serious.

Winsum and Dalfsen accidents: escalation of level crossing collision through derailment

On 18 November 2016, a passenger train collided with a truck on a level crossing in Winsum. The train derailed and ended up in an unstable position above a ditch.

Figure 28: Derailed train at Winsum. (Photo: Dutch Safety Board)

On 23 February 2016, a passenger train collided with a manlift crossing a level crossing in Dalfsen. The train was derailed and ended up on its side.

Figure 29: Derailed train at Dalfsen. (Photo: Dutch Safety Board)

APPENDIX F

LEVEL CROSSINGS ON FREIGHT LINES AND SPECIAL RAILWAYS

F.1 Introduction

The main text of this report focuses on the level crossings on passenger lines in the main railway network, because this is where most of the accidents and most casualties occur. On passenger lines, train speeds normally are between 40 and 140 km/h. This appendix covers the other categories of level crossings; they are situated on the freight lines of the main railway network and on special railways (industrial sidings and heritage railways). On these lines, train speeds normally do not exceed 40 km/h. Together, these categories account for approximately 30% of all level crossings in the Netherlands, for 25% of the accidents and for less than 5% of all fatalities and serious injuries.

F.2 Level crossings on freight lines

The freight lines, as far as these have level crossings, are found mainly in port and industrial areas.[112] In total, this involves approximately 20% of all level crossings in the Netherlands. Approximately 20% of all level crossing accidents occur on these level crossings, which accounts for approximately 3% of all fatalities and serious injuries.[113]

F.2.1 Specific characteristics

The freight lines serve irregular and considerably less intensive traffic than the passenger lines, and their protection is usually simpler. Sometimes the protection has to be enabled and disabled manually. Because the railway lines are part of the main railway network, management is vested with ProRail, just as for the passenger lines. Trains run at a relatively low speed on freight lines with level crossings (usually a maximum of 40 km/h). There are almost 450 public level crossings on freight lines. Approximately half of them are not equipped with a technical protection system, approximately a quarter are equipped with a lights-only system and the remaining quarter have a system with lights and barriers. Some level crossings without a technical protection system are 'protected by personnel', which means that prior to a train passage an individual with a red flag or light instructs road users to keep the level crossing clear or to clear it.

112 There is railway line between the Rotterdam port area and the German border (the Betuweroute), which is for freight trains only but it has no level crossings.
113 The data is based on the database of accidents for the 2012–2016 period (see Appendix E for clarification).

Level crossings on freight lines have a considerably larger variety of protection systems than level crossings on the passenger train network. The explanation for this is that the internal guidelines[114] that ProRail uses permit such variety for specific freight lines. Moreover, these guidelines only apply if a level crossing is being constructed or changed, while some of the level crossings on freight lines have not been changed for decades, so that old types of protection systems can still be found which would no longer be used for new level crossings.

Because of the need to update the overview of the safety situation of level crossings on freight lines, ProRail has recently mapped all level crossings on port lines and industrial lines. ProRail is working on including all these level crossing in a (special) risk register. From now on, their state of maintenance will be inspected periodically.

F.2.2 Level crossing accidents

The Dutch Safety Board analysed the accidents that occur on freight lines in the way set out in Appendix E. On average, seven accidents occur on public level crossings on freight lines each year, with an average of one casualty with minor injuries, and a serious injury once every two years. The accidents mainly occur on level crossings without barriers: almost three-quarters on a level crossing without a protection system and approximately one-quarter on level crossings with lights alone. In general, the outcomes of the accidents are less serious than on level crossings on passenger lines. The most obvious explanation for this is that in many cases both the road user and the train are travelling at low speeds[115]; the accident analyses reveal that trains usually run at low speeds and have often braked before the collision, while the road user was driving slowly (because they were pulling away from standing) or were waiting to drive onto a (priority) road.

The collisions are almost exclusively with motorised road traffic: approximately two-thirds of the accidents involved a car or minibus. Approximately one-third of the accidents involved a truck, and occasionally a cyclist or service bus was involved. The relevant facts and/or immediate cause is not known for more than half of the accidents. In accidents where the immediate cause is known, the following factors played a role in combination with the lack of protection with barriers or another physical barrier (see the boxes for example cases):

- poor view of approaching train (because of sun, obstacles such as containers or because the train was emerging from a curve or approaching from diagonally behind);
- poor recognisability of the level crossing (because the track is integrated into the road situation, e.g. shark's teeth on the road shortly after the track or a track in the hard shoulder parallel to a cycle track); and
- road traffic that distracted attention because priority had to be granted to that traffic (too).

114 This is RLN20420-1-V004 (Level Crossing Protection Systems Road Engineering Guidelines and Standards (*Overwegbeveiliging, verkeerskundige richtlijnen en normen*)) and Engineering Rules OVS20420, 20430 and 20440).

115 Various investigations have revealed that the probability of fatalities is approximately proportional to the speed of the train. See Schöne, E.J., *Ein risikobasiertes Verfahren zur Sicherheitsbeurteilung von Bahnübergangen*, dissertation, TU Dresden, 2013 for a summary.

Pernis accident: Attention to giving way to road traffic when turning off[116]

The driver of a tanker truck carrying ethanol was driving along a through road and wanted to turn left into a side street. When doing so, he had to cross the railway line which was parallel to the through road. It was dark. There was a cycle track next to the railway line, along which a moped was driving towards the tanker truck. Once the moped has passed, the driver turned off to the left, whilst still keeping an eye on the cycle track. Immediately thereafter the tanker truck was hit on the level crossing by a shunted freight train, which was running in the same direction (i.e. to the left and rear of the truck driver). The driver shunting the train, who was standing on the front wagon, suffered multiple fractures in the collision; the tanker truck driver was unharmed.

Figure 30: Pernis accident location: the truck turn left (as the truck on the photo), the train was coming from the lef tand it was dark. (Photo: Dutch Safety Board)

116 Sources: Keyrail's factual report, ProRail, and ILT accident databases, various media websites.

Maastricht accident: Taking position on the railway line prior to pulling onto priority road[117]

A car was standing on a level crossing on the exit from a business site, waiting to turn onto the road. A radio-controlled locomotive was approaching from the right. When the locomotive sounded its horn, the car driver was not able to reverse in time. The driver may have been misled by the shark's teeth which – seen from the business site – were just after the railway line. Moreover, car drivers only see train traffic approaching (from the right) when the car has already stopped on the tracks.

Figure 31: Maastricht accident location: the car was coming from the right, the train was oncoming. (Photo: Google maps)

F.3 Level crossings on special railways

In addition to the main railways, the rail network also includes what is known as special railways. Two categories can be distinguished here: industrial sidings and heritage railways. Both categories differ from the main railways on a number of points; the main differences are explained below.

F.3.1 Specific characteristics

Industrial sidings

Industrial sidings form connections between a business site and the main railway network. A maximum speed limit of 30 km/h applies on industrial sidings, of which there are approximately 300. The train intensity is mostly low, usually only a few (freight) trains run per day or week.

117 Sources: ProRail and ILT's accident databases.

All industrial sidings were originally owned and managed by the former national railways, NS. During the unbundling of the NS (between 1995 and 2005) approximately one-third came under a separate organisation within the NS group (NS Industrial sidings); this part was transferred to Strukton Shortline in 2015. The other two-thirds of the industrial sidings were transferred to the companies connected to the sidings themselves.

In practice, the company that actually handles the maintenance of the railway line is designated as manager. For some of the industrial sidings this is the aforementioned Strukton Shortline, for the other industrial sidings it is the unbundled company itself or the contractor to which maintenance is contracted out.

The state of affairs described above has resulted in there no longer being a central register of level crossings on industrial sidings. Consequently, the Dutch Safety Board has not been able to obtain an up-to-date impression of the total number of level crossings on these lines and the way in which they are protected. The information that was obtained suggests that there are approximately 200 level crossings on industrial sidings, approximately half of which have no protection system, approximately a quarter are protected with lights alone (usually ALI[118]) and the remaining quarter with lights and barriers (AHOB[119]). Some level crossings without a technical protection system are 'protected by personnel', which means that prior to a train passage an individual with a red flag or light instructs road users to keep the level crossing clear or to clear it.

Heritage railways
There are ten railway museums that operate heritage railways in the Netherlands. Heritage trains run on these lines and there is a maximum speed limit of 40 km/h. Most of the heritage railways only operate a few dozen days each year.

The heritage railways, with a total length of approximately 120 km, include approximately 195 level crossings.[120] Less than a quarter of those level crossings are equipped with a protection system (with lights alone or lights plus barriers). On the other level crossings (approximately three-quarters), which are only equipped with St Andrew's crosses, the train sounds a warning signal when approaching the level crossing or the train passages are protected by personnel with a red flag or light.

On heritage railways, rail network management is provided by the museum organisation that operates the line.

F.3.2 Level crossing accidents

Accidents that occur on level crossings on industrial sidings and heritage railways are not recorded centrally. As a consequence of this, there is no clear picture of the number of accidents and their causes.

118 Automatic Light Installation.
119 Automatic Half Barriers.
120 The information about heritage railways and the level crossings they include was provided by Heritage Rail Transport Netherlands (Historisch Railvervoer Nederland, HRN) at the request of the Dutch Safety Board.

The Dutch Safety Board has been able to ascertain the following accident information for the period 2012–2016:[121]

- As far as is known, there were six accidents on the level crossings on industrial sidings in those five years. Four of them involved a passenger car and the other two involved trucks. One person suffered minor injuries in one of the accidents; the consequences of the other five were limited to material damage. There is no information available about the causes.
- We know of two accidents on level crossings on heritage railways in the period concerned.[122] Both accidents involved a passenger car and the consequences were limited to material damage.[123] No other information about the cause of these accidents is known either.

Lieren accident: Level crossing accident on a heritage railway[124]
A heritage train and a passenger car collided on a public level crossing during a steam train festival. The consequences were limited to damage to the car and the locomotive. The level crossing was only equipped with St Andrew's crosses and had no protection system.

Figure 32: Lieren accident location. The car was (probably) oncoming, the train was (as on the photo) coming from the left. (Photo: Dutch Safety Board)

121 The information about accidents on level crossings on industrial sidings was provided by ProRail. The information about level crossing accidents on heritage railways was provided by Heritage Rail Transport Netherlands (Historisch Railvervoer Nederland, HRN).
122 In addition, there was one accident at a level crossing in a part of a heritage railway that is also part of the main railway network. This accident has been incorporated in the analyses of accidents on the main railway network.
123 The last known fatal level crossing accident on a heritage railway was in 2011, and therefore is not within the period analysed by the Dutch Safety Board.
124 Sources: ILT accident database, De Stentor media website.

F.4 Points for improvement

As mentioned above, there have been fewer than two accidents a year on average on approximately 900 level crossings on freight lines, industrial sidings and heritage railways in recent years and there were no fatalities or serious injuries. This is very few in comparison with the level crossings on the passenger network. An obvious explanation for this is the small number of trains and the slow speed at which they run.

Despite the relatively small number of accidents and casualties on these level crossings, the Dutch Safety Board has the following concerns:

- There appears to be very little attention for the safety of level crossings on freight lines and special railways. These level crossings fall outside of the scope of the LVO and NABO programmes. Nor is any attention devoted to these level crossing categories in the Third Rail Safety Framework Memorandum or the Rail Safety Policy Incentive. The Dutch Safety Board did not investigate the underlying reasons for this lack of policy attention.
- Another concern is the fragmentation of the management of special railways across a large number of companies and ten museum organisations, as a consequence of which an unambiguous design for the level crossings is not guaranteed. On the contrary: level crossings that are equipped with a protection system feature a wide variety of designs.
- In addition, it proved to be difficult to gather information about the level crossing accidents that occur on special railways. This information is not collected centrally, which hampers the effective monitoring of safety at these level crossings and the development of a (national) improvement policy if necessary.

APPENDIX G

DEVELOPMENT OF IMPROVEMENT MEASURES

G.1 Introduction

ProRail is developing and realising various new measures to reduce accidents on level crossings. Most of these measured stem from an earlier investigation into the behaviour of road users on and near level crossings started by ProRail in 2012.[125] That project is now part of the current LVO and NABO improvement programmes (which are explained in Chapter 4). In addition, ProRail has developed improvement measures in response to recommendations made by the Dutch Safety Board in its report on the level crossing collision in Dalfsen in 2016. A summary of the measures under development (for protected and unprotected level crossings) can be found below.

G.2 Measures for protected level crossings

Preventing collisions with slow level crossing users (slow traffic):

- ProRail intends to provide periodic information campaigns on older and vulnerable road users crossing a level crossing safely.
- ProRail is developing an information light which indicates if sufficient time remains for users to cross the level crossing at a slow speed. A pilot is currently running on a level crossing in Haarlem where this 'Crossing aid' is being tested in practice. A preliminary estimate sees approximately 100–150 level crossings as being eligible for this measure. It is not yet clear if this measure will actually be introduced and, if it is, on what scale and when.

125 In 2012, ProRail started an investigation into the behaviour of road users on and near level crossings. The first part of the investigation was completed in 2014 and revealed that the majority of level crossing accidents can be blamed on behaviour of road users which can probably be countered effectively. Based on that outcome ProRail, in a second part of the investigation in 2014, started the further investigation of possible measures.

Preventing road users crossing when a train is approaching (slow and fast traffic):

- Reducing the time closed: At approximately 150 level crossings, measures are being implemented to shorten the time closed[126] ('preventing unnecessary closed time') to prevent road users crossing a closed level crossing. Approximately 50 level crossings near stations will be equipped with a 'countdown to departure' on the platform which will accelerate the departure process so that the nearby level crossing is closed for a shorter period of time. In addition, the warning period for the level crossing protection system will be shortened at approximately 100 other level crossings, which means that the protection will not be activated unnecessarily early in relation to the time at which the train arrives at the level crossing. The introduction of these measures is expected to be completed in 2020.
- Improve the recognisability of the level crossing surface: ProRail intends making level crossing surfaces more noticeable with a yellow colour, LED lighting and road markings. It is expected that the decision on whether or not to implement this measure will be taken in the second half of 2018. ProRail believes that approximately 15 million euros will be needed to make all public level crossings recognisable in this way.
- Tightening and expansion of supervision and enforcement: Since 2015, ProRail has increasingly been reporting road users who display dangerous behaviour near level crossings to the police. In addition, a trial of red light cameras is running at two level crossings and a study is being conducted, together with the Central Judicial Collection Agency (*Centraal Justitieel Incassobureau, CJIB*) , on the possibilities for prosecuting users who ignore red lights. It is not yet clear if, when and on what scale these trials will actually lead to measures.

Support for exceptional level crossing passages (slow traffic and fast traffic):

- ProRail has expanded its procedure for providing assistance to exceptionally large vehicles when crossing a level crossing. The modified procedure (Exceptional Transport) is now on the ProRail and Government Road Transport Agency (*RDW*) websites.
- ProRail has developed a procedure for assisting exceptional level crossing passages. This procedure (Exceptional Crossing (*Bijzondere Oversteken*)) is intended for crossings by large groups of people (a procession or other festivity), herds of animals or extremely slow vehicles. The procedure makes it possible to determine, in consultation with ProRail, when and how the crossing can be effected safely and whether additional protection measures (such as road traffic controllers) are needed. The procedure is already available on ProRail's website.

126 Period per train passage that the level crossing is closed to road users.

Preventing collisions with stranded road users (fast traffic):

- ProRail is equipping all level crossings with a sticker showing the contact details for the Railway Control Room. ProRail expects this will have been completed by the end of 2018 at the latest.
- ProRail is developing an education campaign for professional drivers, focusing on their behaviour when crossing a level crossing.
- ProRail intends installing rubber mats next to the level crossing surface. These 'forgiving verges' should prevent vehicles stranding if they end up beside the crossing surface as a result of a steering error or an evasive manoeuvre. It is not clear at present if this plan will actually be implemented and, if it is, when and on what scale.
- ProRail has commissioned a study into the options for introducing a technical system (obstacle detection) to brake a train as early as possible if it is approaching a level crossing that is not clear. The now completed preliminary study revealed that developing such a system is probably feasible. Further investigation should demonstrate if it is also technically feasible on the Dutch railway system and what effect it has on matters such as the time the level crossing is closed and the behaviour of road users. The cost-effectiveness still needs to be investigated. It is not yet clear if this measure will be introduced and, if it is, on what scale and when.

G.3 Measures for unprotected level crossings

ProRail is investigating the options for protecting a level crossing at lower costs or to replace it with an underpass for slow traffic.

- The most advanced study in this regard is into an alternative system for detecting trains that are approaching a level crossing. It is now clear that using detection loops or axle counters will permit the development of a cheaper alternative to the current detection system on protected level crossings. The expectation is that using the alternative detection system could reduce the costs for protecting an unprotected level crossing from approximately 800,000 euros to approximately 500,000 euros. However, it is not clear if such an alternative system will actually be implemented and, if so, on what scale and within what time frame.
- ProRail is investigating the options for developing a cost-effective underpass for walkers, cyclists and riders (what is know as the 'walking tube'). A walking tube is expected to cost 1 to 1.6 million euros. It is not yet clear if this measure will be introduced and, if so, on what scale and when.

APPENDIX H

SITUATION IN OTHER COUNTRIES

The table below shows how level crossing safety is implemented in the Netherlands, Germany, the United Kingdom and Switzerland: this is both administratively (in terms of legislation and responsibilities) and technically (in terms of level crossing protection used).

The factors that could be expected to produce a positive safety effect are shown in green. The Safety Board did not investigate the possible magnitude of such an effect or the considerations made in the country concerned when designing the relevant factor in this way.

Where the Netherlands does not have any actual legislation but does have policy is shown in orange. The waiting time at different types of level crossings is shown in yellow. Both positive and negative effects on safety are conceivable for both long and short waiting times.

	The Netherlands	Germany	United Kingdom	Switzerland
Responsibility				
Deciding the safety level	Rail network manager	Rail network manager, minimum pursuant to legislation	Inspection at the request of the rail network manager	Rail network manager, minimum pursuant to legislation
Cost distribution on modification or improvement	Ministry/region One half each (Not mandatory)	Ministry/rail network manager/road manager One third each	Rail network manager Other parties may contribute	Rail network manager/road manager pro rata developments in traffic volume
Ministry power of assignment	No	Yes	Yes	Yes
Requirements for protection measures				
Depends on road traffic	No	Yes	Yes	Yes
Depends on rail traffic	No[127]	Yes	Yes	Yes

127 Is applicable to special railways.

	The Netherlands	Germany	United Kingdom	Switzerland
Responsibility				
Minimum mandatory form	Unprotected level crossing	Half or full barriers	Results from periodic risk analysis	Half or full barriers
Use of unprotected level crossings	Legislation: no restrictions. Policy: no more on passenger lines after 2028	Single track <2500 veh/day Train <80 km/h	Single track <200 veh/day Train <15 km/h	<160 veh/day Train <50 km/h
Vision on use of level crossings with half barriers	Preferred solution	Use full barriers on renovation.	Not when frequently used by pedestrians. Not where clearance risks exist. Emergency telephone present or train max. 90 km/h. Gradual replacement with full barriers with obstacle detection.	In practice, full barriers are usually used.
Obstacle detection mandatory	No	With full barriers	With full barriers	If train >140 km/h; and with clearance risks
Grade separation mandatory for new build	Yes, policy	Yes, legislation	Yes, policy	Yes, legislation
Mandatory modification to new requirements/insights	No	No	Yes	Yes
Typical design				
Types of lines with level crossings	Main lines Regional lines	Main lines Regional lines	Main lines Regional lines	Regional lines
Typical level crossing design	Half barriers	Half barriers Full barriers	Half barriers Full barriers	Full barriers
Waiting time at half barriers	½ min	½-2 min	½ min	not known
Waiting time at full barriers	2-3 min	2-3 min	2-3 min	1-2 min

Table 17: Situation in other countries

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