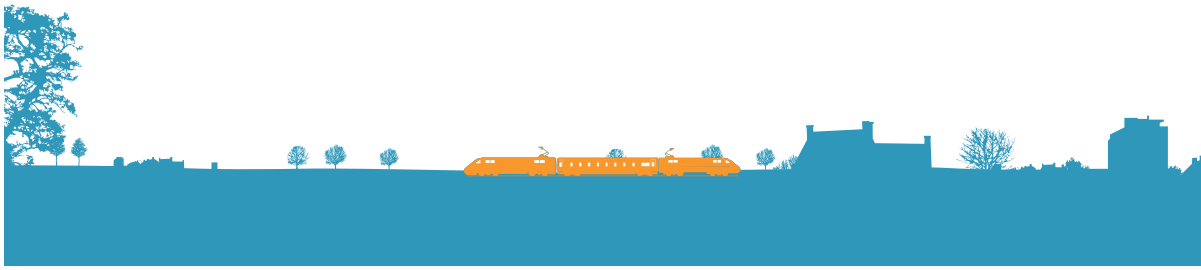
THE DUTCH
SAFETY BOARD



Accident involving a rail grinding train in Stavoren, the Netherlands,

on 25 July 2010

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on 25 July 2010

The Hague, September 2011

THE DUTCH SAFETY BOARD

The Dutch Safety Board has been set up to carry out the task of investigating and determining the causes or probable causes of individual or categories of incidents in all sectors. The objective of these investigations is solely to prevent future accidents or incidents and, when the results give cause to do so, issue recommendations. The organisation consists of a Board with five permanent members and a professional bureau. The Dutch Safety Board appoints guidance committees for specific investigations.

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This report is published in the Dutch and the English language. In the event of conflict in interpretation, the original Dutch text will be binding.

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LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
ARR	Automatic Trip Registration
ATB	Automatic Train Protection System
ATB-EG	Automatic Train Protection System – First Generation
ATB-NG	Automatic Train Protection System – New Generation
ATB-VV	Automatic Train Protection System – Improved Version
ATB-E	Automatic Train Protection System - Basic
AV	General Regulations
BVS	Operating Regulations for Rail Signal Systems
EC	European Community
ERTMS	European Rail Traffic Management System
ERA	European Railway Agency
EU	European Union
IenM	Ministry of Infrastructure and the Environment
IVW	Transport, Public Works and Water Management Inspectorate
LWB	Workplace Safety Leader
NSA	National Safety Authority
NVW	Safety at Work Standards Framework
OBE	Overview of Routes and Railway Yards
OVS	Railway Companies Safety Consultation
OVV	Dutch Safety Board
PCA	Railway Contractor
RI&E	Risk Inventory and Evaluation
RKS	Rail Vehicle Inspection Regulations
RvTV	Dutch Transport Safety Board
SMS	Safety Management System
SPAD	Signal Passed at Danger
TPRB	Locally operated all-relay interlocking system
VenW	Ministry of Transport, Public Works and Water Management
V&G-O	Health and Safety Plan – Design Phase
V&G-U	Health and Safety Plan – Construction Phase
VVW	Safety at Work Regulations
WBI	Workplace Safety Instructions
WTB	Work Train Supervisor
WTI	Work Train Instructions

Explanation of terms, including technical terms
Appendices 5 and 6 contain the definitions of a number of terms, including technical terms, appearing in this report.

Name of the responsible ministry
The Railway Sector formed part of the portfolio of the Ministry of Transport, Public Works and Water Management until 14 October 2010. Since that date the Railway Sector has been incorporated in the portfolio of the new Ministry of Infrastructure and the Environment (IenM). This report uses the name of the ministry that applied at the time of the accident, which is the Ministry of Transport, Public Works and Water Management (VenW).

CONSIDERATION

Accident

Relevant facts
On Sunday evening, 25 July 2010 at approximately 11.30 p.m. a rail grinding train travelling at high speed ploughed through a buffer stop located at the end of the railway track at Stavoren Station. The train then crashed into a parked tanker and drove straight through a shop. The train was en route to Stavoren because it was scheduled to grind the rails of the track section located between Sneek and Stavoren later that night. The accident occurred while the rail grinding train was transferred to Stavoren Station. This was considered a regular train run and the track was in service. The intention was to take the track section out of service after the train had arrived and to subsequently commence the rail grinding activities.

Consequences
The crew on board the train consisted of four people, two of whom were slightly injured. Since there was no one near the station at the time of the accident, there were no other casualties. However, the rail grinding train was severely damaged and the tanker and the shop premises were completely destroyed. The material damage incurred as a result of the accident is estimated to be over EUR 20 million.

Companies involved
The rail grinding activities formed part of a long-term rail grinding project, of which ProRail was the commissioning party. The project was put out to tender in Europe in 2007 and was awarded to Speno International (as the principal contractor) and BAM Rail (as the subcontractor) for the period 2008-2011. BAM Rail hired in staff and services from Spoorflex for the purpose of the rail grinding project. During the transfer journey the rail grinding train was piloted, which means that the train was operated by a vehicle operator, who was driving under the direction and responsibility of a train driver.

The division of the roles of the four companies involved was as follows:
- *ProRail* is the manager of the railway network infrastructure, based on a concession granted by the Dutch government. In addition to being the party commissioning the rail grinding activities, ProRail was also responsible for ensuring track safety of the relevant track section, for allocating the requested capacity for the transfer journey, the scheduled timetable, train traffic control and taking the track section out of service.
- *Speno International* is a Swiss specialist rail grinding company. In addition to being the principal contractor for the rail grinding project, the company was also the owner of the rail grinding train and the employer of part of the crew (including the vehicle operator).
- *BAM Rail* is a railway contractor established in the Netherlands, which is also recognised as a railway company and as a result is authorised to operate trains. Speno and BAM Rail entered in to a collaboration agreement in which it was laid down, among other things, that BAM Rail would carry out the transfer journeys, including planning and submitting applications for journeys as well as providing a qualified train driver.
- *Spoorflex* was[1] an employment agency of railway personnel recognised by the Transport, Public Works and Water Management Inspectorate (IVW). Spoorflex supplied staff by hiring staff from BAM Rail, including the train driver who was piloting the train.

1 Shortly after the accident Spoorflex applied for a moratorium; the company has meanwhile been declared bankrupt.

Investigation

Reason for the investigation
Given the scale of the damage, the accident is subject to a mandatory investigation by the Dutch Safety Board. Incidentally, in view of the potential severity of the consequences of the accident and the fact that an investigation has not previously been conducted into such an accident the Safety Board would have performed an investigation into the accident regardless of its mandatory duty to do so.

Key question
The key question in this investigation is: *What lessons can be learned from the accident in Stavoren in terms of risk management during transfer journeys carried out by rail grinding trains, the relevant regulations and supervision thereof?*

Since the accident relates to both railway safety and safety at work, both perspectives were used to investigate how the companies involved managed the risks and how the government performed supervision thereof. The investigation examined why the companies involved did not recognise the underlying causes in advance or why they had not taken any effective control measures. It was also examined what current laws and regulations stipulate in this connection and how this was interpreted by the companies. Because the accident happened during a train journey that was being carried out in connection with maintenance work on the railway infrastructure, the performance of which had been outsourced by the infrastructure manager (ProRail), it was also examined to what extent contracting out work played a role in the failure of risk management. The investigation did not focus on settling the consequences of the accident.

Immediate and underlying causes of the accident

The accident occurred because the rail grinding train braked too late when approaching the end of the line, because the train driver failed to obey a signal (in the form of an approach marker or *keperbaken*) and the automatic train protection system (ATB) was inoperative. According to the investigation, the failure to obey the signal and the fact that the ATB system was inoperative can be attributed to various underlying causes.

The signal was not obeyed on account of the following:
- The train driver had inaccurate expectations of the signals/signs along the line and his attention had been diverted;
- The signal (approach marker) was an unusual signal, unfamiliar to the train driver, which during darkness moreover is visible for a shorter period of time and was less noticeable than a light signal;
- It was more difficult for the train driver to determine the position of the train because some location markers along the track were missing or illegible.

The train driver's poor route knowledge played a role in respect of his inaccurate expectations of the signals/signs along the route. Another relevant aspect is that the work plan was changed at a late stage, as a result of which the final section of the transfer journey took place along part of a track section that was scheduled to be taken out of service in the original work plan (and for that reason would be carried out at low speed). The track layout plans also contained speed limitation signs that in reality (five years ago in fact) had been removed. In respect of the train driver's attention being diverted, the fact that the train driver himself was not operating the train but was acting as the pilot played a role, as this meant that his attention was more likely to have been focused on other matters. Another aspect that came into play in this connection is that (apart from the vehicle operator and the train driver) a rail grinding train employee was also present in the cabin. As a result of the change in the work plan, the employee was having a conversation with the train driver; during that conversation, which was conducted in German, the train driver looked at the relevant employee, who was located behind him, several times.

The ATB system was inoperative because the trainborne ATB equipment was incompatible with the trackside ATB equipment[2]. As a result the train driver did not receive an alert upon passing the approach marker, no warning signal was subsequently sounded when the braking system was not manually operated and no automatic braking intervention occurred when the driver failed to brake manually. Because the rail grinding train's trainborne ATB equipment was switched off, the train was able to travel faster than 40km/h despite the incompatibility of the ATB systems.

The following aspects are relevant in this connection:
- Compatibility between the ATB systems of the train and the track was not mandatory in this situation;
- The train equipment had been set to offline mode automatically by the ATB switch off mechanism at the beginning of the line (the actual reason for which had already ceased to apply for several years);
- Current laws and regulations do not explicitly set out compensatory control measures, and
- The Transport, Public Works and Water Management Inspectorate did not hold the relevant companies accountable for their statutory duty of care.

Safety shortcomings

In the Safety Board's opinion the course of events described above paint a disturbing picture of how the safety risks relating to the relevant transfer journey were controlled. In addition, a number of the underlying factors that played a role in Stavoren were not unique to this particular accident but also came into play during transfer journeys carried out by other self-propelled maintenance machines. These factors are as follows: driving without ATB protection on track sections equipped with New Generation ATB (ATB-NG), having several people in the cabin, a train driver piloting the train, having limited route knowledge, errors in track layout plans, missing location markers and deviating from work plans without following the mandatory escalation procedure. A further observation in respect of the above is that a total of 18 instances of self-propelled maintenance machines passing a signal set at danger took place in the Netherlands between 2001 and mid-2010, in which some of the same underlying factors played a role as in the Stavoren accident.
Below is a summary of the safety shortcomings which, according to the Safety Board, gave rise to this situation.

Safety risk inventory and analysis
It has emerged that the risks relating to transfer journeys carried out by rail grinding trains were inadequately controlled largely because the companies involved failed to recognise that special control measures were required for transfer journeys. The companies treated the transfer journeys as regular train journeys for which no additional safety measures were required. Such journeys, however, may actually involve other risks or other risk combinations, as the Stavoren accident has shown. In this context, the fact that no serious accidents had occurred for a considerable time prior to the Stavoren accident also plays a role. However, the companies should have nevertheless performed an adequate risk inventory and analysis. This is mandatory under the Railways Act.

2 The rail grinding train was equipped with ATB-E (Basic) and the route section with ATB-NG (New Generation).

In conformity with the Working Conditions Act, the companies had drawn up a Health and Safety Plan (V&G Plan) for the rail grinding project but the plan only dealt with the risks relating to the railing grinding activities and not with the risks involved in transfer journeys. Incidentally, transfer journeys carried out by maintenance machines are not incorporated as standard into the Health and Safety Plan covering the relevant work carried out on the railway. The Safety Board would like to point out that the relevant section of sector regulations in this respect is unclear. The Safety at Work Standards Framework (*Normenkader Veilig Werken*, NVW) and the Safety at Work Regulations (*Voorschrift Veilig Werken*, VVW) do not elaborate on the issue of transporting staff and equipment to the relevant work location.[3]

Outsourcing the rail grinding project
The train journey was carried out as part of maintenance work on the railway infrastructure that had been contracted out by the infrastructure manager (ProRail). It was therefore also examined to what extent outsourcing the project played a role in the inadequate control of the safety risks. The Safety Board's conclusion is that the outsourcing arrangement (with Speno as the principal contractor and BAM Rail as the subcontractor) largely focused on the performance of the rail grinding activities and less on monitoring safety. The company that supplied the 'tools' and 'production staff' acted as the principal contractor while a subcontractor deployed safety staff (hired from an employment agency). In the Safety Board's opinion the outsourcing arrangement as such would not have caused any problems if the companies had made sound agreements about controlling the safety risks and had held each other accountable for implementing and complying with those agreements. This condition was not met: it was agreed that BAM Rail should perform the transfer journeys but ProRail and Speno had not laid down what control measures and what level of control BAM Rail was required to ensure. In addition to the above, the consultations conducted between the companies failed to achieve a joint approach. On account of the lack of sound agreements or proper consultations, the situation arose in which the control of safety risks during transfer journeys was transferred to a company, BAM Rail, which as the subcontractor did not feel obliged to take far-reaching measures of its own accord.

Regulations and supervision
A higher level of risk clearly applied to the transfer journeys carried out by rail grinding trains than to 'normal' train journeys. On a substantial part of the journeys there was no ATB monitoring, a train driver was structurally deployed to pilot the train and individuals were allowed to travel in the cabin. Except for the train driver piloting the train, the higher level of risk applies in a broader context to transfer journeys carried out by self-propelled maintenance machines. This is because the companies involved "loosely" interpret various aspects of the regulations in respect of the relevant train journeys and rail vehicles. This applies inter alia to passengers travelling in the cabin, to the train drivers' route knowledge and to the compatibility between the trainborne ATB equipment and the trackside ATB equipment. Furthermore, the Safety Board would like to point out that the Stavoren accident also revealed that unnecessary risks were taken relating to other aspects of the relevant transfer journey and regulations were not complied with (i.e. travelling with a switched off dead man's system and exceeding the permitted speed with filled water tanks on board).

The Safety Board believes that in fact more stringent rules or a stricter interpretation of the rules should apply to such transfer journeys of maintenance machines because these journeys are carried out by railway contractors and driving trains does not form part of these companies' core activities.

According to the Safety Board, government supervision of risk control relating to transfer journeys was inadequate in two areas:
- Supervision of compliance with the Railways Act focused on specific rules rather than on the companies fulfilling their own responsibility;
- Supervision of safety at work focused solely on the rail grinding activities rather than on the transfer journeys.

3 The sector safety-at-work-regulations relating to work on the railway tracks which incorporate the Safety at Work Standards Framework (NVW) and the Safety at Work Regulations (VVW) are administered by railAlert, a foundation representing the companies involved and the relevant inspectorates.

Taking all of the above into consideration, the Safety Board is of the opinion that an incorrect interpretation of tasks played a role in two ways in the poor risk control:

Own responsibility
As stated earlier, in managing risk the companies involved exclusively limited themselves to taking mandatory measures. In doing so, they only fulfilled the individual responsibility that lies with them – as stipulated in the Railways Act – to a limited extent. The essence of that individual responsibility is that the railway companies are required to ensure adequate control of the safety risks and that they themselves are required to determine which measures need to be taken, in addition to those required by law. The relevant companies only fulfilled this obligation to a limited extent.

The Safety Board had already submitted a recommendation on this aspect to the Minister of Transport, Public Works and Water Management in a previous report (on the derailment of a goods train near Muiderpoort Station in Amsterdam on 22 November 2008). In response to the recommendation, in September 2010 the Minister stated that the Transport, Public Works and Water Management Inspectorate, in connection with its licensing task, would ensure that railway companies draw up an explicit ALARP[4] evaluation for the current main railway safety issues, as part of their Safety Management System. In connection with the Minister's response, the Safety Board has not put forward a recommendation on this issue in this report. However, in this context the Safety Board wishes to express its concern about a comment in the joint response received from the Ministry of Infrastructure and the Environment (IenM)[5] and the Transport, Public Works and Water Management Inspectorate in connection with the review procedure for this particular report. The response states that it would seem rather paradoxical to monitor the fulfilment of one's own responsibility (because that would defy the purpose of individual responsibility). The Safety Board does not share the view of a supposed conflict between companies fulfilling their 'own responsibility' and 'government supervision' thereof. On the contrary, in respect of parties fulfilling their own responsibility, the Safety Board deems it vital to ensure adequate supervision of the safety management performance of the relevant companies, both on paper and in practice. The investigation into the Stavoren accident serves to explicitly underline the importance thereof.

ProRail responsibilities
In respect of controlling the risks relating to transfer journeys carried out by self-propelled maintenance machines, the Safety Board believes that ProRail fulfils a central role because the company functions as both the infrastructure manager and the party commissioning the work on the railway, of which work the transfer journeys form part. In both capacities, in the Safety Board's opinion, ProRail should also have assumed a directive/corrective role as regards the equipment on board the rail grinding trains and the operational performance of the transfer journeys.
ProRail holds a different view. In connection with the review procedure relating to the present report (see Appendix 2) the company has stated that it does not consider itself responsible for controlling the operational safety risks arising during transfer journeys carried out by self-propelled maintenance machines. With reference to the primary allocation of roles between the railway companies, ProRail states that that responsibility lies with the transport operator (in this case BAM Rail) and that ProRail does not fulfil a position of authority in this context that would allow it to provide safety instructions to a transport operator.

4 ALARP is the abbreviation for 'As Low As Reasonably Practicable'.
5 The railway sector formed part of the portfolio of the former Ministry of Transport, Public Works and Water management until 14 oktober 2010. The sector has since been incorporated into the portfolio of the Ministry of Infrastructure and the Environment.

The Safety Board disagrees with ProRail's view based on the following two arguments:

- According to the primary allocation of roles in the railway sector, in respect of transfer journey risk control, ProRail (as the infrastructure manager) is indeed responsible for the railway infrastructure, the scheduled timetable and train traffic control. The owner/holder of the vehicle is responsible for the equipment and its state of repair while the official transport operator is responsible for operating the train journey, including the events in the cabin. However, to ensure adequate control of the safety risks the companies must not limit themselves to the primary allocation of roles but must make a maximum contribution to controlling all the risks and must hold other companies accountable for their respective shares. The Safety Board would point out that this is supported by the Railways Act and the management concession, which apart from the quality requirements imposed on the different system components (railway infrastructure, equipment, scheduled timetable and train traffic control) also stipulate a 'duty of care' towards rail safety. The duty of care (applicable to both the transport operators and the infrastructure managers) is not limited to the risks posed by the relevant company itself or that can be dealt with individually.
- Transfer journeys carried out by self-propelled maintenance machines form part of work on the infrastructure commissioned by ProRail. In the Safety Board's opinion, ProRail's responsibility as the commissioning party is not limited to the relevant work carried out on the railway; in its capacity as the commissioning party the Safety Board expects ProRail to assume a directive and if necessary a corrective role in controlling the risks relating to transporting staff and equipment to and from the work location. According to the Safety Board, ProRail - as the commissioning party - also has the opportunity to do so. Concerning the latter aspect, the Safety Board wishes to point out that as a result of the Stavoren accident ProRail requires that railway contractors (including BAM Rail) limit the speed of a maintenance machine carrying out a transfer journey without ATB monitoring to 40km/h.

The Safety Board previously expressed its views about the allocation of responsibilities in the railway sector in its report on the derailment of a goods train near Muiderpoort Station in Amsterdam (published in 2010). The responsibilities attached to functioning as the commissioning party are discussed in the reports on the collision of two metro vehicles in Amsterdam (published in 2011), the safety of passenger transport by hydrofoil across the North Sea Channel and on the River IJ in Amsterdam (published in 2009) and the explosion of a natural gas condensate storage tank at NAM in Warffum, the Netherlands (published in 2007).

Recommendations

On the basis of the investigation, the Safety Board has formulated the following recommendations:

Following the Stavoren accident, the companies involved, the Ministry of Infrastructure and the Environment and the Transport, Public Works and Water Management Inspectorate have taken a range of measures to ensure improved control of the safety risks that played a role in that accident. The Safety Board believes that it is vital to actively implement these measures and any other necessary measures. The Safety Board furthermore believes that the improvements should not only relate to transfer journeys carried out by rail grinding trains but also to other maintenance machines, to the extent applicable. The Safety Board believes ProRail should assume a central role because of its position as the railway infrastructure manager and the party commissioning the outsourced maintenance work.

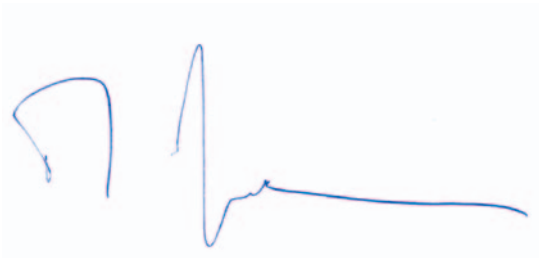
Recommendation 1: ProRail
Take full responsibility for the safety of your own projects, including work that has been outsourced. This implies inter alia to implementing the required measures to adequately control the safety risks relating to transfer journeys carried out by rail grinding trains and other self-propelled maintenance machines.

Furthermore, the Safety Board deems it necessary that a number of the aspects of the general and sector-specific regulations be clarified/tightened.

Recommendation 2a: Netherlands Association for Railway Regulations and Documentation (VSD)
Ensure that the sector regulations concerning passengers travelling in the cabin are tightened.

Recommendation 2b: railAlert Foundation
Ensure that the issue of 'transporting staff/material/equipment' becomes an integral part of sector regulations for safety at work when working on the railways (Safety at Work Standards Framework, NVW, and the Safety at Work Regulations, VVW).

Recommendation 2c: ProRail
Ensure that the rules relating to the application of uncommon signals and signs (such as the approach markers) are tightened.



T.H.J. Joustra
Chairman of the Dutch Safety Board

M. Visser
General Secretary

1 INTRODUCTION

1.1 Reason for the investigation

During a transfer journey late in the evening of 25 July 2010 a self-propelled maintenance vehicle, (a rail grinding train) travelling at high speed ploughed through a buffer stop at the end of the railway line at Stavoren Station. The train derailed, subsequently first hit an empty tanker and then drove straight through a shop. Four people were on board the rail grinding train, two of whom sustained mild injuries. At the time of the accident there were no bystanders at the location where the train came to a halt. The damage to the train and the surrounding area is estimated to be more than EUR 20 million.

Given the scale of the damage, the accident is subject to a mandatory investigation by the Dutch Safety Board.[6] A further reason for the investigation is that based on the information gathered at the site of the accident, there are reasons to suspect that the accident was caused by a combination of factors that were inadequately controlled. Another factor that has been taken into account is that a serious accident occurred with a similar rail grinding train near Zwolle in 2007.[7]

1.2 Purpose and research questions

The purpose of the Safety Board's investigation is to learn safety lessons from the accident in Stavoren with a view to preventing similar accidents or limiting their consequences in the future.

The key question in this investigation is: What lessons can be learned from the accident in Stavoren in terms of risk management during transfer journeys carried out by rail grinding trains, the relevant regulations and supervision thereof?

The key question has been elaborated in the following research questions:

1. What were the immediate causes of the accident and what are the underlying factors that played a role in this context?
2. To what extent are the underlying factors unique to this accident?
3. What procedures did the companies follow in managing the safety risks during the transfer journeys carried out by the rail grinding trains and to what extent have the companies fulfilled their own responsibilities in this respect?
    a. To what extent have the companies involved predefined the safety risks related to journeys carried out by grinding trains?
    b. How did the companies involved deal with the risks and what role has current legislation played in this context?
    c. To what extent have the companies involved learned lessons from comparable incidents that have occurred in the past?
    d. How was risk management dealt with in respect of the transfer journeys in the context of contracting out work, and to what extent did that approach play a role in the failure of risk management?
4. To what extent has the government monitored compliance with the relevant legislation?
5. What measures have the companies involved and the government taken as a result of the accident in Stavoren?

6 Pursuant to Article 8a of the Dutch Safety Board Decree, the Safety Board is required to investigate a train crash or derailment if the material damage sustained is instantly estimated to be at least EUR 2 million

7 See under 5.6.3.

1.3 Scope of the investigation

The investigation focused on the relevant facts, the circumstances and the causes of the accident; the investigation did not focus on settling the consequences of the accident. The investigation furthermore focused on the fact that the rail grinding train was being transferred while the line was in service, prior to commencing the rail grinding activities. The maintenance work itself – rail grinding – was not investigated. The investigation into the underlying problems mainly focused on the extent to which the possibilities for controlling the risks were actually utilized.

1.4 Reading guide

Chapter 2 describes the relevant facts, consequences and backgrounds to the accident in Stavoren. The chapter also contains information on other recent incidents involving self-propelled maintenance equipment.
Chapter 3 describes the reference framework used for the purpose of the investigation. This comprises the statutory regulations, the rules and regulations applicable in this context and the reference framework that the Dutch Safety Board has drawn up regarding safety management.
Chapter 4 provides an overview of the parties involved and their risk management responsibilities.
Chapter 5 contains the analysis, which in consecutive order covers the cause of the accident, the structural safety issues that came into play, the management of safety risks by the companies involved and the monitoring thereof. The chapter concludes with an overview of the measures taken as a result of the accident in Stavoren.
Chapter 6 contains the conclusions and Chapter 7 the recommendations.

2 THE TRAIN ACCIDENT

2.1 Relevant facts

A special rail grinding train was scheduled to carry out rail grinding activities on the Leeuwarden-Stavoren track section during the night of 25 to 26 July 2010. The railway was to be taken out of service for that purpose. Prior to commencing the rail grinding activities, the rail grinding train was transferred as a 'normal train' to the starting point where the railway was to be taken out of service. This was originally scheduled to be Sneek but the staff involved decided to change the work plan so that the starting point where the railway would be taken out of service would begin at Stavoren. The rail grinding train therefore travelled across the track adhering to the speed limit (maximum 100km/h) to the terminus of the relevant line section, which was Stavoren Station. The intention was to take the track out of service after the rail grinding train had arrived in Stavoren, and to subsequently deploy the rail grinding train as a work train on the railway track that had been taken out of service.

The accident occurred when the rail grinding train arrived at Stavoren Station at around 23.30 hours. Due to the fact that the rail grinding train braked too late, it drove at a speed of approximately 80km/h through a buffer stop located at the end of the line. On account of its high speed the train only came to a halt approximately 70 metres further on. After colliding with the buffer stop, the train first crashed into a parked tanker, which was empty, and then shot straight through the premises of a shop.

Figure 1: This photograph shows the situation shortly after the accident. The train was driving from left to right. The railway terminus is located just outside the left frame of the photograph. The photograph shows that the train, with the tanker in front of it, has ploughed straight through the shop premises. (Source: National Police Services Agency, KLPD).

2.2 Circumstances

Track section

- The Leeuwarden-Stavoren track section is a regional railway line in Southwest Friesland along which Arriva operates regular passenger services. ProRail manages the infrastructure and train traffic control.
- This is a single-track, non-electrified track section that begins in Leeuwarden and ends in Stavoren. Seven railway stations are located between Leeuwarden and Stavoren. Passing tracks have been installed at several locations along the track section.
- The track section is known as a locally operated relay interlocking (TPRB) track section,[8] which means that the route controls are not performed by the rail traffic controller but by the train drivers themselves (this means that they operate a control cabinet on the platform with a key before leaving a station).[9] The rail traffic controller does not have any facilities for monitoring the current train running status but only has a diagram of the train schedule on paper and a number of track layout plans at his disposal.
- The track section and the Arriva trains running regular services on that route have an Automatic Train Protection System (*Automatische Treinbeïnvloeding, ATB*). Just as the other regional diesel lines, the track section is equipped with ATB-NG[10] and not with the more common ATB-EG[11].
- Stavoren Station does not have the usual light signal entering a railway station. However, a series of approach markers (*keperbaken*) are located alongside the railway track at a distance of approximately twelve hundred metres from the end of the railway track (see figures 4 and 5). These approach markers consist of three signs located alongside the railway track spaced at an intermediate distance of approximately 70 metres from each other. These markers have the same meaning as an amber light signal ('limit speed to 40km/h, or reduce speed as much as is necessary in order to be able to stop at the next signal commanding the train to stop').

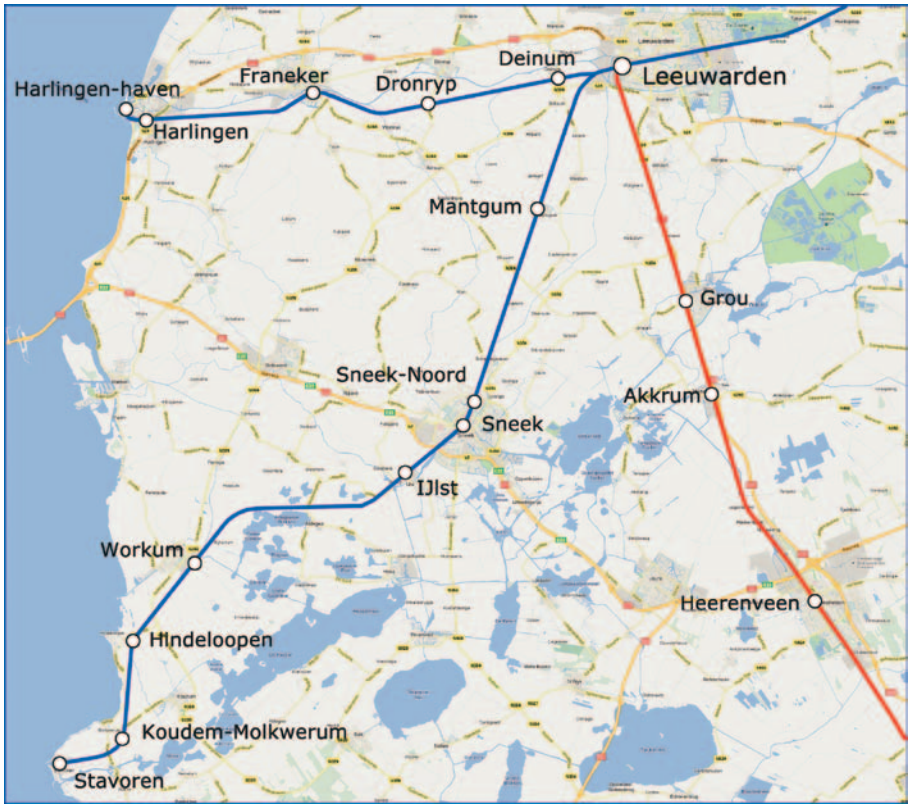


Figure 2: Section of the railway map showing the Leeuwarden – Stavoren track section.

8 TPRB = locally operated all-relay interlocking system.
9 The train drivers of regular Arriva trains use remote control for this purpose. Train drivers of non-regular trains, such as rail grinding trains, must exit the train and operate a control cabinet with a key.
10 ATB-NG = Automatic Train Protection System - New Generation.
11 ATB-EG = Automatic Train Protection System - First Generation.

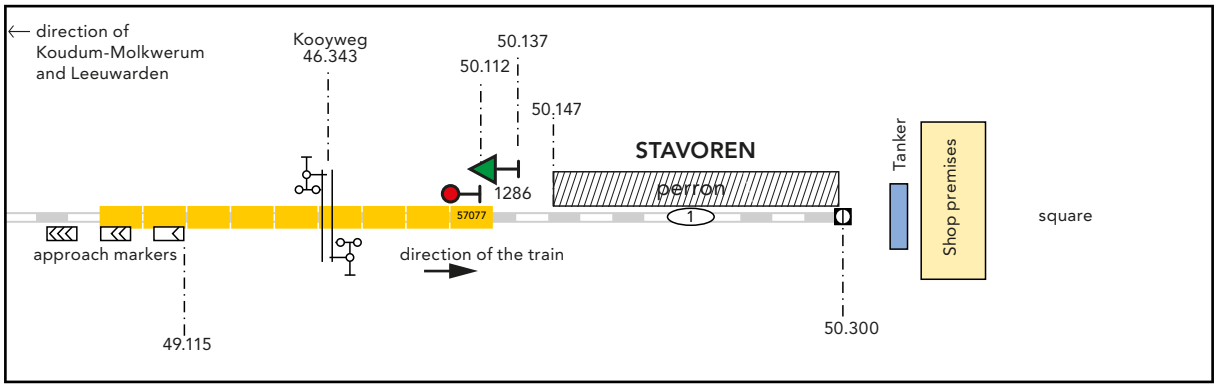


Figure 3: Diagram showing the last part of the Leeuwarden-Stavoren track section (source: IVW)

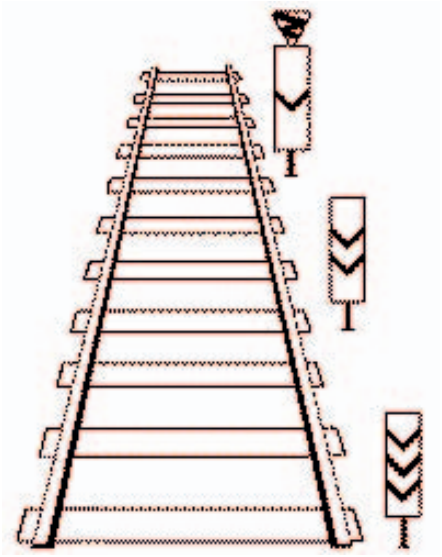


Figure 4: Illustration of the approach markers (consisting of a series of three signs with an intermediate distance of approximately 70 metres).

Figure 5: Photograph of the approach marker near Stavoren (photographed during darkness using a flashlight).

Rail grinding activities and rail grinding train

- To maintain the rails in good condition, the profiles of the rails are periodically restored by means of grinding (this involves removing cracks and bumps and adjusting the profile to reduce 'wheel to rail' noise). The rail grinding activities are planned and put out to tender by ProRail (as the railway infrastructure manager). These activities have been contracted out for some thirty years now to Speno International, a Swiss company that specializes in this type of grinding activity. The company has operations in many parts of the world.
- Speno has some forty special rail grinding trains in Europe. These are self-propelled machines, the largest of which are over 100 metres in length (such as the train involved in the accident in Stavoren). The rail grinding trains are deployed by Speno, including the crew, who are usually Italian. Five of Speno's rail grinding trains (two large and three smaller trains) are used on an almost continuous basis in the Netherlands.
- The relevant Speno rail grinding trains are officially permitted in the Netherlands, which means that the Transport, Public Works and Water Management Inspectorate (IVW) has issued a deployment certificate based on an admission inspection. For admission purposes, rail grinding trains must feature equipment such as GSM-R (an international standard for railway communication used for communication between trains and traffic control centres) and an ATB system, type ATB-E.[12] The deployment certificate contains a maximum speed in connection

12 ATB-E stands for 'Basic ATB' (simplified version of ATB-EG).

with the axle load and the axle configuration of the rail grinding train based on transporting full water tanks.

- The company Speno International is not recognised as an official 'railway company' in the Netherlands by IVW. For that reason transfer journeys carried out by rail grinding trains in the Netherlands are performed under the flag (a safety certificate) of a company that is officially recognized as a railway company. BAM Rail[13] is the company that has been carrying out the transfer journeys since 2006.

Figure 6: This photograph shows a rail grinding train similar to the one involved in the Stavoren accident. (source: Vincent Prins)

Transfer journeys and piloting

- Rail grinding activities are usually carried out at night. In the intervening periods the rail grinding trains must be parked at designated parking stands, designed for the purpose of refuelling, filling water tanks, depositing waste and performing maintenance. Six parking stands were allocated under the contract but only three of these were operating at the time of the accident, which meant that relatively large distances had to be covered during the transfer journeys. During the relevant transfer journey, the train drove from the parking stand near Rotterdam to the deployment area in Southwest Friesland.
- A train must be driven by a fully qualified driver, who moreover has adequate route knowledge and sufficient knowledge of the equipment. In the case of the transfer journeys carried out by the rail grinding trains, these three requirements were not satisfied by one person as usual, but by two people: first, a vehicle operator (having the required knowledge of the equipment) and second, a train driver who was 'piloting'[14] the train (and was fully qualified and possessed the required route knowledge). During the transfer journeys the train was operated by the vehicle operator, who was acting under the directions and responsibility of the driver piloting the train.[15] The vehicle operator was Italian (employed by Speno) and the train driver was Dutch (hired in from Spoorflex by BAM Rail).

13 BAM Rail is one of the four largest railway contractors operating in the Netherlands. The company is an officially recognised railway company, having held a safety certificate since 1997.

14 In this context, piloting means 'guiding' or 'navigating', in which case the train driver is also referred to as the pilot.

15 The train driver who was piloting the train had disposal of a red lever located left in front of his seat for the purpose of applying the emergency brakes, and GSM-R equipment for communication purposes.

2.3 Consequences

None of the four people on board the rail grinding train were seriously injured. Two of the Italian employees on the rail grinding train sustained mild injuries. No one outside the train was injured thanks to the fact that no one was in the relevant zone, the shop premises or the tanker at that time. However, the rail grinding train was severely damaged and the tanker and shop premises were completely destroyed. The material damage is roughly estimated to be more than EUR 20 million.

Figure 7: Front of rail grinding train RR48M-5 after the crash with the tanker in front that had been pushed through the shop.

2.4 What took place before the train accident occurred

The night before the train accident in Stavoren, the same rail grinding train performed rail grinding activities elsewhere in the Netherlands. The driver piloting the train, who was working on the night of the accident, was not involved in these activities. However, the BAM Rail subcontractor and the Spoorflex Workplace Safety Leader were involved. At the end of the night, they discussed the work plan for the following night. During their meeting they decided to attempt to deviate from the work plan for that night. Time savings of around 30 minutes could possibly be achieved by not commencing the activities at Sneek, but by instead first driving on to Stavoren. The Workplace Safety Leader would try to seek approval for the change of plan from the rail traffic controller on Sunday evening, prior to commencing the activities. However, in breach of the mandatory escalation procedure stipulated by BAM Rail the Workplace Safety Leader and the contractor did not contact the relevant BAM Rail officer.

On Sunday, 25 July 2010, the rail grinding train, towed by a locomotive, was transferred from the parking stand in Rotterdam North Cargo to Zwolle Cargo. The Italian rail grinding train crew had spent the day in Zwolle. The reason for transporting the rail grinding train behind a locomotive was to reduce the work time of the Italian crew. The locomotive towing the rail grinding train

arrived in Zwolle at approximately 19:00 hours. The driver piloting the train also arrived in Zwolle at around the same time to start work. The train driver assisted in preparing the rail grinding train as well as with a number of shunting activities. The rail grinding train departed for Leeuwarden at approximately 21:00 hours.

En route to Leeuwarden the train driver was informed by the Workplace Safety Leader by telephone of the intention to change the work plan. During the telephone conversation, which lasted approximately three minutes, the train driver argued that he did not have the correct version of the necessary WBI/WTI documents and that he had not thoroughly prepared for a transfer journey between Sneek and Stavoren because, according to the original plan, that section would be taken out of service. The train driver furthermore stated that he was familiar with the relevant track section (between Sneek and Stavoren). The train driver did not request BAM Rail or ProRail to change the timetable for the Leeuwarden-Stavoren section of the track.

After arrival in Leeuwarden, the rail grinding train was prepared for departure on the Leeuwarden-Stavoren track section. At around the same time, the Workplace Safety Leader in Sneek issued safety instructions[16] to the team of workmen who were involved in the rail grinding activities during the night. The employees on the rail grinding train were not present when the instructions were given. The plan was that they would receive instructions later in Stavoren. The Workplace Safety Leader informed the team of workmen about the changed work plan. He also contacted the rail traffic controller, who agreed with the change in the work plan. Apart from the time of commencement the WBI did not need to be changed for this purpose. The rail traffic controller had no contact with the train driver about the missing timetable between Sneek and Stavoren.

The rail grinding train left Leeuwarden at 22:16 hours, travelling in the direction of Stavoren. The train driver had contacted the rail traffic controller prior to departure and the rail traffic controller indicated at which stations the train had to wait for passenger trains passing in the opposite direction. This information is important on a TPRB track section because the train driver himself is required to operate the signals. It was furthermore agreed that the rail grinding train would drive to Stavoren and that the railway track would then be taken out of service. On leaving Leeuwarden, in addition to the vehicle operator and the train driver an Italian rail grinding employee was also located in the operating control cabin of the rail grinding train. He occupied the third seat in the cabin. Another Italian rail grinding employee was located in the control cabin, which did not have an operator, at the rear of the train. The front lighting had been set in 'dipped'[17] position and the cabin lights were off.

On leaving Leeuwarden the rail grinding train travelled along the railway track in the direction of Harlingen/Stavoren, which branches off into the line to Harlingen and the line to Stavoren, just outside Leeuwarden. The shared part of both lines contains an ATB switch off section. When the train passed this, the trainborne ATB equipment automatically switched to the offline mode. The rail grinding train subsequently travelled along the line to Stavoren.

The line to Stavoren contains the following seven way stations: Mantgum, Sneek-Noord, Sneek, IJlst, Workum, Hindeloopen and Koudum-Molkwerum. The rail grinding train made an intermediate stop at four of the above stations. The first intermediate stop was made in Mantgum, the duration of which was approximately 26 minutes; during that intermediate stop two passenger trains travelling in the opposite direction passed. The duration of each of the other three intermediate stops in Sneek, Workum and Hindeloopen respectively was around half a minute.

After the last intermediate stop (in Hindeloopen at 23:18 hours) the Workplace Safety Leader and the train driver again spoke to each other by telephone. According to the train driver this took place approximately five minutes before the rail grinding train arrived in Stavoren. In response to the

16 It is mandatory for a Workplace Safety Leader to provide safety instructions prior to taking any railway track out of service. The employees who receive the instructions are required to sign a form for this purpose.

17 There also is a 'main lights' position. The train driver decided not to use the main lights because these may attract animals. The train driver determines whether to use the main lights or dipped/low beam lights.

question asked during the telephone conversation the train driver stated that he was about two kilometres from Stavoren at that time.

When approaching Stavoren, the rail grinding employee located in the cabin with the train driver and the vehicle operator asked the train driver a question about the rail grinding activities that were to be carried out later. In response to the question, the train driver consulted the visual instructions (a track layout plan) and spoke to the relevant employee (who was located behind him). On account of the language barrier the train driver turned his head in the direction of the Italian rail grinding employee for a number of seconds. As a result, the train driver was temporarily unable to see the section of the railway track in front of the train. The train driver himself estimates that the entire conversation took approximately half a minute. During that period the rail grinding train, which was travelling at a speed of approximately 95km/h, passed three approach markers (*keperbaakborden*) located alongside the railway track approximately 1200 metres from the end of the line. The train driver did not notice the approach markers, or in any event failed to recognise the significance of the approach markers. The Italian vehicle operator was not familiar with the approach markers and maintained the speed of the train (approximately 95km/h).

The 'Koeweg / Kooijweg' level crossing is located approximately 200 metres after the approach marker. This level crossing is well lit and the railway workers who were to carry out the rail grinding activities later on were standing there. When the train failed to reduce speed in passing the railway workers waved their arms in an attempt to attract the attention of the rail grinding train crew. In response to their signals, the rail grinding train employee in the rear cabin asked via the intercom whether the train should stop. The train driver thought he recognised the relevant level crossing and expected to see a speed sign shortly after the crossing indicating that the train should reduce speed to 40km/h. That sign was shown on the visual instructions that he had consulted just before that time. However, the sign did not follow. He then looked for a kilometre sign as a reference point but was also unable to locate that particular sign. Almost immediately after that, the train driver saw the end of the railway track further on and responded by instructing the vehicle operator to brake in German: *'Bremsen, bremsen, bremsen'*. The vehicle operator promptly initiated an emergency braking action, but by that time the distance to the buffer stop was too short to halt the train on time. However, the three men still managed to get out of their seats and move to the rear wall of the cabin. The train then crashed into the buffer stop.

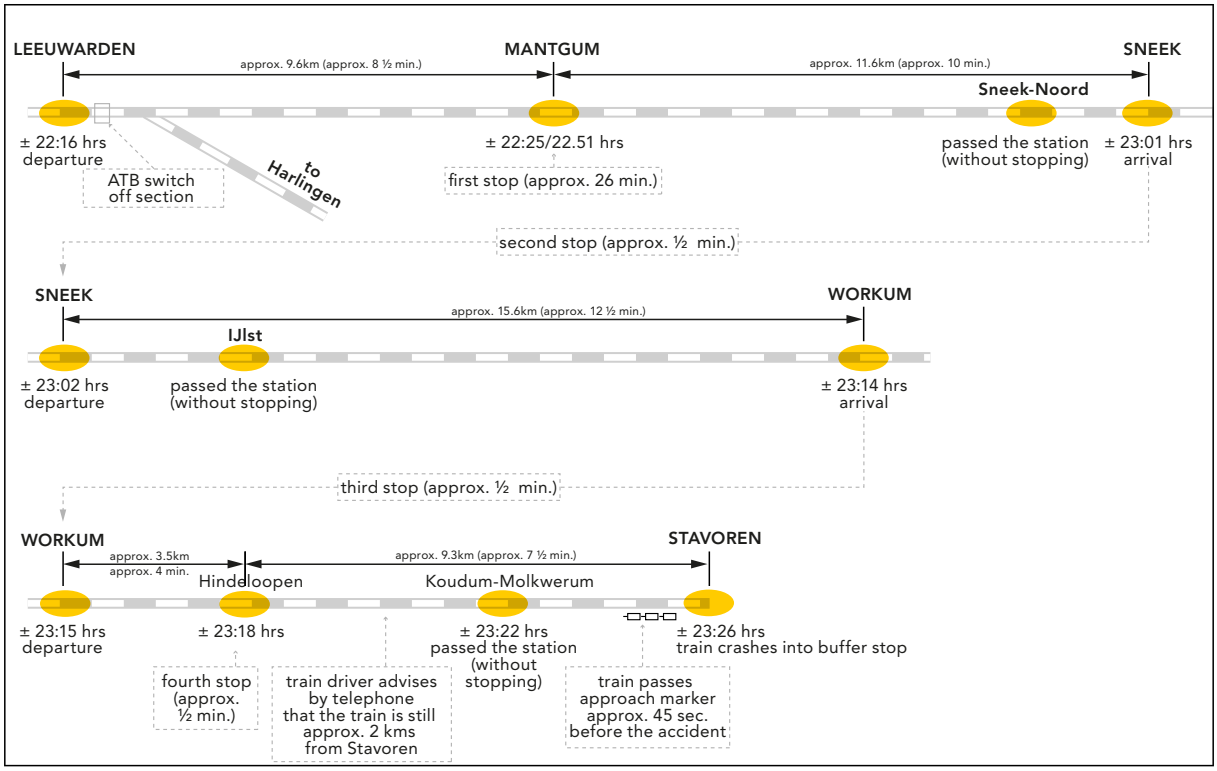


Figure 8: Diagram showing the course of the transfer journey from Leeuwarden to Stavoren

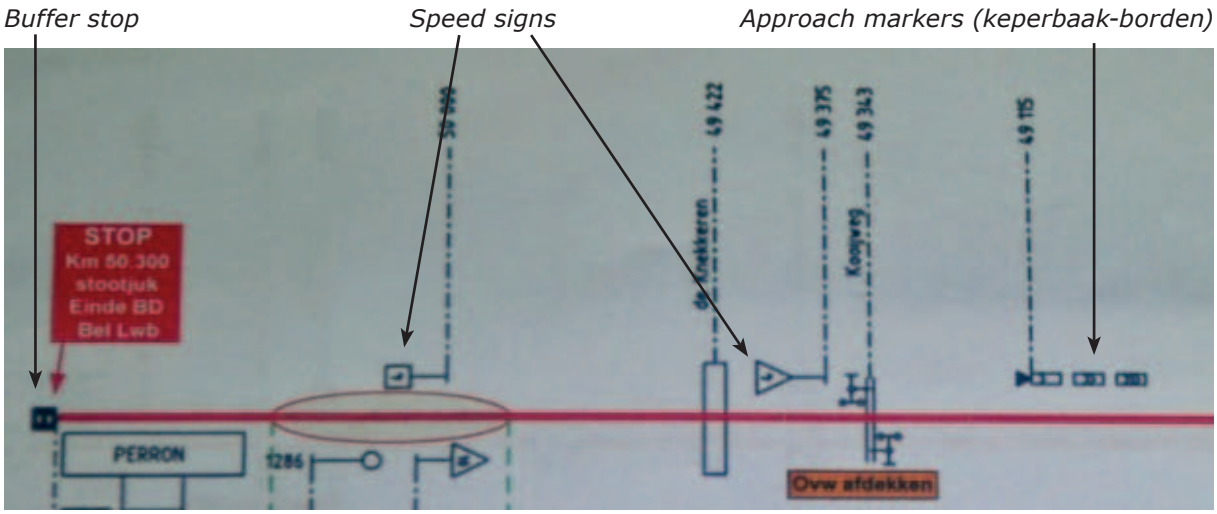


Figure 9: Part of the visual instructions (track layout plan) used by the train driver. The track layout plan shows the speed limit signs that were no longer present. It also shows the approach marker (keperbaak). The track layout plan furthermore states that it must not be used as a safety document.

3 REFERENCE FRAMEWORK

This chapter describes the reference framework applied by the Safety Board for the purpose of this investigation. The reference framework comprises three parts: the relevant laws and regulations, the sector standards and guidelines, and the general safety management criteria formulated by the Safety Board.

3.1 Laws and regulations

The accident involved a self-propelled maintenance machine that was en route to the deployment area with part of the team of workmen on board. At the time of the accident, the machine was driving as a 'normal' train on a railway track that was in service. The train was therefore participating in both rail traffic and in the maintenance work being carried out on the railway infrastructure (the rail grinding project).

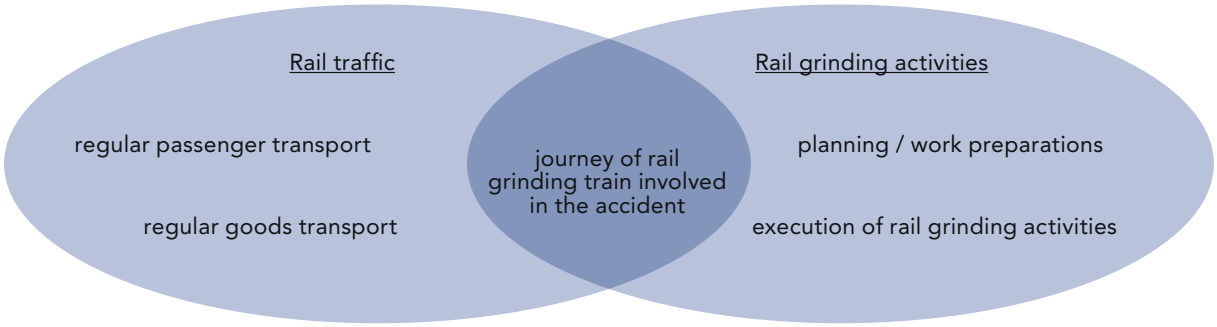


Figure 10: Diagram showing the context in which the rail accident occurred.

The above implies that in this particular case two Acts apply: the Railways Act (*Spoorwegwet,* which focuses on rail safety, among other things), and the Working Conditions Act (*Arbeidsomstandigheden-wet,* which focuses on the health and safety of employees, among other things).

3.1.1 Railway legislation

Railway safety legislation has been drawn up at both European and national level. The European Union has drawn up various directives focusing on this area, the most relevant of which is the Railway Safety Directive. The European directives must be transposed into national laws and regulations by the member states. In the Netherlands the safety of the national rail network is regulated by the Railways Act. Various decrees and regulations have been laid down in implementation of this Act. The European directives referred to above have been implemented in the Railways Act and the relevant decrees/regulations.

a) European Directives

The purpose of the European Railway Safety Directive (Directive 2004/49/EC on safety on the Community's railways, hereafter referred to as the Directive) is to improve safety in the Community rail system as a whole.[18] The Directive lays down the safety targets the EU member states are required to pursue and the safety indicators and measurement methods that are applied to determine whether these targets have been achieved.

18 Since Directive 1996/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC on the interoperability of the conventional rail system also address safety systems, these directives also concern rail safety.

In accordance with the Directive, in order to ensure the development and improvement of railway safety the EU member states are responsible for the following:

- Ensuring that responsibility for the safe operation of the railway system and risk management is assigned to the infrastructure manager and railway undertakings.
- Obliging them to implement the necessary risk control measures, where appropriate in cooperation with each other, to apply national safety rules and standards, and to establish[19] a safety management system (SMS).[20]

The Directive furthermore stipulates the following with respect to rail safety and the responsibilities of the various parties involved:[21] '*All those operating the railway system, infrastructure managers and railway undertakings, should bear the full responsibility for the safety of the system, each for their own part. Whenever it is appropriate, they should cooperate in implementing risk control measures*.'

b) Railways Act, management concession and safety certificate

The Railways Act, which entered into force on 1 January 2005, regulates the construction, management, accessibility and use of the railways as well as rail traffic. The Act makes a distinction between *management of the infrastructure*, on the one hand, and *railway traffic*, on the other.

The Minister of Transport, Public Works and Water Management grants a concession for *the management* of the network infrastructure to one or more infrastructure managers.[22] In addition to ensuring the quality, reliability and availability of the railway infrastructure, infrastructure management also includes the allocation of capacity and train traffic control. The Minister attaches conditions to the concession, which guarantee that the infrastructure can be used safely and effectively, and that the safety risks relating to the use and management of the infrastructure are analysed and adequately controlled by taking appropriate risk control measures.[23] In this context, account must be taken of the particular requirements relating to the expected business operations and the state of the art.

The above conditions have been incorporated in the management concession[24], which also stipulates that the manager must have disposal of an adequate safety management system (SMS) that meets certain requirements. In accordance with these requirements, the infrastructure manager must guarantee:[25]

- that it will analyse the safety risks involved in the use and management of the network infrastructure and will take appropriate measures, including taking a section of the railway network out of service where necessary in order to control these risks adequately, taking into account the specific requirements relating to the expected business operations and the state of the art;
- that its SMS meets the requirements stipulated in the Railway Safety Directive with respect to that point[26], including the following:
  - procedures and methods for assessing and controlling risks if new risks associated with the infrastructure or the activities arise as a result of a change in the operating environment or as a result of new equipment;
  - procedures to ensure that accidents, incidents, near accidents and other hazardous incidents are reported, investigated and analysed and that the necessary preventive measures are taken;
  - provisions for performing periodic internal SMS audits.

19 Article 4 of Directive 2004/49/EC on safety on the Community's railways.
20 The European Directive refers to a 'safety management system' while Dutch legislation refers to a 'safety care system'. In other documents issued by the government and the parties involved in the railways, the term 'safety management system' (SMS) is usually used. The latter term is also used in this report.
21 Directive 2004/49/EC on safety on the Community's railways, Consideration 5.
22 Section 16 of the Railways Act.
23 Section 17 (1b and c) of the Railways Act.
24 The Railway Infrastructure Management Concession was granted to ProRail for the period 1 January 2005 to 1 January 2015.
25 Railway Infrastructure Management Concession, Article 3.
26 Railway Infrastructure Management Concession, Article 7 (1).

The Minister of Transport, Water Management and Public Works has entrusted the 'railway companies' with *railway traffic.* An operating licence granted by the Minister[27] is required in order to operate a railway company. Railway companies are furthermore required to hold a safety certificate[28], which is granted by IVW, in order to use the network infrastructure. A safety certificate is granted on condition that the company is able to demonstrate sufficiently that - by applying an adequate Safety Management System - it is in a position to use the railway safely.[29] The Act imposes functional requirements on the Safety Management Systems used by railway companies.[30] Among other things, the system must guarantee that the railway company:

- 'will not cause damage, nor unnecessarily obstruct or endanger any person and will ensure that railway traffic can be handled without disruption as far as possible during normal business operations and in the event of foreseeable deviations therefrom;
- will take account of the specific requirements if normal operations affect the operations of other rail users or those of the infrastructure manager;
- has identified the operational risks involved and will take appropriate measures to control these adequately, thereby taking into account the state of the art, the knowledge available within the sector and the guidelines for ensuring safe operations;
- will establish and apply procedures for taking corrective measures in the event of deviations and incidents, as well as ensure continuous improvement of the level of safety with a view to changing circumstances, and based on the experience gained;
- will ensure that employees fulfilling a safety function are given the necessary training, and follow the required periodic or additional training, education and studies with a view to maintaining their suitability, knowledge and professional competence in line with the relevant role'.

The Railways Act furthermore imposes education and suitability requirements on personnel that fulfil a safety function[31] and on equipment driven on the railway.[32]

As stated above, the Railways Act and the management concession stipulate that the infrastructure manager and the transport operators must 'adequately' control the safety risks 'by taking appropriate measures.' In line with the Railways Act and the management concession, the Second and Third Rail Safety Framework Policy Documents[33], which set out government railway safety policy, define what this means. The above framework policy documents state that the ALARP[34] principle is the standard that applies to the adequate control of safety risks. This principle means that the responsible parties must ensure that the available measures are taken unless these involve demonstrably unreasonable costs and/or consequences.

c) Decrees and regulations

The Railways Act is set out in greater detail in a number of decrees and regulations. The sections of the decrees and regulations relevant to this investigation are examined below.

27 Section 27 (2a) of the Railways Act.
28 Section 27 (2b) of the Railways Act.
29 Section 32 (1b) of the Railways Act.
30 Section 33 (2) of the Railways Act.
31 Sections 49 and 50 of the Railways Act.
32 Section 36 of the Railways Act.
33 Ministry of Transport, Public Works and Water Management, Veiligheid op de rails (Rail Safety). Second rail safety framework policy document, November 2004 (Lower House of Dutch Parliament, session year 2004-2005, 29 893, nos. 1 and 2); Ministry of Transport, Public Works and Water Management, Veilig vervoeren, veilig werken, veilig leven met spoor (Safe carriage, safety at work, living safely with the railways). Third rail safety framework policy document, June 2010 (Lower House of Dutch Parliament, session year 2009-2010, 29 893, no. 106).
34 As low as reasonably practicable.

c1) Network Infrastructure Decree and Regulations
The Decree primarily contains provisions relating to the inspection, certification, maintenance and repair of the network infrastructure and the protection of the network and its environment. The Regulations describe aspects such as the basic technical requirements that the network infrastructure and rail vehicles are required to meet.

Among other things, the Regulations stipulate that the network infrastructure[35] safety system must guarantee separate routes for trains.[36] They also stipulate that the safe condition of the routes must be communicated to train drivers by means of signals or cabin signals.[37] The Regulations furthermore prescribe that the railway network must be equipped with a train protection system that transmits information about the applicable signal images to rail vehicles (the minimum functionality of which system must correspond with that of the First Generation ATB system, ATB-EG).[38]

c2) Rail Vehicle Inspection Decree and Regulations
The Rail Vehicle Inspection Regulations (*Regeling Keuring Spoorvoertuigen,* RKS) set out requirements that rail vehicles must meet in order to obtain a deployment certificate. One of the provisions of the Regulations stipulates that self-propelled rail vehicles (such as locomotives, trains, cab control cars and special vehicles[39]) must be equipped with an Automatic Train Protection System (ATB) having the minimum functionality of ATB-EG.

c3) Operating and Safety Certificate (Main Railways) Decree and Regulations
The Decree stipulates further rules for the operating licence and the safety certificate. The operating licence regulates access to the profession of railway operator. This licence alone does not provide access to the rail network. The Railways Act contains additional conditions, including possession of a safety certificate. The operating licence and the safety certificate both incorporate safety requirements. The difference between the two is that the safety requirements stipulated in the operating licence relate mainly to the railway company's internal organisation, whereas the safety requirements in the safety certificate are geared towards safe participation in day-to-day rail traffic.

The (Main Railways) Safety Certificate Regulations further specify a number of provisions relating to the assessment and issue of the mandatory safety certificate for railway companies.

c4) Railway Personnel Decree and Regulations
The Decree stipulates that rail vehicle drivers must fulfil a number of requirements in respect of general knowledge and professional competence.[40] One of these requirements is that train drivers must have adequate route knowledge. The criteria and the assessment thereof have not been specified in detail. Another person who has adequate knowledge of the vehicle's operation in order to operate it is permitted to operate the vehicle based on the directions given by the train driver. In such cases, the train driver 'piloting' the vehicle must be able to intervene in the operation of the vehicle. The Decree furthermore imposes requirements on medical and psychological suitability, the company pass and business operations as well as on the organisational structure.

The Railway Personnel Regulations set out in detail four topics provided for in the Railway Personnel Decree, namely the assessment procedure, medical and psychological requirements and the practical programme for trainee train drivers. These Regulations do not include route knowledge.

35 Section 7 (1) of the Railways Act stipulates that main railways permitting speeds exceeding 40km/h must be equipped with a safety system.
36 Section 13 (1) Network Infrastructure Regulations.
37 Section 13 (2) Network Infrastructure Regulations.
38 Section 14 Network Infrastructure Regulations.
39 In this context 'special vehicles' also mean historic locomotives and self-propelled maintenance equipment, such as the rail grinding train in this investigation.
40 Article 24 of the Railway Personnel Decree.

c5) Rail Traffic Decree and Regulations

The Rail Traffic Decree and Regulations contain further provisions relating to the safe and undisturbed use of the network infrastructure. These cover aspects such as train composition, driving speeds and the placement of signals. For the purpose of this investigation, two aspects are important. They are as follows:

- The Regulations generally explain in which situations the manager (ProRail) must place signals and signs, and provide rules concerning their mutual relationship. Appendix 4 of the Regulations contains more information on the nature, implementation and meaning of the different signals and signs. The approach marker (keperbaak) is examined in the Chapter on 'signals additional to light signals'.
- The Regulations furthermore stipulate[41] that railway companies must take measures to ensure that there is no risk that the train driver's attention will be diverted from the traffic. To that end, the railway companies are entitled to decide who may be in the driver's cabin apart from the train driver.

3.1.2 Working conditions legislation

Working conditions legislation comprises of the Working Conditions Act (*Arbeidsomstandighedenwet*), a General Order in Council (the Working Conditions Decree, *Arbobesluit*) and ministerial regulations (the Working Conditions Provisions, *Arboregeling*). The Working Conditions Act is a framework act that provides employers and employees with a statutory framework for promoting employee health and safety. The Act applies to the relationship between the employer and the employee, whereby the relationship of authority is the determining factor rather than whether the employee is employed by the employer and receives a salary. In addition, the Working Conditions Act sets out the safety at work responsibilities of the commissioning party and the contractor(s) when work is contracted out[42]. The Working Conditions Act has been set out in detail in the Working Conditions Decree and in the Working Conditions Provisions.

The following sections of the Working Conditions Act are relevant to this investigation:

- *Working conditions policy*: employers are required to pursue a working conditions policy that is as sound as possible. Given the prevailing state of knowledge, the work must be organized in such a way that it does not have any adverse effects on employee health and safety as far as is reasonably possible. In this context the employer is obliged to prevent or limit the dangers and risks at source as far as possible.[43]
- *Risk Inventory and Evaluation*: employers are required to conduct a risk inventory and evaluation (RI&E), which must be laid down in writing. This must include a description of the risk control measures as well as an action plan (including a time period) for resolving any shortcomings.[44]
- *Information and instruction*: employers must ensure that employees are properly informed about the work to be carried out and the related risks, and about the measures aimed at preventing or limiting those risks.[45]
- *Employee obligations*: in respect of their activities at the work place, and in line with the education/training and instructions, employees are obliged to ensure their own health and safety as well as the health and safety of other persons to the best of their ability.[46]
- *Various employers*[47]: if several employers are involved in the work at a temporary or mobile[48] work site, they are required to cooperate effectively to ensure compliance with the Working Conditions Act.

41 Section 36 of the Rail Traffic Regulations.
42 The regulations concerning the responsibilities of commissioning parties and contractors relate to temporary and mobile construction sites, see Articles 2.23 through 2.35 of the Working Conditions Decree.
43 Section 3 of the Working Conditions Act.
44 Section 5 of the Working Conditions Act.
45 Section 8 of the Working Conditions Act.
46 Section 11 of the Working Conditions Act.
47 Section 19 of the Working Conditions Act.
48 Articles 2.23 through 2.35 of Section 5 of the Working Conditions Decree.

- *Health and Safety Plan*: pursuant to the Working Conditions Decree, a Health and Safety Plan (*V&G-plan*) must be drawn up[49] for projects involving particular risks[50] or for extensive projects.[51] This obligation applied due to the scale of the rail grinding project, in which context the train journey took place. The commissioning party[52] must ensure that a Health and Safety Plan - Design Phase (*V&G-plan Ontwerp*) is drawn up, which must subsequently be elaborated in a Health and Safety Plan - Construction Phase (*V&G-plan Uitvoering*) by the contractor(s). The Health and Safety Plan must at least include the following:[53]
  - a description of the project, a list of the companies involved and the coordinator responsible for the design and construction phase;
  - an analysis of the dangers arising specifically as a result of simultaneous or consecutive activities;
  - the measures taken based on the above risk analysis and the agreements made in this context;
  - the manner in which supervision of those measures is performed;
  - the choices made in the design phase from a construction, technical and organisational point of view in connection with the health and safety of the employees;
  - the manner in which information and instructions are given to the employees.

3.2 Sector regulations

In addition to the above laws and regulations, additional regulations have been drawn up in the railway sector for controlling the risks involved in rail traffic. For the purpose of this investigation, the Safety at Work Standards Framework (*Normenkader Veilig Werken, NVW*) published by the railAlert Foundation (*stichting railAlert*), the ProRail regulations for the use of signals and signs, and the Handbook for the Transportation Process published by the Dutch Association for Railway Documentation (VSD) are particularly relevant. These are examined in detail below.

3.2.1 Safety at Work Standards Framework

The Safety at Work Standards Framework (NVW) further elaborates the safety regulations for working on the railway infrastructure pursuant to the Railways Act and the Working Conditions Act. The NVW has in turn been further elaborated in the Safety at Work Regulations (*Voorschrift Veilig Werken,* VVW) and various sector guidelines. These sector regulations are administered by the railAlert Foundation (see under 4.2).

The NVW and the underlying regulations regulate the relationship between and the responsibilities of the companies involved in terms of safety at work. The regulations apply to all commissioning parties and contractors/employees who perform or who arrange for the performance of process and project-based work within the context of ProRail's infrastructure management function. The NVW states that the deployment of people and equipment as well as the supply and removal thereof fall under the scope of the NVW. This literally means that the NVW also applies to transfer journeys carried out by rail grinding trains and other self-propelled maintenance equipment. The relevant regulations in this area, however, are unclear, see 5.4.1.

The basic principle of the NVW and the underlying regulations is that the companies must apply the principles of occupational hygiene strategy with respect to the safety of employees at work. In short, the principles imply that the dangers and risks must be tackled at the source (by preventing or eliminating them) and that effective control measures must otherwise be taken, with collective

49 Article 2.28 of the Working Conditions Decree, Section on the Construction Process.
50 This relates to projects involving particular risks as referred to in Directive 92/57/EEC, Annex II, which states which types of construction work are classed as high-risk. This includes work involving particular risks, (such as diving and working with explosives), or working at dangerous locations.
51 Article 2.27 states that this relates to construction work expected to cover more than 30 working days, with more than 20 employees carrying out activities simultaneously at the construction site, or construction work that will involve more than 500 man days.
52 According to Article 1.1 (2c) in this context the commissioning party is defined as the person bearing the costs of the construction work.
53 Article 2.28 of the Working Conditions Decree.

measures taking precedence over individual measures. The regulations stipulate that the principle of reasonableness applies to the required level of safety, according to which principle a decision to apply a lower level of safety may only be based on well-founded technical, operational or economic[54] arguments.

The duties and responsibilities of the commissioning party and the contractor are described as follows in the NVW:

- *The commissioning party* must ensure the following:
  - that the risks on which the company can exercise influence have been removed/controlled;
  - that the control measures to be taken or the level of safety to be achieved, based on a risk analysis, have been established;
  - that a Health and Safety Plan - Design Phase has been drawn up and provided to the contractor;
  - supervision of the entire process (including the activities performed by the contractor) by means of audits and inspections among other things;
  - that a Health and Safety coordinator has been appointed (if several parties are involved).
- *The contractor* must ensure the following:
  - that the control measures have been specified and implemented, based on a risk analysis;
  - that a Health and Safety Plan - Construction Phase has been drawn up;
  - the availability of its own Health and Safety coordinator.

The contracts between the commissioning party and the contractor must stipulate that the NVW applies, as a result of which compliance with the NVW is intrinsically linked to the agreements. A further key aspect is that both the commissioning party and the contractor must actively work towards improvement.

3.2.2 Use of signals/signs

As previously stated under 3.1.1, the Rail Traffic Regulations stipulate in which situations ProRail is required to place signals and signs, what their mutual relationship is required to be and what they mean. In the implementation thereof, ProRail applies design, adjustment and measurement regulations. The regulations on placing and adjusting signals are incorporated in Infrastructure Design Regulation 6000 'General Regulations for Signalling Devices' (*Ontwerpvoorschrift 6000 'Algemene Voorschriften Seintechnische installaties*). The regulations do not contain any specific rules relating to the application/placement of the approach marker (*keperbaak*).

3.2.3 Handbook for the Transportation Process

The Handbook for the Transportation Process describes the various safety functions and the associated duties and responsibilities set out in Railway legislation. The handbook is published by the Dutch Association for Railway Regulations and Documentation (VSD, see under 4.2).

3.3 Safety management

The Dutch Safety Board has formulated five criteria for the purpose of assessing the quality of the safety management system of the parties involved in the incident investigated. These have been set out in a reference framework that the Safety Board applies to all of its investigations. As regards rail accidents, the criteria defined by the Safety Board are largely consistent with the requirements imposed on the companies' safety management systems under the current laws and regulations (Railways Act, Working Conditions Act and the corresponding regulations). These requirements were previously described in section 3.1. For the sake of completeness, the reference framework applied by the Safety Board is set out below in full.

54 Potential measures relating to the risk of carcinogens and biological agents may only be omitted if it is technically impossible to implement such measures.

The reference framework applied by the Safety Board contains the following issues requiring attention:

- *Insight into risks as a basis for the safety strategy*
  The starting point for achieving the required level of safety is to conduct a review of the system, followed by an assessment of the associated risks. This serves as a basis for establishing which hazards need to be managed and which preventive and repressive measures should be taken to achieve this.
- *Demonstrable and realistic safety strategy*
  In order to prevent and manage undesirable events, a realistic and practicable safety strategy or safety policy, including the associated starting points, should be defined. This safety strategy should be adopted and controlled at management level, and is based on the following: (a) the relevant current laws and regulations, and (b) the applicable industry standards, guidelines and best practices, the organisation's own views and experiences and the safety objectives drawn up specifically for that organisation.
- Implementing and enforcing the safety strategy
  The safety strategy has been implemented and is enforced, and the identified risks are managed by means of the following:
  - a description of the way in which the defined safety strategy is implemented, focusing on the specific objectives and plans, including the resulting preventive and repressive measures;
  - a division of responsibilities for safety in practice with regard to the implementation and enforcement of safety plans and measures that is transparent, consistent and accessible for everyone;
  - a clear definition of the required staff and necessary expertise in the various roles;
  - clear and active central coordination of safety activities.
- *Tightening the safety strategy*
  The safety strategy should be continuously assessed and tightened up based on the following:
  - periodic risk analyses, observation rounds, inspections and audits, which activities should in any event be performed whenever changes to basic principles are made (proactive approach);
  - a system for monitoring and investigating incidents, near accidents and accidents as well as an expert analysis of these accidents (reactive approach). This will serve as a basis for carrying out evaluations (that will bring to light improvement areas which can be actively managed) and for making adjustments to the safety strategy by management, where applicable.
- Guidance provided by management, commitment and communication
  The management of the parties and organisations involved should ensure the following:
  - that internal expectations in relation to safety objectives are clear and realistic, and to guarantee a climate of continuous safety improvements in practice, in any event by leading by example and, to conclude, by making available a sufficient number of people and resources for this purpose;
  - clear external communications regarding the general procedures, how these are assessed, procedures to be used in the event of deviations and so on, based on clearly defined and documented arrangements with the community.

4 PARTIES AND RESPONSIBILITIES

This chapter describes which parties were involved in the Stavoren accident and their roles and responsibilities. A distinction has been made between *companies* (4.1), *umbrella organisations* (4.2) and *government bodies* (4.3).

4.1 Companies

The self-propelled rail grinding train involved in the accident at Stavoren was en route to the deployment area. This particular train should therefore be viewed from both a railway safety and a safety at work perspective, because the train was participating in rail traffic and in the rail grinding project.

Rail traffic
The rail grinding train is owned by *Speno International*, a foreign, specialist rail grinding company. The relevant transfer journey carried out by the rail grinding train took place 'under the flag' or formal responsibility of *BAM Rail*. This company is a railway contractor established in the Netherlands, which is also recognized as a railway company (and as a result is authorized to operate trains). BAM Rail also submitted the application for the train journey to the railway infrastructure manager (ProRail).

The train journey was piloted: the train was operated by an Italian vehicle operator employed by Speno and was 'piloted' by a Dutch train driver. The train driver involved was fully qualified. He was employed by *Spoorflex*[55] (an employment agency of rail personnel recognized by IVW) and hired in by BAM Rail.

The management of the relevant line had been contracted out to *ProRail* by means of a management concession. In addition to ensuring the safe condition (maintenance) of the track, ProRail had approved the capacity request for the train journey and for taking the railway track out of service (scheduled timetable), and was responsible for conducting train traffic control.

Section 3.1.1 describes the legislative requirements for managing the safety risks involved in train journeys. The essence thereof is that the risk management responsibility lies with the infrastructure manager and the transport operator (in this case ProRail and BAM Rail). They are required to ensure that the risks have been reduced to ALARP level by ensuring that appropriate measures have been taken based on an adequate RI&E. In addition, two other companies were involved in the accident at Stavoren and are jointly responsible, namely the owner of the rail grinding train (Speno) and the employment agency (Spoorflex). Legislation prescribes that these two companies must ensure that the equipment and technical condition of the rail grinding train, and the train driver's level of education, training and experience, respectively, fulfil the criteria.

55 A few weeks after the Stavoren accident, Spoorflex applied for a moratorium; the company has meanwhile been declared bankrupt.

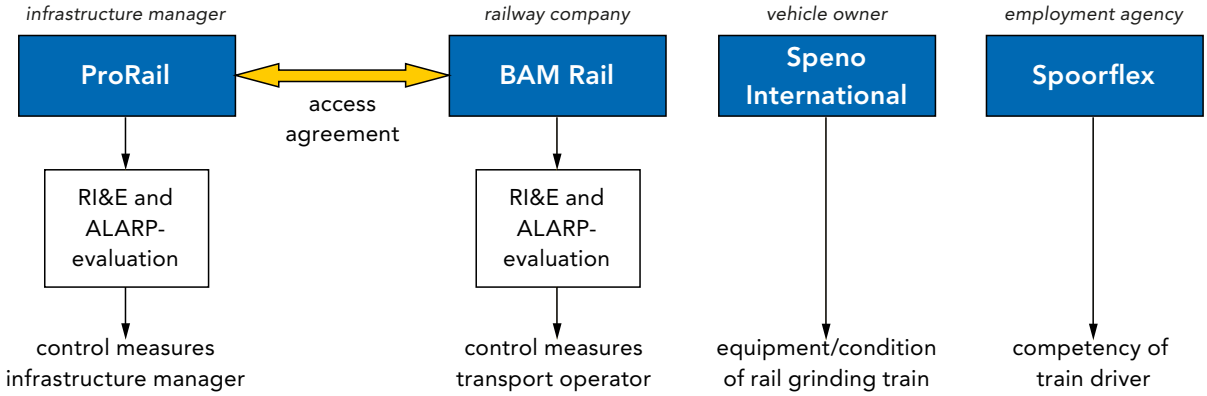


Figure 11: Diagram showing the responsibilities pursuant to the Railways Act.

Rail grinding project

The relevant train journey took place in connection with rail grinding activities that were to be performed later that night, which in turn formed part of an extensive rail grinding project *commissioned by* ProRail. ProRail contracted out the rail grinding project by means of a European tendering procedure. Speno and BAM Rail jointly submitted a tender which took the form of a 'contractors' consortium'.[56] The tendering procedure took place in 2007, as a result of which the rail grinding activities for the period 2008-2011 were awarded to Speno (as the *principal contractor*) and BAM Rail (as the *subcontractor*). For the purpose of the commission, Speno and BAM Rail entered into a collaboration agreement in which it was agreed, among other things, that BAM Rail would carry out the transfer journeys, including planning and submitting applications for journeys as well as providing a qualified train driver.

As previously stated, the train driver involved in the accident had been hired in by BAM Rail from an *employment agency* (Spoorflex). BAM Rail also hired in other staff and services from Spoorflex in connection with the rail grinding activities. The diagram in figure 12 shows the relationships between the companies involved. As indicated by the yellow arrows in the diagram below, the following three 'contracts' applied: a framework agreement between ProRail (the commissioning party) and Speno (the principal contractor), a collaboration agreement between Speno (the principal contractor) and BAM Rail (the subcontractor), and an agreement between BAM Rail and Spoorflex for hiring in staff and services.

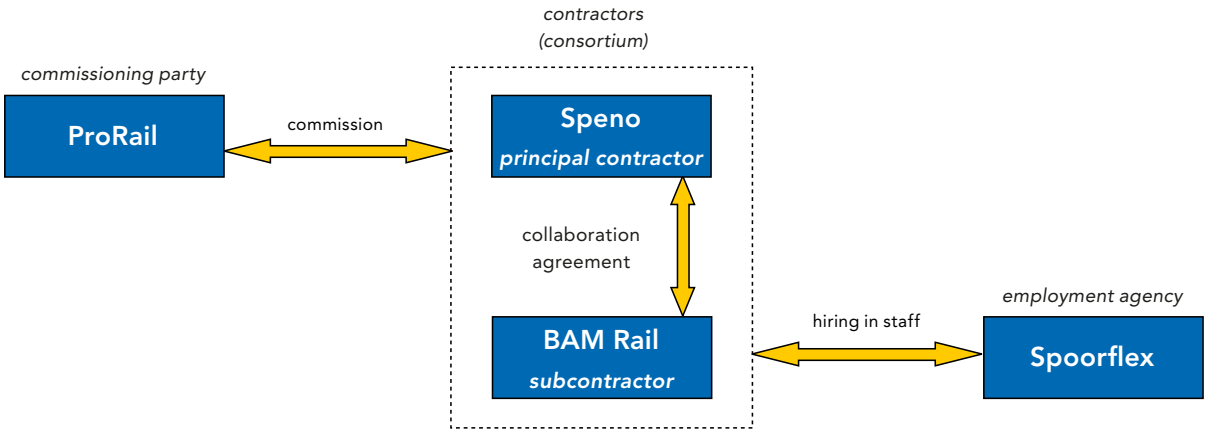


Figure 12: Diagram of the companies involved and their respective roles in the 'rail grinding project'.

56 A 'contractors' consortium' refers to contracting out work to a consortium of parties, in which one party acts as the principal contractor, and one or more other parties act as subcontractors.

Sections 3.1.2 and 3.2.1 describe the requirements with which the companies involved must comply pursuant to working conditions legislation and the accompanying sector regulations in respect of rail infrastructure maintenance work that has been contracted out. The essence thereof is shown in the diagram in figure 13, and can be summarized as follows:

- The *commissioning party* (in this case ProRail) must carry out the following:
  - perform an inventory/analysis of the risks and assess the required measures (to be documented in a Health and Safety Plan (*V&G-plan*);
  - remove/control the risks on which the company can exercise influence;
  - the general coordination and overall supervision of Health and Safety activities.
- The *contractors* (in this case the principal contractor Speno, subcontractor BAM Rail and subcontractor Spoorflex) must carry out the following:
  - within the context of the Health and Safety Plan - Design Phase and based on their own assessment/analysis of the risks, stipulate control measures (and document these in a Health and Safety Plan - Construction Phase (*V&G-plan Uitvoering*);
  - the coordination and implementation of control measures.

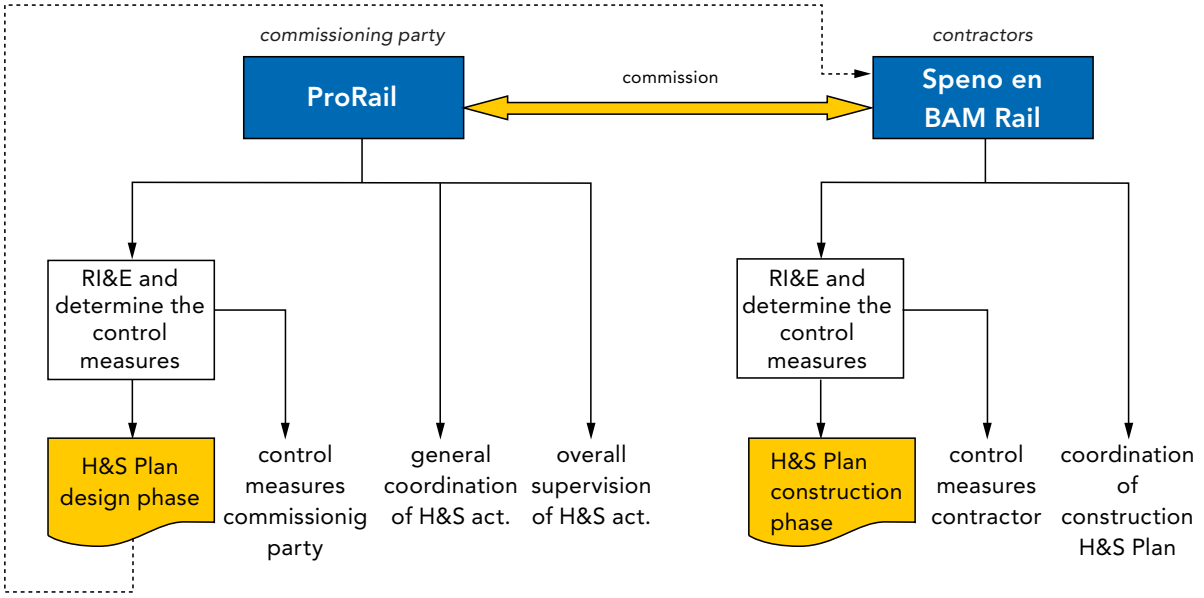


Figure 13: Responsibilities relating to work contracted out

Roles and responsibilities of the companies involved

The above means that the roles and responsibilities of the companies involved should be viewed from both the perspective of railway safety and safety at work. The table below shows the roles and responsibilities of the four companies involved in the accident in Stavoren.

Company	Roles and responsibilities from a railway safety perspective	Roles and responsibilities from a safety at work perspective
ProRail	INFRASTRUCTURE MANAGER • Ensure safe railway infrastructure that is in good condition, the safe allocation of capacity and train traffic control; • ALARP control of the risks associated with the management and use of the railway network.	COMMISSIONING PARTY • Draw up the Health and Safety Plan - Design Phase based on a risk analysis and determine the control measures; • Implement the commissioning party's share of the control measures; • Assess and select contractors; • General coordination and overall supervision of Health and Safety measures.
Speno	OWNER OF THE RAIL GRINDING TRAIN • Ensure the availability of the prescribed equipment and ensure the technical condition of the rail grinding train.	• CONTRACTORS (with Speno being the principal contractor and BAM Rail the subcontractor) • Draw up the Health and Safety Plan - Construction Phase based on the Design Plan, their own risk analysis and determine the control measures; • Implement the contractor's share of the control measures; • Coordinate the implementation of the Health and Safety control measures.
BAM Rail	RAILWAY COMPANY • ALARP control of the risks involved in the train journey; • Ensure that the train driver and vehicle operator receive adequate education and training.	
Spoorflex	EMPLOYMENT AGENCY • Ensure that the train driver receives adequate education and training.	CONTRACTOR • Ensure that own staff implement the control measures.

It should be noted that the Railways Act and Working Conditions Act overlap in this particular case. This is due to the nature of the activities carried out at the time of the accident, i.e. a train journey. In that light, pursuant to two different Acts, ProRail (as the manager of the railway infrastructure and the party commissioning the rail grinding project) and BAM Rail (as the official transport operator performing the train journey, and contractor performing the rail grinding project) were mainly responsible for controlling the same safety risks, namely the risks involved in the relevant transfer journey carried out by the rail grinding train.

4.2 Umbrella organisations

In the context of the accident in Stavoren, the following two umbrella organisations are relevant:

- railAlert Foundation, which administers the sector's Safety at Work regulations for work carried out on railway infrastructure (the Safety at Work Standards Framework (*Normenkader Veilig Werken*, NVW) and Safety at Work Regulations (*Voorschrift Veilig Werken*, VVW), see 3.2.1). The relevant companies (ProRail, the railway contractors and the civil engineers) are members of the Foundation as are the relevant inspectorates (the Health and Safety Inspectorate and the Transport, Public Works and Water Management Inspectorate, IVW).
- On behalf of its members the Dutch Association of Railways Regulations and Documentation (*Vereniging Spoorwegregelgeving en Documentatie*, VSD) manages, maintains, updates, amends and makes changes to the Handbook for the Transportation Process (*Handboek Vervoersproces*), see 3.2.3. The Association's members are mainly transport companies, contractors, security companies and employment agencies operating in the railway sector.

4.3 Government bodies

The diagram below shows the government bodies that were involved in the accident and their respective roles.

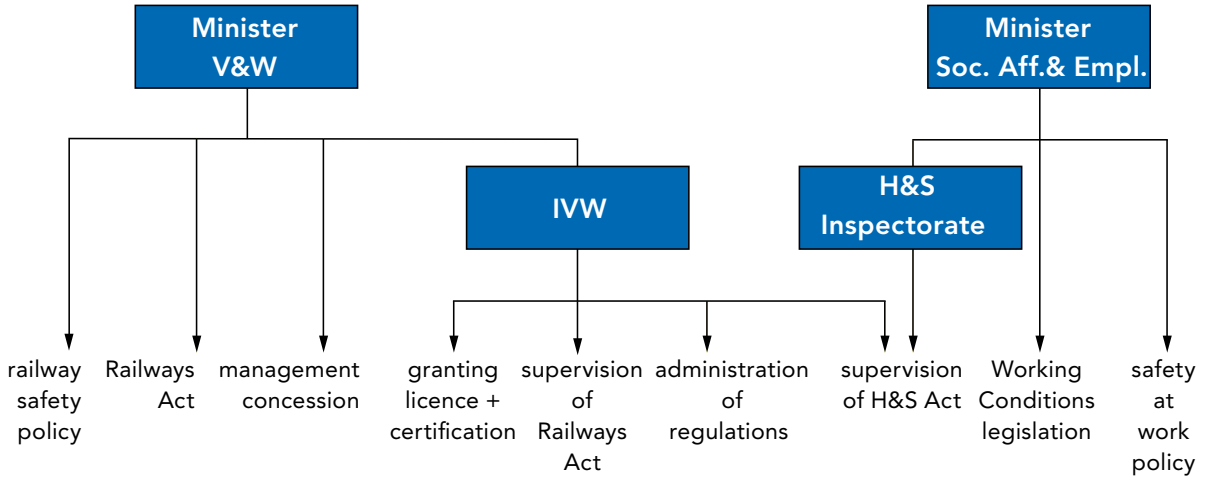


Figure 14: Diagram showing the government bodies involved and their respective roles

Further details of the tasks and responsibilities of the above bodies are given below. In line with the earlier description of the companies' responsibilities, a distinction has been made between railway safety and safety at work.

a) Railway safety

The responsibility for the railway safety system lies with the Minister of Transport, Public Works and Water Management.[57] This means that the Minister is responsible for formulating policy, the operation of legal frameworks, initiating new laws and regulations, and for establishing, organising and performing the supervision of railway safety.[58] The Minister is also responsible for granting licences and certificates. In this particular investigation this involves approving ProRail's Safety Management System, granting BAM Rail a safety certificate, certification of Spoorflex as an approved employment agency and granting the rail grinding train a deployment certificate. The Minister of Transport, Public Works and Water Management is also responsible for establishing frameworks for managing and maintaining the main railway infrastructure. These frameworks have been stipulated in the concession granted by the Minister to the infrastructure manager (ProRail).

The Transport, Public Works and Water Management Inspectorate (IVW) supervises compliance with the Railways Act and grants licences/certificates on behalf of the Minister. In addition, effective 2006 IVW became the designated National Safety Authority (NSA).[59] Apart from granting licences/certification and performing enforcement, in the above capacity IVW's duties include administering/developing the regulatory framework and the railway safety regulations.

b) Safety at Work

The Minister of Social Affairs and Employment is responsible for safety at work policy and legislation and for supervising compliance thereof. The Health and Safety Inspectorate is charged with the supervision/enforcement of the Working Conditions Act under the Minister's responsibility. Effective 1 January 2010, IVW is jointly authorized to perform supervision on 'the occupational risk of being involved in a collision while working on the railway tracks'.

57 The name of the portfolio was changed to 'Infrastructure and the Environment' on 14 October 2010. This report uses the name of the portfolio that applied at the time of the incident, which is 'Transport, Public Works and Water Management'.

58 Ministry of Transport, Public Works and Water Management. Third railway safety framework policy document, June 2010, page 24.

59 Among other things, the Railway Safety Directive prescribes that all EU Member States must establish a safety body. Effective 21 December 2006, IVW was designated as the Dutch safety body within the meaning of the Railway Safety Directive.

5 ANALYSIS

5.1 Research questions

The key question in this investigation is: *What lessons can be learned from the accident in Stavoren in terms of risk management during transfer journeys by carried out by rail grinding trains, the relevant regulations and supervision thereof?*

This key question was elaborated in five research questions, based on the following considerations:

- In accordance with standard Safety Board investigation procedure, this investigation is based on an assessment of the immediate causes of the accident and the underlying factors that played a role in this context. In assessing these underlying factors, it is essential to determine whether these factors are unique to the accident or of a more structural nature.
- In assessing the relevant risk management measures, it is important to determine why the companies involved did not identify the underlying causes in advance and take effective control measures. Current laws and regulations are also relevant in this regard, as is government compliance monitoring.
- The train journey was noteworthy in that it took place as a part of railway infrastructure maintenance work that had been contracted out by the infrastructure manager. It is thus important to determine to which extent the contracting out of maintenance work played a role in the failure of risk management measures.

The five research questions are as follows:

1. *What were the immediate causes of the accident and what are the underlying factors that played a role in this context?*
2. *To what extent are the underlying factors unique to this accident?*
3. *What procedures did the companies follow in managing the safety risks during the transfer journeys carried out by the rail grinding trains and to what extent have the companies fulfilled their own responsibilities in this respect?*
   a. *To what extent did the companies involved take stock of the safety risks relating to transfer journeys carried out by rail grinding trains?*
   b. *How did the companies involved deal with these risks, and what role did current laws and regulations play in this regard?*
   c. *To what extent have the companies involved learned lessons from comparable incidents in the past?*
   d. *What role did risk management of the transfer journeys play in the outsourcing process, and what role did this approach play in the failure of risk management?*
4. *To what extent has the government monitored compliance with the relevant legislation?*
5. *What measures have the companies involved and the government taken as a result of the accident in Stavoren?*

5.2 Research question 1: Immediate causes and underlying factors

The relevant causes and underlying factors were ordered on the basis of the Tripod analysis described in Appendix 1.

5.2.1 Immediate causes

The immediate cause of the train accident in Stavoren lies in the fact that the brakes were applied too late. The train was travelling at a speed of approximately 95km/h, which normally corresponds with a braking distance of about 800-1000 metres. However, the brakes were not applied until the train was about 150 metres from the buffer stop. This conclusion is based on an analysis of the rail grinding train's automatic trip registration system records (see Appendix 3). This course of events was confirmed by the vehicle operator and the (pilot) train driver. The investigation of the rail grinding train and railway infrastructure (see Appendix 3) has shown that there was no brake system malfunction and that the rails were not slippery.

Three safety measures were in place to ensure that the train would halt on time, but they could not prevent the rail grinding train at Stavoren from crashing against the buffer stop at high speed. These three measures - and their failure to prevent the collision - are explained in further detail below.

- *Signal compliance by train driver*
  The track section had been fitted with a signalling system. A signalling system is a network of (light) signals and signs with unique, clearly defined meanings. Drivers must adhere to these signals and signs at all times. Proper adherence to the signalling system will ensure that trains stop on time at dangerous locations. In order for the system to function properly, it is essential that the infrastructure manager correctly installs and maintains the signals and signs so that they can be noticed on time and interpreted accurately by the train drivers. In order for the train to come to a timely standstill through normal braking, the brake system should have been activated at eight hundred to one thousand metres distance from the Stavoren station. To this end, a signal had been installed alongside the rails at twelve hundred meters from the station. This signal had the following meaning: brake until the train reaches a speed of 40 km/h (or less if necessary) so that the train can come to a standstill at the next signal. However, the signal - consisting of three signs (jointly referred to as approach marker) – was not noticed by the train driver or the train driver failed to recognise its significance. As a result, the brake system was not engaged on time, and actual braking was not initiated until the train was about 150 metres from the buffer stop.

- *Supervison of signal compliance by Automatic Train Protection*
  The track section had been fitted with an Automatic Train Protection system. This system gathers information at certain points along the railway network in order to determine which track sections are safe and with which speed they can be passed, and transmits this information to the train's Automatic Train Protection system. Under normal circumstances, the Automatic Train Protection system sends an alert to the train driver if the train is travelling too fast or the brake system is activated too late. If the train driver does not respond to the alert, the system will intervene and automatically activate the emergency brakes. However, this will only work if the ATB system along the route is communicating normally with the Automatic Train Protection system in the train. However: the track section between Leeuwarden and Stavoren is fitted with ATB-NG, whereas the rail grinding train (only) had an ATB-E system, which is not compatible with ATB-NG. As a result, the train driver did not receive an automatic alert upon passing the approach marker, and the brakes were not automatically activated when the driver failed to brake manually.

- *ATB speed reduction monitoring*
  The rail grinding train was fitted with ATB-E, which is configured to automatically activate the brakes if no ATB-EG signal is being transmitted from the railway network and the train's speed exceeds 40 km/h. This speed reduction function was not activated, because the trainborne ATB equipment had been automatically switched to offline mode by the ATB switch off section at the start of the line.

5.2.2 Underlying factors

The section below outlines the underlying factors that played a role in the failure of the above three safety measures.

Reason for train driver's failure to comply with signalling system

The signalling system failed, in the sense that the approach marker signalling that the train was approaching Stavoren and needed to brake did not result in application of the brake system. This is due to the fact that the rail grinding train driver either did not notice the approach marker or failed to realize its significance, namely the need to brake. The following five aspects played a role in this regard: 1) the train driver expected a different type of signal, 2) this type of approach marker is uncommon, and the train driver did not feel it deserved a great deal of attention, 3) the approach marker was only visible for a relatively short period of time and was not highly noticeable, 4) the train driver was distracted from his driving duties at the time and 5) it was difficult for the train driver to determine the train's position on the basis of the location markers. These five aspects will be explained in further detail below.

1) The train driver did not expect the approach marker
The rail grinding train driver had inaccurate expectations regarding the signalling system. As a result, he was looking for a speed reduction sign and was not focused on the approach marker. He was unfamiliar with the track section, and had consulted a track layout plan that did not correspond with the actual situation. Based on the track layout plan, he expected to see two speed signs along the railway line just before entering Stavoren. According to the track layout plan, these signs would signal a speed reduction to 40 km/h and a maximum speed of 40km/h, respectively. These signs had been in position in the past, but were removed in 2006. The train driver stated that he aimed to use the speed signs as a point of reference for his 'approach to Stavoren'. The train driver did not focus on the approach marker itself, which was also indicated on the track layout plan. Approach markers - as will be explained in further detail in section 2 – are not commonly used, and the train driver had little to no experience in reading them. These factors may also have played a role in this regard. The fact that the train driver was 'looking for' a speed sign may have played a role in his failure to (consciously) notice the marker. This phenomenon (whereby people fail to notice one thing because they are looking for another) is referred to as inattentional blindness.

According to the investigation results, the following aspects played a role in this regard:

- *Train driver's lack of familiarity with the route*
  The train driver was deployed to drive rail grinding trains throughout the Netherlands. As a result, the frequency with which he visited certain track sections (especially on the secondary lines) was low. The train driver's route knowledge had been tested by the manager responsible for his deployment and performance (from Spoorflex). However, when questioned by the Dutch Safety Board, the manager was unable to demonstrate that he himself was familiar with the relevant track section. It should be pointed out that the driver's route knowledge is usually tested by a manager from the transport operator which regularly uses the track section. No such testing was conducted in this case. In addition, it could not be demonstrated that the train driver had 'maintained' sufficient route knowledge. According to the applicable standard, train drivers are expected to use a track section at least once every twelve months. According to the administrative records, it had been 14 months since the train driver was deployed to the Leeuwarden-Stavoren track section. The train driver stated that he had travelled on the track section in a passenger train approximately six months before the accident, but this information was not confirmed. Clearly, train driver's demonstrable failure to meet the standard for (maintaining) route knowledge did not prevent either Spoorflex (as the employer) or BAM Rail (as the formal transport operator) from deploying the driver in question on the journey.
- *Error in track layout plan*
  The train driver prepared for the transfer journey by consulting a track layout plan of the route and signalling system issued to him in aid of the rail grinding activities to be conducted later that night.[60] The train driver compared the visual instructions with the route directions, a diagram of the route section intended for train drivers issued by ProRail. The visual instructions and the track directions provided the same information about the situation at Stavoren. Both track layout plans, however, contained an error, i.e. they erroneously showed speed signs shortly before Stavoren. The error was also found in the official ProRail track layout plan on which the visual instructions and route directions were based. The error occurred during the digitisation process conducted by ProRail around 2005. This process involved the scanning and digitisation of all track layout plans that were still unavailable in digital format. The scan for the Leeuwarden-Stavoren track section was erroneously based on an outdated track layout plan which still featured the removed speed signs. This error had not yet come to light. This was partly due to the fact that the scanned track layout plans had not been subjected to any systematic checks, and no major work (involving the use of these track layout plans) had been conducted on the track section in the past few years.
- *Last-minute changes to work plan*
  The planning schedule for the rail grinding activities was changed during the transfer journey. According to the original work plan, the rail grinding activities were to be conducted in the direction Sneek à Stavoren. Under the amended plan, this direction was reversed. As a result, the first half of the transfer journey ended at the final part of the line (in Stavoren) rather than

60 Although the relevant visual instructions had been derived from the official ProRail track layout plan, officially it was not intended to be used to 'refresh the train driver's route knowledge'.

halfway along the route (in Sneek). According to the original plan, the train driver was not required to prepare for the final part of the journey. The train driver had in fact familiarised himself with the final section of the route (Sneek-Stavoren) but to a lesser extent than with the first section of the route (Leeuwarden-Sneek).

2) Approach markers are an unusual type of signal
There was no light signal before Stavoren, as would normally have been the case. Instead of a signal, an approach marker had been positioned at approximately 1200 metres from the end of the railway track. An approach marker has the same significance as an amber light signal (brake to a speed of 40 km/h or less in order to ensure that the train can be brought to a standstill before the next signal set at danger appears). However, there is one key difference between the two: all train drivers encounter amber light signals with great regularity, whereas most (including the train driver in question) hardly ever encounter an approach marker. This is due to the fact that there are over ten thousand light signals on the Dutch railway network, while the number of locations with an approach marker is highly limited (20). In addition, all these approach markers are located along track sections that most train drivers (including the train driver in question) have rarely or never used. This explains why the training programme for train drivers barely devotes any attention to approach markers, and most drivers never come across one during their work. As a result, most train drivers will not devote a great deal of attention to an approach marker if they encounter one in practice. Most train drivers (and this may also apply to the Italian vehicle operator involved in this accident) tend to devote a great deal of attention to amber light signals, as they are generally followed by a signal set at danger. Experienced train drivers will almost automatically (routinely) start braking as soon as they see one. Responding appropriately to an approach marker, however, requires a greater mental effort, a factor that may have reinforced the above inattentional blindness.

3) The approach marker was only briefly visible
Like all other approach markers, the marker at Stavoren has not been fitted with any lighting. As a result, the marker was only visible (at night, that is) during the relatively short period in which it was illuminated by the train's headlights. If we take into account that the rail grinding train was travelling at approximately 100km/h and was – according to the train driver – using dipped headlights, this period probably lasted less than ten seconds. A light signal that emitted light of its own accord would have been visible from a greater distance and would thus be noticeable for a longer period of time (ten to twenty seconds).

4) The train driver was distracted
Shortly before the accident, the train driver was unable to devote his full attention to the signals. Around the time the train approached and passed the marker, the train driver was looking at documentation and consulting with a member of the rail grinding train crew. As a result, he was less focused on the route ahead. This made it less likely that he would realise his expectations were inaccurate and that he would notice and correctly interpret the approach marker on time. The following four aspects are relevant in terms of the train driver's inattention:

- *Piloting*
  As mentioned before, the rail grinding train's transfer journey was piloted. This means the train was being driven by a vehicle operator rather than a train driver, as would normally be the case. In addition to consulting with the rail traffic controller, the train driver piloting the train is expected to observe the signals/signs and issue appropriate driving and braking commands to the vehicle operator. The latter is a partial, visual task that involves a low level of mental strain. As a result, there is a greater likelihood that the pilot train driver's attention will stray to other activities.
- *Passengers in the cabin*
  For the duration of the transfer journey to Stavoren, two rail grinding train crew members were present in the cabin in addition to the train driver and the vehicle operator. One of them was seated in the front cabin (together with the train driver and vehicle operator). The other was sitting in the rear cabin. As the rail grinder approached the scene of the accident, the crew member and train driver in the front cabin engaged in a conversation. As a part of this conversation, the train driver consulted documentation. The train driver has stated that this third person (who was seated behind him) was asking questions and that he briefly turned to face him several times while answering. As a result, he was temporarily unable to see the railway track ahead of the train.

- *Last-minute changes to the work plan*
  The above last-minute changes to the work plan may have played a role in this regard. The staff member acting as pilot train driver on the transfer journey was scheduled to serve as Work Train Supervisor (WTB) during the rail grinding activities to be conducted later that night. If we factor in that the rail grinding activities were scheduled to start immediately after the rail grinding train's arrival in Stavoren, it is clear that the staff member was under some pressure to take notice of the work plan changes during the transfer journey.
- *Use of multiple languages*
  The Italian rail grinding train crew did not speak Dutch, and had limited command of English and German. As a result, the Dutch train driver had to communicate with them in a language that was not his own, and had to regularly check whether they had understood what he had said. This put more mental strain on the train driver, and distracted him from paying attention to the signals.

5) The train driver had difficulty in determining the train's position
Due to the fact that the accident took place in darkness and the track section was situated in a rural area, the train driver depended almost entirely on the location signs along the track when determining his location. In order to help train drivers determine their location, kilometre and hectometre signs have been placed along the track; the kilometre signs are high up, while the hectometre signs are situated near the ground. Inspections after the accident brought to light that the kilometre signs along the final part of the track were either missing or turned in such a way that they could not be read from the train cabin (see Appendix 3). The train driver stated that the lack of signs played a role in his failure to realize that the train was nearing its final destination. It should be pointed out that train drivers or work train supervisors on self-propelled maintenance equipment use these signs more often than regular train drivers, as they often need the signs to carry out their work.

Explanation about lack of ATB monitoring (signal compliance and speed reduction)
As mentioned, the ATB monitoring system failed in two respects:
- The train had not been fitted with the same Automatic Train Protection system as the track (ATB-NG). As a result, the train driver did not receive an alert upon passing the signal instructing him to brake. In addition, no warning signal was sounded to alert him that the brake system had not been manually activated after passing the signal, nor did any automatic braking intervention take place when the driver failed to brake manually.
- The rail grinding train's Automatic Train Protection system (ATB-E) was set to offline mode. As a result, the train was able to travel faster than 40km/h despite the incompatibility of the two ATB systems.

It has also become clear that no compensatory safety measures had been put in place to make up for the lack of ATB monitoring. The following three underlying factors played a role in this regard: 1) compatibility between the ATB systems 'on the track' and the systems installed in the rolling stock is not mandatory for certain trains, 2) the trainborne ATB equipment was automatically set to offline mode and 3) compensatory measures are not clearly required or mandated under these circumstances. These three factors are explained in further detail below.

1) No mandatory ATB compatibility between infrastructure and rolling stock
As described in chapter 3, the law requires that both self-propelled rail vehicles and railway infrastructure are fitted with an Automatic Train Protection system.[61] However, a number of different systems (ATB-EG, ATB-NG, ATB-E and ERTMS[62]) which are not necessarily compatible have been introduced over the years. The law does not specify that rail vehicles may only use a track section if the on-board ATB system is compatible with the system used in the track.

61 Source: Rail Vehicle Inspection Regulations, Article 26.
62 ERTMS is an automatic train protection system developed at European level. The acroynym stands for: European Rail Traffic Management System.

However, IVW has further tightened these guidelines to a certain extent by including a clause in the deployment certificate for passenger trains and locomotives that ensures these vehicles may only be deployed on track sections fitted with a compatible ATB system. However, IVW does not apply this restriction in deployment certificates for self-propelled maintenance equipment (such as rail grinding trains), other than the limitation that these vehicles may not be deployed to track sections with ERTMS.[63] Self-propelled maintenance equipment only needs to be fitted with ATB-E (in view of the required investment) but according to the deployment certificate may be deployed to both track sections with ATB-EG (compatible with ATB-E) and sections with ATB-NG (not compatible with ATB-E).

2) Trainborne ATB system automatically switched to offline mode
The trainborne equipment for the ATB system (ATB-EG) and the ATB-E system derived from ATB-EG is configured so that the vehicle's speed will be automatically limited to a maximum of 40km/h when travelling over a track section without ATB-EG. This speed limit can be deactivated by setting the trainborne ATB system to offline mode. This can be done manually by pressing a button in the cabin, but can also be automated via a signal from the railway infrastructure to the trainborne equipment. This indicator system is referred to as the 'ATB switch off section'. When a vehicle with ATB-EG or ATB-E drives over an ATB switch off section, the trainborne ATB system's offline mode will be automatically activated or deactivated, depending on the driving direction.

The switch off sections were installed in the past in order to compensate for the fact that some track sections had not been fitted with ATB. In order to ensure that trains with ATB could be limited to a speed of 40km/h on tracks that had not yet been fitted with ATB, the trainborne equipment was automatically deactivated when the vehicle left the ATB zone. Once all secondary lines (including the Leeuwarden-Stavoren track section) had been fitted with ATB, the switch off sections basically became obsolete. Once the system had been installed, trains could exceed 40km/h on all track sections with ATB monitoring. However, the switch off sections at the start of the secondary lines are still operational. As a result, self-propelled maintenance machines that have only been fitted with ATB-E will be automatically switched to offline mode as soon as they enter a secondary line. As a result, the rail grinding train was able to exceed 40km/h.

3) Compensatory measures were not explicitly required and/or mandated
Various measures could be implemented in order to control the risks involved in driving a rail grinding train with ATB-E over a track section with ATB-NG, such as: 1) having the vehicle towed by a locomotive fitted with ATB-NG and (2) limiting the vehicle speed (to a maximum of 40km/h, for example). Such measures must be subjected to an ALARP assessment: all available measures must be implemented unless they demonstrably involve unreasonably high costs and/or other consequences.

The companies involved had not conducted an ALARP assessment of the above measures. It should be pointed out that they were required to do so on the basis of the Railways Act. Although the ALARP requirement (see chapter 3) is not explicitly featured in the Railways Act, it is included as part of the obligation to ensure railway safety (according to which all safety risks must be addressed through the application of appropriate measures). IVW did not demonstrably inform the involved railway operators – at least not prior to the accident at Stavoren – that they were in default of this obligation.

63 This is because there are no markers alongside the railway track on ERTMS route sections: trains travelling on these sections use cabin-based signalling; the lack of a techical 'safety net' to correct human errors by the train driver does not play a role in this regard.

5.2.3 Subconclusions

Subconclusions regarding the immediate and underlying causes of the accident at Stavoren:

- The immediate cause of the accident lies in the fact that the train was braked too late upon approaching the end of the route section due to the train driver's failure to comply with the signal and the failure of the ATB system.
- The driver's failure to comply with the signal was due to the fact that:
  - the train driver's expectations regarding the signals/signs along the route section and his attention had been diverted;
  - the signal (approach marker or *keperbaak*) was of an uncommon type, unfamiliar to the train driver and which, during darkness moreover was less visible, and only for a shorter period of time, than the usual light signals;
  - the train driver had difficulty in determining the position of the train because a number of the location signs along the route were missing or illegible.

  A factor that played a role in the inaccurate expectations of the train driver is that he had inadequate route knowledge. This was also caused by the fact that the work plan had been changed at a late stage (as a result of which part of the journey took place along a route section that would be driven in the opposite direction during the return journey, according to the original plan). Another factor involved in the train driver having inaccurate expectations is that the route section track layout plans showed speed signs which in reality had already been removed five years ago.

  A factor that played a role in the train driver being distracted from his driving duties was that he was not operating the train himself but acted as the pilot, which means that his attention was more likely to have been focused on other matters. Another factor that played a role in this context is that a rail grinding employee was also located in the cabin and the employee was holding a conversation with the train driver, also as a result of the change in the work plan. Since the conversation was also conducted in a foreign language, German, the train driver regularly looked at the relevant employee, who was located behind him, during the conversation.
- The failure of the ATB system was due to the on-board ATB equipment's incompatibility with the ATB system installed along the route section. In addition, the ATB equipment had been switched to offline mode. The following additional factors also played a role in this regard:
  - compatibility between on-board ATB systems and infrastructure ATB systems is not mandatory;
  - the on-board ATB equipment had been automatically switched to offline mode by a switch off section at the start of the route section (the actual reason for doing so had already ceased to apply in 2005);
  - current laws and regulations do not explicitly mandate compensatory control measures, and IVW has not informed the railway operators involved of their responsibilities in connection with the legal obligation to ensure railway safety.

5.3 Research question 2: Scope of the issues

This section examines whether the safety problems at Stavoren are unique to the incident or should be viewed in a broader (and more structural) context. It also explores whether the risks involved in the Stavoren incident are also relevant to other rail grinding trains or comparable machines (see 5.3.1) and examines whether these risks have led to other safety incidents in the past (see 5.3.2).

5.3.1 Risks

The accident in Stavoren involved a rail grinding train travelling on a railway line that was in service. Rail grinding trains are classified as self-propelled maintenance machines. These machines are designed to carry out maintenance work on railway tracks that have been taken out of service. Unlike many other maintenance machines, rail grinding trains are fully self-propelled. This means they do not need a locomotive to travel to the out-of-service railway section or return to the location where they will await their next deployment.

Various risks involved in the Stavoren accident also affect transfer journeys by other self-propelled maintenance equipment. These are:

- The lack of ATB monitoring on track sections with ATB-NG: the majority of maintenance machines is only fitted with ATB-E.
- Travelling with multiple passengers in the cabin: many maintenance machines only have one seating area, so that the entire crew often spends the transfer journey 'in the cabin with the train driver'.
- Limited route knowledge: the drivers of maintenance machines drivers often conduct transfer journeys on unfamiliar track sections. Difficulties in determining the location: the lack or illegibility of location markers also proved to be a common occurrence on other track sections.

5.3.2 Other incidents

The Dutch Safety Board examined whether there have been other incidents during transfer journeys carried out by self-propelled maintenance machines that were caused by the underlying factors responsible for the accident in Stavoren. To this end, the Board consulted the IWV incident database.[64]

All incidents that took place between 1 January 2001 and 1 July 2010[65] involving self-propelled maintenance machines passing a signal set at danger while being transferred journeys on railway tracks that were in service[66] were selected (see Appendix 4 for further details). The Board focused on incidents involving passing a signal set at danger, as this aspect is basically key to the Stavoren accident: the rail grinding train could not be brought to a standstill before the stop sign on the buffer stop because the driver failed to respond to the approach marker.

According to the analysis results, a total of eighteen incidents took place in which self-propelled maintenance machines passed a signal set at danger during the period under examination (almost ten years), five of which involved rail grinding trains. This means on average almost two incidents per year took place in which a rail grinding train or another self-propelled maintenance machine passed a signal set at danger during a transfer journey. The analysis also brought to light that the underlying causes of the five incidents with rail grinding trains did not differ significantly from the causes of the thirteen incidents involving other self-propelled maintenance machines.

Just as in the Stavoren accident, the absence of ATB monitoring played a role in the above 18 incidents in which a signal set at danger was passed (*STS-passage*)[67]. In the previous incidents, there was no ATB equipment on board the train whereas the rail grinding train involved in the Stavoren accident in fact carried ATB equipment on board but the equipment was incompatible with the ATB equipment installed along the route.

The investigation also established the ratio between the number of incidents and the overall number of incidents in which signals set at danger were passed. The total number of incidents during the period under investigation was approximately 2,400, representing an average of around 250 incidents per year. The number of incidents in which a self-propelled maintenance machine passed a signal set at danger thus represents a 'mere' 0.75 percent of the total number of incidents. However, it should be pointed out that the number of kilometres travelled with such maintenance equipment (less than 1 million kilometres per year) only represents approximately 0.6 percent of the total number of kilometres travelled by trains in the Netherlands (approximately 145 million km per year). Although this number is relatively small, the Safety Board feels it is important to identify and – where reasonably possible – eliminate or control the specific risks involved in transfer journeys. After all, incidents in which self-propelled maintenance machines pass signals set at danger can – as we know from the Stavoren accident – have serious consequences.

64 This was the Misos database until 1 January 2006, which was subsequently replaced by the Hazard database.
65 The Board decided to include incidents up to 1 July 2010 since it is uncertain whether all the incidents that took place after that date were included in the database. The accident in Stavoren thus falls outside that period.
66 The databases do not clearly state whether the railway on which these incidents took place was operational or out of order. The data was interpreted on the basis of contextual information on the accident.
67 STS-passage is the Dutch term for passing a signal set at danger indicating that the train must stop.

5.3.3 Subconclusions

Subconclusions as to whether the safety problems that occurred at Stavoren were unique to that accident:

- Several of the risks that played a role in the accident at Stavoren are also relevant to transfer journeys carried out by other self-propelled maintenance machines. This is especially pertinent with regard to: driving without ATB safeguards on track sections with ATB-NG, multiple persons in the cabin, driving with a pilot train driver and limited route knowledge. Errors in track layout plans, missing location signs and changes to work plans are also common.
- In the period between 2001 and mid-2010, there were a total of eighteen incidents in which a self-propelled maintenance machine passed a signal set at danger (five of which involved a rail grinding train) that involved the same risk factors as the accident in Stavoren.

5.4 Research question 3a: Risk analyses

As described in section 3.3, the basis for adequate safety management lies in identifying and analysing the risks involved in the relevant process or project. With regard to the train journey to Stavoren, current laws and regulations explicitly require that the companies involved identify and analyse the relevant risk factors.

- According to the Working Conditions Act, ProRail (in its capacity as the Commissioning Party) must prepare a Health & Safety Design Plan, while Speno and BAM Rail (as the Contractors) are required to draw up a Health & Safety Construction Plan on the basis of this Design Plan.
- According to the railway legislation, both the infrastructure manager (ProRail) and the official transport operator (BAM Rail) are required to prepare a suitable rail traffic risk inventory and evaluation.

5.4.1 Health & Safety plan

A Health & Safety plan was prepared for this rail grinding project (both for the Design and the Construction Phase), containing a description of the risks involved and required control measures. However, the Health & Safety plan related exclusively to the rail grinding activities. The plan did not cover transfer journeys by rail grinding trains. The parties involved did not feel this would be necessary, as they regarded and treated the transfer journeys as 'normal train journeys' which would not require any specific control measures. According to ProRail and Speno, BAM Rail – in its capacity as official transport operator – is solely responsible for risk management of transfer journeys.

In the view of the Dutch Safety Board, the parties involved should have prepared a specific risk inventory and evaluation of the transfer journeys. This is clearly demonstrated by the accident at Stavoren. The Safety Board does not concur with the parties' arguments against preparing a specific risk inventory and evaluation, for the following reasons:

- Transfer journeys with rail grinding trains may involve other (combined) risk factors than normal train journeys. For example, normal passenger and cargo trains almost never encounter situations in which there is no ATB monitoring on an ATB-NG track section. The same applies to 'passengers in the cabin' and 'piloting' (as a standard procedure), whereas the problems caused by limited knowledge of secondary lines do not occur amongst train drivers assigned to drive normal passenger trains.
- As the official transport operator responsible for the rail grinding train transfer journeys, BAM Rail should have provided a suitable risk inventory and evaluation. However, ProRail (in its capacity as infrastructure manager and commissioning party) and Speno (as principal contractor) shared in this responsibility and should have made efforts to monitor compliance.

The Safety Board was surprised to find that there was no legal requirement to include the issue of risk management for transfer journeys in the Health & Safety plan. As far as the Safety Board is concerned, transfer journeys should be considered part of the relevant activities. After all, these journeys serve to transport staff and equipment to and from the work site. The fact that transfer

journeys take place on railway lines that are in service does not alter this conclusion. The situation would be different if the maintenance machine were transported as part of a normal freight train and the crew members were transported on a normal passenger train.

Legislation in this area has been elaborated in sector-specific regulations, more particularly in the Safety at Work Standards Framework (NVW) and Safety at Work Regulations. However, the investigation revealed that sector-specific regulations in this area are unclear. On the one hand, the Safety at Work Standards Framework would appear to confirm the Safety Board's position, describing its scope as follows: "the Safety at Work Standards Framework specifies the relationships and responsibilities in the area of railway work, *including the transport* and deployment of people, equipment and materials." On the other hand, neither the Safety at Work Standards Framework nor the underlying Safety at Work Regulations further define the term "transport and deployment of people, equipment and materials" or specify which risks are to be analysed and managed in this regard.

The Safety Board discussed this issue with the sector organisation responsible for administering and developing this legislation, the railAlert Foundation (*Stichting RailAlert*). The discussion brought to light that:

- When the Safety at Work Standards Framework (NVW) was drawn up some five years ago, the transport of staff and equipment was included in the description of the framework's scope. At the time, this related to situations in which railway workers are required to briefly enter railway lines that are in service in order to reach their work site. It was then assumed that they would only have to travel over railway lines that are in service for a distance of several kilometres at the most;
- The fact that staff and equipment might also need to be transported over considerably greater distances in some situations, and that such transfer journeys could involve specific safety risks, had not yet been discussed at railAlert.[68] As a result, the Safety at Work Standards Framework (NWV) and Safety at Work Regulations (VVW) do not yet specify any procedures for transfer journeys.
- As a result of the consultations, railAlert will now tackle this issue.

5.4.2 Infrastructure-related risks

ProRail conducted a general risk inventory and evaluation of the potential risks involved in a train journey. However, the two infrastructure-related risks ('driving on NG track sections without ATB monitoring' and 'the use of an uncommon signal') that occurred during the rail grinding train's journey were not featured in this risk inventory and evaluation, as ProRail did not regard them as relevant safety risks prior to the accident in Stavoren.

It is the Safety Board's view that ProRail should have conducted a risk analysis and ALARP evaluation of these aspects. As section 5.2 outlines, these were serious risks for which appropriate control measures were available. Sections 5.5.1 and 5.5.5 provide further details on the way in which ProRail and the other companies dealt with these issues.

5.4.3 Transport operator-related risks

BAM Rail prepared a general risk inventory and evaluation on train journeys over railway lines that are in service. This general risk inventory and evaluation deals with two of the four transport operator-related risks that occurred at Stavoren, namely 'driving on NG track sections without ATB monitoring' and 'train driver's lack of route knowledge'. Section 5.5 focuses on BAM Rail's approach to these issues.

The Safety Board concludes that BAM Rail's risk inventory and evaluation fails to deal with the other two transport operator-related risks that played a role in the accident at Stavoren. These are 'piloting' and 'passengers in the cabin'. BAM Rail justified these omissions by claiming that both aspects, with the exception of the accident in Zwolle (see section 5.6.3) had not yet resulted in any

68 The accident at Stavoren had been previously discussed by railAlert, in order to assess to which extent the incident warranted the amendment of laws and regulations. However, railAlert had concluded that the journey could be regarded as standard and did not have to be treated as part of work on the railway tracks.

serious incidents or accidents, and that both piloting and passengers in the cabin are allowed under the current regulations. In the view of the Safety Board, these arguments do not justify BAM Rail's failure to conduct an ALARP evaluation. Section 5.5 will focus on this issue in greater detail.

5.4.4 Subconclusions

Subconclusions regarding the risk inventory and analysis conducted by the transport operators:

- A risk analysis of the rail grinding project had been conducted as a part of the Health & Safety plan, but this analysis only related to the risks involved in the grinding work itself rather than the transfer journeys carried out by the rail grinding trains. The Safety Board feels the latter aspect should have been included, as the journeys can involve specific risks or combinations thereof. The Safety Board has established that legislation in this area is unclear: according to the Safety at Work Standards Framework, the transport of staff and equipment does fall within its scope, but the issue has not been further elaborated in the underlying guidelines (including the Safety at Work Regulations, VVW).
- ProRail and BAM Rail have conducted general risk analyses of the risks involved in train journeys, but these analyses do not deal with the various infrastructure and transport operator-related risks that played a role in the accident at Stavoren. The Safety Board is of the opinion that ProRail and BAM Rail also should have conducted an ALARP evaluation of these risks.

5.5 Research question 3b: Controlling the risks

5.5.1 Signalling

The signalling system on the Leeuwarden-Stavoren track section is atypical on two accounts:

- In the section before Stavoren station, signalling is limited to an approach marker (instead of a light signal or marker in combination with a light signal).
- The railway section before the buffer stop has a speed limit of 100km/h rather than the usual limit of 40km/h.

Approach marker (keperbaak)

While approach markers do have the same significance as amber light signals according to current laws and regulations,[69] approach markers, however, are intended as signals announcing light signals. For that reason a permanent amber light signal should have been installed at Stavoren instead of an approach marker. An approach marker could have been installed to announce that particular light signal if the distance between the light signal and the buffer stop was less than the necessary braking distance. The above is supported by the historic background of the approach marker, see Appendix 6.

The difference described above is important, if we take into account that a light signal is considerably more visible in the dark (for a longer period of time and more noticeable) than an approach marker. In addition, nowadays approach markers are rarely used. If used, they can only be found in situations most train drivers hardly ever (or never) encounter (at border tracks and in the case of 'running on the wrong track'[70]), see also Appendix 6.

ProRail has stated that it was unaware that the use of an approach marker at Stavoren was in conflict with applicable guidelines. The Safety Board notes that current legislation in this area is unclear. In the opinion of the Safety Board, the legislation should clearly and unambiguously describe which situations warrant the use of an approach marker. At present, this is not the case.

69 Appendix 4 to the Railway Traffic Regulations

70 The term 'Running on the wrong track' refers to situations in which a train drives along a railway that only features signals for trains in the opposite direction. This situation is almost non-existent in the Netherlands.

The fact that the approach marker is less visible, and only for a shorter period of time, during darkness and the relative uncommonness of this type of signal did not prompt ProRail to adjust the situation. Instead, ProRail relied on the existing ATB monitoring (ATB-NG). However, the ATB monitoring system in this track section is only compatible with trains that normally use the track, not with self-propelled maintenance machines (which are not equipped with ATB-NG and are automatically switched to offline mode at the start of the line).

Track section speed upon approaching buffer stop
Nearly all buffer stops are located on railways with a maximum track section speed of 40km/h. In Stavoren, however, the maximum speed in the section leading up to the buffer stop was 100 km/h. However, the marker at approximately 1200 metres before Stavoren instructed train drivers to reduce the train's speed to 40km/h or less in order to ensure that the train could be brought to a standstill before the buffer stop. Nevertheless, the maximum track section speed was not reduced to 40km/h. Until 2006, the maximum speed in the final track section was reduced to 40km/h by means of speed signs. In 2006, the track section was fitted with ATB-NG, which ensures that trains fitted with the system are automatically braked on time. In connection with the introduction of this system, the speed limit for the final part of the track section before the buffer stop was abolished (by removing the speed signs). As a result of this decision to abolish the speed limit, however, the marker was the only remaining safety barrier for trains that had not been fitted with ATB-NG, such as self-propelled maintenance machines. In the opinion of the Safety Board, this should have formed an extra incentive for ProRail to take or call for compensatory measures for trains that had not been fitted with ATB-NG.

5.5.2 Route knowledge
According to the Railway Personnel Decree,[71] train drivers are required to have sufficient route knowledge. The Decree does not specify any criteria for this route knowledge, or outline how it should be acquired or tested. As a result, these aspects are the responsibility of the transport operator and the employment agency. The below section outlines the criteria applied by BAM Rail and Spoorflex. A distinction has been made between 'acquiring' and 'maintaining' route knowledge.

- In order to determine whether a train driver has acquired sufficient knowledge of a specific track section (by travelling the route with another driver) a test will be conducted by an expert from BAM Rail or Spoorflex familiar with the current track section situation. If BAM Rail or Spoorflex cannot provide such an expert, the train driver will take an examination at another transport operator who is familiar with the track section.
- The criterion for determining whether a train driver has maintained his knowledge of a specific track section is defined as follows: the driver must have travelled on the relevant section within the past year. If a train driver has not travelled over a track section for more than a year, he must refresh his knowledge by travelling the route with another driver. The latter will not be tested, and is the responsibility of the train driver.

BAM Rail and Spoorflex have pointed out that their approach and criteria are no different than the commonly applied standards for train drivers and self-propelled maintenance machines. In the opinion of the Safety Board, greater efforts are needed in order to ensure adequate route knowledge. The Board also feels the procedures for testing drivers' route knowledge (especially in terms of maintaining this knowledge) need to be improved. The Safety Board's investigation showed that the transport operators in question apply more stringent criteria when it comes to the knowledge of passenger train drivers. The investigation showed that at least one other railway contractor commissions the transport operator responsible for services on the relevant track section to test its train drivers' route knowledge on a structural basis.

BAM Rail conducted a one-off assessment and made a record of the Spoorflex train drivers' route knowledge. It was up to Spoorflex to subsequently ensure that the train drivers kept their route knowledge up to date.

Audits of Spoorflex conducted by BAM Rail and IVW prior to the accident at Stavoren revealed that the company's procedures for safeguarding and registering route knowledge were inadequate.

71 Article 24, subsection 2a, Railway Personnel Decree.

However, IVW did not take any steps to implement additional supervision or other measures in response to the audits. BAM Rail did take action: after having conducted additional audits at Spoorflex, the company then started monitoring Spoorflex train drivers' route knowledge. However, these efforts were not enough to ensure that the train driver on board at the time of the accident in Stavoren had sufficient demonstrable and proven route knowledge. ProRail did not take any control measures in this regard in its capacity as commissioning party.

In general the Safety Board has established that the Dutch railway sector has not developed a uniform approach to the development and safeguarding of train drivers' route knowledge. There is no clearly defined legal basis and the various operators apply different standards when it comes to their drivers' route knowledge. In the view of the Safety Board, the accident in Stavoren clearly demonstrates the need to develop a more effective approach to the safeguarding of drivers' route knowledge.

5.5.3 Piloting

Piloting is allowed under current laws and regulations: Article 24, subsection 3b of the Railway Personnel Decree states that a train may be driven by a person other than a train driver, providing this person has sufficient knowledge of the train's operating procedures, the train driver can instantly take over the controls in an emergency and can issue the other person all the necessary commands.

The positions of the companies involved are as follows:

- ProRail does not object to piloting during transfer journeys by rail grinding trains and points out that the practice is allowed under current legislation. In ProRail's opinion, this is the responsibility of the official transport operator (BAM Rail, in this case) and ProRail cannot and should not be in a position to exert any influence in the matter.
- Speno has stated that the company needs local train drivers, as its own staff do not have sufficient knowledge of the local situations and circumstances. This is why Speno originally used pilot train drivers in multiple countries. Speno has since changed its policy in many countries, and is training local drivers to operate rail grinding trains. The objective is to ensure that these newly trained local drivers will be able to operate the rail grinding trains on their own, thus reducing the likelihood of incidents and accidents. Speno has also called for the abolishment of piloting in the Netherlands. Speno had already called for such measures prior to the accident in Stavoren, but found that the operation of rail grinding trains by BAM Rail drivers posed a problem in terms of liability insurance. As a result of these insurance issues[72] piloting had not yet been abolished at the time of the accident in Stavoren.[73]
- In response to the 2007 accident in Zwolle (see section 5.6 for further details), BAM Rail decided it would be better to abolish the practice of piloting. BAM Rail then requested Speno's permission to deploy BAM Rail and/or Spoorflex drivers to rail grinding trains on transfer journeys. However, the aforementioned insurance issues soon came into play.

ProRail takes the position that piloting was legally permitted and did not constitute an unjustifiable risk. BAM Rail and Speno preferred to have all trains operated by drivers, but had failed to implement this practice at the time of the accident as a result of insurance issues. According to the Safety Board, the practice of piloting was one of the reasons the driver was distracted (see section 5.2.2). The Board feels the parties involved should have taken measures to control this safety risk by limiting piloting to exceptional cases. Furthermore, the Safety Board is of the opinion that ProRail could and should have exerted influence in this matter, taking into account that the transfer journeys are conducted on behalf of ProRail.

72 These insurance issues were complex: Speno International is a Swiss company, and is subject to Swiss insurance law, which is considerably more stringent than its Dutch counterpart.

73 After the accident in Stavoren, the practice of piloting was abolished despite the fact that these insurance issues had not yet been resolved. As of December 2010, Speno rail grinding trains are operated by BAM Rail drivers during transfer journeys. This is partly due to a restriction in BAM Rail's safety certificate, enforced by IVW.

5.5.4 Passengers in the cabin

As regards passengers in the cabin, the railway legislation specifies that:

- the railway company responsible for operating a train must take measures to ensure that the driver is not distracted from his duties;
- the driver's cabin is off limits to all other individuals, unless they have been granted permission by the official railway company.

Railway sector guidelines on this issue are featured in the Handbook for the Transportation Process. The section on transfer journeys by maintenance machines specifies that the train driver may allow a maximum of two people to enter the cabin, unless the cabin also serves as accommodation for the duration of the journey.

During the transfer journey in question, the cabin contained one of the rail grinding train crew members in addition to the pilot driver and the vehicle operator. This was in accordance with normal procedures. ProRail, Speno, Spoorflex and IVW did not object to this practice, as it was allowed by the railway company in question (BAM Rail) and did not contravene current legislation.

However, the Safety Board points out that the railway legislation also requires the responsible railway company to take measures in order to ensure that the train driver is not distracted. In the opinion of the Safety Board, this practice is in direct contradiction with the aforementioned requirement. The Safety Board finds it objectionable that rail grinding trains and other self-propelled maintenance machines are subject to less stringent requirements than passenger trains (where railway companies do not allow other individuals in the cabin) when it comes to the presence of other individuals in the cabin. The Safety Board is thus of the opinion that the Handbook for the Transportation Process should be adjusted to tighten up the regulations in this regard.

5.5.5 Driving without ATB monitoring

According to current laws and regulations, both the railway infrastructure and self-propelled rail vehicles must be fitted with an ATB system that offers ATB-EG functionality at minimum. IVW must also issue deployment certificates for each vehicle (based on an inspection), which may feature restrictions in terms of the vehicle's deployment to specific track sections. IVW applies the following policy in this regard:

- Under normal circumstances, passenger trains and freight trains that have only been fitted with ATB-EG may only be deployed to track sections with ATB-EG; as regards normal use on track sections with ATB-NG, IVW requires that these vehicles are also fitted with ATB-NG. The latter applies to Arriva passenger trains on the fixed schedule between Leeuwarden and Stavoren.
- Until 1 April 2008, IVW exempted self-propelled maintenance machines and historic rolling stock from this ATB requirement; these vehicles were issued deployment certificates for the entire railway network, despite the fact that they had not been fitted with ATB systems. Since 1 April 2008, IVW requires these vehicles to feature ATB-E, which is comparable to ATB-EG in terms of functionality. Since that date, the deployment certificate does not contain any restrictions in terms of deployment to specific track sections (unlike the certificates for passenger trains and locomotives).

This means normal passenger and freight trains may only be deployed to track sections with ATB-NG if they have been fitted with trainborne ATB systems of the same type, while self-propelled maintenance machines and historic rolling stock is allowed to use these track sections even if they have not been fitted with ATB-NG systems. This exception was based on the consideration that these vehicles are not deployed on a regular basis (an average of less than 10,000 km per year), while the costs of installing ATB-NG equipment are relatively high (approx. EUR 250,000 per vehicle).

Maintenance machines and historic trains/locomotives can therefore also be deployed on track sections with ATB-NG, even if there is no ATB monitoring. As of 2008, these vehicles must be fitted with ATB-E, which basically ensures that they cannot exceed 40km/h on track sections without ATB-EG. However, the effect of this measure is invalidated by the fact that ATB-NG track sections still feature switch off sections that will automatically switch ATB-EG or ATB-E equipment to offline mode once the train enters the track section. As a result, maintenance machines and historic trains/locomotives can travel ATB-NG track sections at the speed limit despite the lack of ATB

monitoring. It should be pointed out in this regard that trainborne ATB systems may be switched to offline mode under current laws and regulations.

As regards the grinding project, the companies involved took no action other than the only explicitly mandated control measure, namely the obligation to install ATB-E systems in the rail grinding trains. In doing so, the companies felt they were complying with current laws and regulations, as IVW did not require them to take any additional measures.
According to the Safety Board, however, there were other ways of compensating for the lack of ATB monitoring:

- refraining from switching the trainborne system to offline mode (resulting in a maximum speed of 40km/h); and/or
- ensuring that rail grinding trains were towed by locomotives with ATB-NG when travelling over NG track sections.

The Safety Board would point out that ProRail (in its capacity as infrastructure manager) and BAM Rail (in its capacity as official transport operator) should have conducted an ALARP evaluation of these measures (see 3.1.1).

The above ATB problems are not limited to rail grinding trains. In view of the fact that ATB switch off sections at the start of ATB-NG track sections are still operational, all maintenance machines and historic trains/locomotives that have only been fitted with ATB-EG or ATB-E systems can still travel these track sections at the speed limit despite the lack of ATB monitoring. This vehicle category includes a total of some fifty self-propelled maintenance machines, including several video observation trains which are used to inspect the railway infrastructure on an almost daily basis. The Safety Board was thus surprised to learn that the switch off sections had not been deactivated years ago. The Safety Board is of the opinion that such measures should have been taken as a part of the effort to reduce the number of incidents involving passing signals set at danger.

5.5.6 Adjustment of work plans

There are no legal standards with regard to the adjustment of work plans. However, guidelines applied by ProRail do specify that adjustments to Workplace Safety Instructions must be conducted on the basis of an 'escalation procedure'. This means that the Workplace Safety Leader and the rail traffic controller must consult with a higher echelon in their own organisations. BAM Rail has furthermore stipulated that the train driver, the Work Train Supervisor and/or the Workplace Safety Leader are also required to follow a mandatory escalation procedure if a work plan is changed.

As stated before, with respect to the transfer journey carried out by the rail grinding train to Stavoren the work plan was changed rather than the Work Safety Instructions (WBI) and the mandatory BAM Rail escalation procedure was not followed.

Both BAM Rail and ProRail have established that over the course of the years staff have developed the habit among themselves of diverging from work plans while working on the railway tracks, i.e. failing to apply the mandatory escalation procedure. These practices were especially common during rail grinding activities, and were actually regarded as an alternative way of reaching productivity targets. The Safety Board would like to highlight that the staff taking these decisions are often either not in a position to assess the associated risks properly or do not have the opportunity to do that. This could result in ignoring the risks assessments that were made when preparing the original work plan. The Safety Board has furthermore established that within and among the companies involved no adequate supervision was performed of the mandatory escalation procedure.

Over the course of the investigation, two other incidents involving the breach of safety guidelines came to light. During the transfer journey in question, the rail grinding train's dead man's system was switched off, and its water tanks were full, in violation of current regulations and the relevant deployment certificate. These aspects have not been included in the report because in the Safety Board's opinion they did not play a substantial role in causing or shaping the outcome of the incident. However, they do reflect the fact that safety guidelines were also ignored in other areas.

5.5.7 Subconclusions

Subconclusions regarding the risk management approach of the companies involved and the role of legislation:

- With regard to transfer journeys carried out by rail grinding trains, the companies involved failed to apply optimal risk management in the following areas:
  - ProRail installed an approach marker at Stavoren (instead of the more familiar light signal, which would also have been visible for a longer period of time).
  - Speno equipped the rail grinding trains with ATB-E equipment (instead of ATB-NG equipment which is compatible with both ATB-EG and ATB-NG route sections).
  - Speno and BAM Rail allowed the rail grinding trains to be piloted (instead of ensuring that they were operated by Dutch train drivers).
  - As regards the train drivers' route knowledge, the standards applied by BAM Rail and Spoorflex were considerably lower than those for passenger train drivers.
  - Speno and BAM Rail allowed crew members to travel in the cabin despite the fact that there was no urgent need to do so.
  - ProRail did not deactivate the ATB switch off sections at the start of the ATB-NG route despite the fact that nearly all route sections (around 2005) and vehicles (around 2008) had been fitted with ATB.
  - BAM Rail failed to ensure that its staff followed the mandatory company escalation plan when diverging from work plans.
- As regards legislation, the Safety Board is of the opinion that the current rules must be made clarified and/or tightened in the following areas:
  - the situations in which approach markers are permitted to be used;
  - testing train drivers' route knowledge;
  - passengers travelling in the cabin.

5.6 Research question 3c: Lessons learned from previous (near) accidents

The Dutch Safety Board assessed whether there have been comparable incidents with rail grinding trains in the past, and the extent to which the companies involved learned safety lessons from these incidents.

5.6.1 Overview of past incidents

Two of the eighteen above incidents (see 5.3.2) involved an accident or near-accident involving a rail grinding train passing a signal set at danger while carrying out a transfer journey as follows:

- on 2 March 2003, a near crash between a rail grinding train and an empty passenger train took place at Halfweg due to passing a signal set at danger;
- on 11 June 2007, a train passed a signal set at danger at Zwolle, and passed over an open set of points.

At the time, these incidents were not investigated by the Dutch Safety Board or its legal predecessor, the Dutch Transportation Safety Board.

5.6.2 Incident at Halfweg (2003)

The incident in Halfweg concerned a near crash between a rail grinding train and an empty passenger train. The rail grinding train was shunted to a secondary line in order to start the rail grinding activities. The passenger train would then pass the rail grinding train over the main line. The rail grinding train was moved into position for the grinding work. After having passed a signal set at danger, the train drove over the railroad switch that had been set for the incoming passenger train. A timely warning was sent to the passenger train, averting a crash. At the time of the accident, the rail grinding train was being piloted by a Railion driver. The train journey had been scheduled on behalf of BAM/NBM (BAM Rail's legal predecessor).

At the time, the incident was investigated by the IWV, which identified the following safety problems:

- The division of tasks and responsibilities between the Speno employee operating the rail grinding train and the Railion employee acting as pilot was unclear. IVW concluded that the Railion employee was to be regarded as pilot train driver, and should thus have been fully qualified as an engine driver. This was not always the case at the time. IVW also concluded that the Speno employee was acting as vehicle operator and should thus have acted in accordance with the relevant guidelines;
- There was uncertainty as to who was responsible for the train journey´s safety certificate: Railion (in its capacity as the pilot train driver´s employer) or BAM/NBM (the party on whose behalf the journey had been scheduled). IVW concluded that BAM/NBM should be regarded as official transport operator in this case;
- There had been communication problems due to the fact that Speno employees only spoke Italian whereas the Workplace Safety Leader and train driver only spoke Dutch.

The Dutch Safety Board concludes that the problems identified by IVW have since been resolved and did not – at least not in the same form – play a role in the accident at Stavoren, with the proviso that the communication problems have not been resolved although agreements on the use of a common language were made (German or English).

5.6.3 Incident at Zwolle (2007)

The incident at Zwolle concerned a rail grinding train which, after having finished its rail grinding activities, drove to Zwolle at a speed of approximately 90km/h. Upon approaching Zwolle station, the train failed to take heed of an amber signal announcing that the next signal would be red and required braking. As a result, the train – which was still travelling at high speed – passed the next red signal and subsequent railroad switch. In the process, the railroad switch was damaged.

Like the accident at Stavoren, a signal failed to be obeyed prior to the accident and the following underlying risks played a role in both incidents:

- The absence of ATB monitoring;
- The train was being operated by a piloting train driver/work train supervisor;
- The train driver was distracted, due to the fact that other crew members were travelling in the cabin;
- Staff diverged from the work plan;
- The track layout plans were out of date.

Two aspects of the incident in Zwolle did not play a role in Stavoren:

- The train was driving fast along a railway line that was not in service.
- After the incident, the train driver carried out the return journey without the rail traffic controller’s permission.

IVW, ProRail and BAM Rail investigated the incident at Zwolle at that time. The relevant investigations resulted in the following measures:[74]

- IVW mandated ATB-E for rail grinding trains as soon as the system became available (in 2008). In response, Speno installed ATB-E on all rail grinding trains operating in the Netherlands in 2008.
- IVW stated that the deployment of trains and manpower was only permitted if the relevant certificate had been issued. In response, BAM Rail started checking the documents of hired staff members and equipment.
- ProRail has allocated the overall internal responsibility for Health and Safety during the rail grinding process differently in order to avoid a conflict of interest between safety and rail grinding production activities, in accordance with the relevant provisions stipulated in the Safety at Work Standards Framework (NVW).
- Within the NVW framework, in 2010 ProRail issued a sector directive imposing requirements on the ‘content and form’ of work instructions. The purpose of the directive includes ensuring that the correct basic track layout plans are used.

74 Only the measures that were taken and relate to the Stavoren accident are stated.

- ProRail has tightened the rules on conversational discipline during communication between a train driver/Workplace Safety Leader/work train supervisor and the rail traffic controller. Among other things, this has resulted in a conversational discipline module and an instruction video.
- BAM Rail has decided to set up, train and deploy fixed crews on all rail grinding trains (Workplace Safety Leader, train driver/work train supervisor).
- BAM Rail has established that it would be more effective if train drivers operated rather than piloted the rail grinding trains during transfer journeys. However, this practice had not yet been implemented at the time of the Stavoren accident due to insurance issues.
- BAM Rail has taken the following measures to improve conversational discipline in rail grinding train cabins: the use of translation sheets, the improvement of crew members´ English and German language skills and the monitoring of conversational discipline by means of voice recorders in rail grinding train cabins.[75]

A recommendation proposed by ProRail to revise the current contract structure for rail grinding activities with a more explicit focus on the safety aspects was not implemented. The Safety Board believes that ProRail itself should implement this recommendation in its role as the commissioning party.

The Safety Board has established that a number of the safety risks that played a role in the Zwolle incident had still not been resolved at the time of the Stavoren accident two years later. This mainly concerns the aspects of piloting, crew members in the cabin and the lack of ATB monitoring (see the comments in sections 5.5.3, 5.5.4 and 5.5.5).

5.6.4 Subconclusions

Subconclusions regarding the lessons learned from previous, comparable accidents:
- In the decade preceding the Stavoren accident, two serious incidents occurred in which similar issues were involved. IVW and ProRail conducted investigations into these incidents.
- IVW, ProRail, Speno and BAM Rail took measures in response to the two previous incidents. However, a number of the risks that also played a role in one of the previous incidents (in Zwolle in 2007) still came into play in the Stavoren accident, i.e. a train driver piloting a train, passengers travelling in the cabin and the absence of ATB monitoring.

5.7 Research question 3d: Contractual agreements

This section describes the companies' approach to the risk management of outsourced transfer journeys and the extent to which the Safety Board feels this approach played a role in the failure of risk management.

To this end, the Board assessed outsourcing models, relevant agreements and mutual certification and monitoring procedures.

5.7.1 Outsourcing model

The rail grinding project during which the accident occurred involved a total of four companies: ProRail, Speno, BAM Rail and Spoorflex. Section 4.1 contains an extensive description of these companies and their mutual relationships. In summary, ProRail outsourced the rail grinding project to two companies in 2007, namely Speno and BAM Rail. Speno acted as principal contractor, with BAM Rail taking on the role of subcontractor. The mutual agreements between the two parties were recorded in a framework agreement between ProRail (in its capacity as commissioning party) and Speno (in its capacity as contractor and principal contractor) and a collaboration agreement

75 These voice recorders were active at the time of the accident at Stavoren. However, the recorder in the front cabin turned out to be damaged. As a result, conversations between the crew members could not be monitored. Recorder data from the rear cabin, which was at the front of the train until Leeuwarden, could still be accessed.

between Speno and BAM Rail. BAM Rail, in turn, made agreements with Spoorflex with regard to the outsourcing of staff.

5.7.2 Agreements regarding transfer journeys

The mutual agreements between the companies involved outline the following agreements:

- Framework agreement between ProRail and Speno
  - The following aspects were deemed applicable in this regard: the Work Conditions Act, the Safety at Work Standards Framework and regulations on taking railways sections out of service. The safety-related activities and the removal of rail grinding residues were conducted within the framework of BAM Rail's quality and safety system.
  - Speno/BAM Rail were responsible for preparing the Health & Safety plan (both the design version and the construction version), preparing and maintaining the Health & Safety dossier and supplying the Health & Safety coordinator.
  - ProRail was entitled to change the composition of crews provided by Speno/BAM Rail. ProRail was also entitled to make specific demands regarding the format and composition of the Health & Safety dossier, and was required to approve the Health & Safety plan.
- Collaboration agreement between Speno and BAM Rail
  - Speno was responsible for ensuring that the rail grinding train deployment certificates and qualifications of operating staff were in order.
  - BAM Rail was the officially recognized railway company responsible for the transfer journeys. BAM Rail supplied fixed safety teams (including the pilot train driver) and was responsible for ensuring its drivers´ route knowledge.
- Hiring staff from Spoorflex by BAM Rail
  - BAM Rail and Spoorflex agreed that Spoorflex would provide (pilot) train drivers for the transfer journeys. According to the terms of the agreement, the train drivers were to be fully authorized and have sufficient route knowledge.

The Health & Safety plan for the grinding project outlines the various risks and the measures that the companies involved needed to take to control them. However, the Health & Safety plan only relates to the rail grinding activities, not to the transfer journeys.

5.7.3 Mutual certification/monitoring

As regards outsourcing, the Safety Board considers it essential for the commissioning party to verify in advance whether the contractor is capable of carrying out the activities in a safe manner and supplying qualified staff, and that it monitors compliance with the relevant safety agreements during implementation. The below section summarizes the companies´ efforts to meet these requirements.

ProRail

According to ProRail's policy, the company itself will assess whether contractors are capable of adequately identifying, analyzing and controlling the risks of railway work. ProRail will assess whether this is the case by certifying the companies involved through audits and inspections. ProRail had issued general certification to BAM Rail and Spoorflex, in their capacity as railway contractor and employment agency respectively. ProRail had also conducted an assessment of Speno. This was not a general certification, but rather an assessment conducted specifically in aid of the grinding project.

In terms of monitoring actual work on the railway, ProRail limited its scope of the rail grinding project to the actual rail grinding activities. In ProRail's view, BAM Rail (as the officially recognized railway company) was solely responsible for the safety of transfer journeys, which was to be monitored by IVW.

Speno

Speno did not certify or monitor any of the (safety) activities outsourced to BAM Rail. Speno did not feel it had sufficient knowledge of the situation and regulations in the Netherlands to do so in a meaningful way. Speno did have a representative in the Netherlands who conducted monitoring activities as part of the rail grinding project. However, this monitoring focused solely on the rail grinding activities rather than the transfer journeys.

BAM Rail
As regards staff, equipment, and maintenance of its own stock, BAM Rail only utilizes IVW certified suppliers. BAM Rail initially assumed that IVW certification would ensure sufficient quality and safety. Based on its own experiences, BAM Rail started to monitor the quality and safety standards of all key suppliers in 2008 by means of periodic checks. As regards the rail grinding project, BAM Rail conducted annual audits of Spoorflex from 2008 onwards, in order to assess aspects such as train drivers' route knowledge. The first of these audits (in 2008) identified failings in the methods used by Spoorflex to document their train drivers' route knowledge. BAM Rail then called on Spoorflex to make improvements, but the company was slow to address the problems. In early 2010, BAM Rail decided to assume responsibility for maintaining drivers' route knowledge.

5.7.4 Consequences in terms of transfer journey risk management
In the view of the Safety Board, the outsourcing construction (in which Speno acted as principal contractor) was geared towards the execution (quality and production targets) of the rail grinding activities rather than the management of safety risks. After all, the company responsible for supplying the 'tools' and 'production staff' acted as principal contractor, whereas safety staff were supplied by a subcontractor (outsourced from an employment agency). According to the Safety Board, this construction does not necessarily have a negative impact in terms of controlling safety risks. However, effective safety management will require clear agreements between the companies involved and mutual efforts to monitor compliance.

In the view of the Safety Board, this precondition was not met. The transfer journeys were 'uncharted territory' in terms of agreements, certification and monitoring. According to the agreements between ProRail and Speno, subcontractor BAM Rail was responsible for controlling safety risks during transfer journeys. However, these agreements did not specify which control measures BAM Rail was expected to take or the extent of these measures. As a result, the responsibility for risk management on transfer journeys was delegated to a company that was in no position to fulfil this duty. Controlling these risks involved aspects on which BAM Rail could not make independent decisions. For example: installing ATB-NG in the rail grinding trains would require an investment of around a quarter million euros per vehicle. If a lower speed limit was set for ATB-NG route sections, transfer journeys could no longer be conducted 'in between normal passenger trains', while the towing of rail grinding trains (by a locomotive with ATB-NG) would put undue strain on locomotive capacity and result in relatively high costs.

In the view of the Safety Board, BAM Rail was assigned responsibility for transfer journey risk management without any clear agreements having been made in this regard. This had a twofold effect on the incident in question:
- Prior to the accident at Stavoren, Spoorflex had indicated that it felt the lack of ATB monitoring on transfer journeys along track sections with ATB-NG was basically irresponsible. At the time BAM Rail also consulted and corresponded with IVW on the issue. However, Spoorflex and BAM Rail were unable to convince ProRail and/or Speno that additional control measures would be needed in this area. BAM Rail and Spoorflex, in their respective capacities as subcontractor and employment agency, did not feel it was their responsibility to take action.
- BAM Rail also indicated – well before the accident in Stavoren – that it would prefer to see an end to the practice of pilot drivers on rail grinding train transfer journeys. According to BAM Rail's proposal, fully-certified Dutch train drivers would receive additional training so that they could operate the rail grinding trains themselves. However, the proposal was not implemented prior to the accident at Stavoren, as BAM Rail and Speno could not agree on insurance issues.

The Safety Board has concluded that both of the above issues were addressed after the Stavoren accident (see 5.9) and is of the opinion that the parties involved could have been expected to do so earlier. This could (and should) have been achieved through adequate mutual agreements between the companies involved. The Safety Board is of the opinion that ProRail, in its capacity as commissioning party, should have explicitly stated which control measures were needed in order to ensure the safety of transfer journeys, and/or indicated to which extent the risks were to be controlled.

The Safety Board is aware that the lack of clear agreements can be partly attributed to ProRail's failure – as described in section 5.4 – to recognize (prior to the accident in Stavoren) that transfer

journeys with rail grinding trains involve other (combinations of) risks than normal passenger train journeys. In the opinion of the Safety Board, the aforementioned situation also reflects ProRail's failure to prioritize the safety aspects during the rail grinding project.

The Safety Board would also point out that the contractors (Speno, BAM Rail and Spoorflex) should have independently assessed the need for control measures on the basis of their own responsibility, regardless of whether such agreements had been put in place.[76]

5.7.5 Subconclusions

Subconclusions regarding the extent to which outsourcing played a role in the failure of risk management:

- The construction chosen should not have caused any problems in controlling the safety risks provided the parties had made clear agreements and monitored compliance. However, they failed to do so, and the consultations among the parties did not result in achieving a joint approach.
- The lack of clear agreements or proper consultations resulted in a situation where the management of safety risks was delegated to a company, BAM Rail, who as the subcontractor, did not feel it was its task to take far-reaching control measures of its own accord.
- The lack of clear agreements and constructive consultations can be attributed to the companies´ failure to recognize the specific risks involved in transfer journeys.

5.8 Research question 4: Government supervision

This section describes government supervision of the parties' compliance with laws and regulations. Similar to the description of laws and regulations in Chapter 3, this section distinguishes between the Railways Act and the Work Conditions Act.

5.8.1 Railways Act

IVW is responsible for the safety aspects of Railways Act compliance (see chapter 4). The below section summarizes IVW´s approach to the underlying causes of this accident in its capacity as supervisory authority (see 5.2.2).

- As regards two of the underlying causes, the situation was not in accordance with applicable laws and regulations:
  - According to Article 24 of the Railway Personnel Decree, the train driver's route knowledge should have been in accordance with the standards applied by his employer, which was not (at least not demonstrably) the case here. IVW monitors compliance in this area by conducting random checks as a part of its audits of railway companies and employment agencies, in order to assess whether train drivers meet the company's requirements in terms of their route knowledge. This audit is administrative rather than substantive. In the case of this accident, IVW (in 2007 and 2008, respectively) conducted audits of Spoorflex and BAM. In both cases, the audit resulted in an extension of the certificate and/or recognized status for a period of three years.
  - According to the Rail Traffic Regulations, approach markers are categorized as 'supplementary to existing light signals'. However, the approach marker at Stavoren was used independently, not as a 'supplement to an existing light signal'. IVW does not conduct systematic inspections in this area to check whether the signalling system has been implemented in accordance with the relevant laws and regulations. Although IVW does assess the implementation of signalling systems as a part of accident investigations, no such assessments of the marker were conducted prior to the accident at Stavoren.

76 This is also stipulated in Article 3 (paragraphs 3 and 4) of the European Railway Safety Directive (2004/49/EC).

- As regards the three other underlying causes (lack of ATB monitoring, piloting and crew members in the cabin) the situation at Stavoren – as mentioned before – complied with applicable laws and regulations.
- The remaining three underlying causes (divergence from the work plan, error in track layout plan and lack of location markers) are not subject to any laws or regulations.

Section 3.1.1. describes how the railway legislation – in addition to the specific aforementioned requirements – also contains an obligation to ensure safety. In essence, railway managers and railway companies are expected to ensure that the safety risks of rail traffic are adequately controlled through suitable measures. Based on this obligation, IVW could require ProRail and BAM Rail to take more extensive control measures than those specifically prescribed. The Safety Board feels this was justified with regard to rail grinding train transfer journeys. After all, these journeys - as outlined in previous sections of this report - involved a higher risk level than 'normal' train journeys. In addition to the practice of piloting and crew members in the cabin, the Safety Board is mainly referring to the lack of ATB monitoring on track sections with ATB-NG.

As described below in section 5.9, IVW did call on the companies involved to take compensatory control measures for transfer journeys carried out by self-propelled maintenance machines along track sections with ATB-NG as a result of the accident at Stavoren. The Safety Board is of the opinion that IVW should have done so at an earlier point in time. According to the Safety Board, a previous incident with a rail grinding train (in Zwolle in 2007, see 5.6.3) provided sufficient grounds to do so. This accident also involved a combination of risk factors (such as piloting and passengers in the cabin) and the lack of ATB monitoring. Shortly after the incident in Zwolle, IVW did determine that all self-propelled maintenance machines were to be equipped with ATB systems. The Safety Board feels it would have been better if IVW had simultaneously obliged the companies involved to take additional measures for situations in which trainborne ATB systems do not result in effective ATB monitoring. IVW could have used the deployment certificate as a means of achieving this goal.

5.8.2 Working Conditions Act

The monitoring of Working Conditions Act compliance (in the area of maintenance work on the railway infrastructure) is conducted by IVW, and consists of inspections and incident investigations.

Government supervision of safety at work while performing work on railway tracks covers the activities themselves as well as the associated transfer journeys. In day-to-day practice, however, focus was seldom placed on the latter. The reason for that is that prior to the Stavoren accident the Health and Safety Inspectorate had not identified any major safety-at-work risks associated with the transfer journeys.

A Health and Safety Inspection was not conducted in connection with the Stavoren accident. Normally speaking an inspection of this nature is only performed if an accident involves fatalities, permanent injury or hospitalisation, which, as previously stated, was not the case.

5.8.3 Subconclusions

Subconclusions regarding government supervision of compliance with laws and regulations:

- The Transport, Public Works and Water Management Inspectorate (IVW) could have reminded the companies involved of their own responsibility prior to the accident in Stavoren, and requested that they take additional measures for situations in which the ATB systems do not result in effective ATB monitoring. IVW did request that the companies involved do so in response to the accident at Stavoren. The Safety Board feels IVW should have done so at an earlier opportunity.
- The supervision of safety at work when performing work on the railways focused on the actual activities rather than the transfer journeys involved in these activities. In the opinion of the Safety Board, this distinction is unjustified.

5.9 Research question 5: Measures taken by the parties involved

This section describes the measures implemented by the companies involved, the Ministry of Transport, Public Works and Water Management and IVW.

5.9.1 Measures taken in response to Stavoren

a) Measures taken by IVW
On 27 July 2010 (two days after the accident) IVW concluded that there were similarities between the incident at Stavoren and the 2007 incident in Zwolle (see 5.6.3). These similarities include piloting, ensuring the train driver's route knowledge, communication between the train driver and other individuals in the cabin during the journey and – in a more general sense – the measures taken as part of the obligation to ensure railway safety. IVW came to the preliminary conclusion that there had been insufficient structural improvements in these areas and decided to suspend journeys with rail grinding trains over railway tracks that are in service until further notice (by introducing a limitation to the BAM Rail safety certificate). In order for the ban to be lifted, BAM Rail was required to meet the following preconditions: identify the risks of driving with rail grinding trains, take suitable control measures and monitor compliance.

BAM Rail and IVW then prepared the following package of provisional measures over the course of a consultation on 28 July 2010:
- An Independent Safety Assessor (ISA) was to conduct an independent assessment of BAM Rail's project management system for the rail grinding process.
- The rail grinding trains would no longer be allowed to drive independently during transfer journeys, but would now be towed by a locomotive.

Based on these preconditions, BAM Rail received permission from IVW to resume rail grinding train journeys over railway lines that are in service in an email of 30 July 2010 and a letter of 2 August 2010.

The subsequent ISA assessment concluded that BAM Rail had sufficient control over the rail grinding project. In parallel to this assessment, BAM Rail conducted a risk analysis establishing that the practice of towing rail grinding trains to the work site heightened the risk level on-site, due to the need for additional shunting activities. The analysis showed that the overall risk could be lowered by driving the rail grinding train to the work location on its own (with a pilot train driver). In response to the accident at Stavoren, BAM Rail then entered into an agreement with Speno to abolish the practice of piloting and allow BAM Rail train drivers to operate the rail grinding trains. To this end, the train drivers did require retraining. As a result, the measure could not take effect until 1 December 2010.

Based on the ISA assessment[77] and BAM Rail's announcement that it would be abolishing the practice of piloting, IVW revoked the restrictions on BAM Rail's safety certificate in a letter dated 8 October 2010.

IVW sent out a safety warning to all railway companies on 5 August 2010, regarding the dangers of driving without ATB monitoring. As this warning pointed out, applicable laws and regulations imply that the companies involved are expected to assess the need for additional control measures in such situations (based on their own responsibility and obligation to ensure safety).

77 Remarkably, the assessment (in accordance with the assignment coordinated between IVW and BAM Rail) mainly focused on rail grinding activities and only to a limited extent on transfer journeys. BAM Rail deals with the transfer journeys in a general RI&E, while the assessment – as instructed by IVW – focused on BAM Rail's specific RI&E with respect to the rail grinding project. The assessor's report explicitly states that the assessment was not aimed at the accident in Stavoren.

b) Measures taken by ProRail

Based on its own investigation (report published on 20 October 2010) and its consultations with other companies and the Ministry, ProRail implemented/announced the following measures:

- On 4 August 2010, ProRail revoked its certification of Spoorflex. As a result, Spoorflex was no longer authorised to supply safety staff for ProRail activities. The revocation of the certification was reversed following interim injunction proceedings on 13 August 2010. Spoorflex applied for a suspension of payments several weeks later, and has meanwhile been declared bankrupt.
- ProRail decided to decommission the ATB switch off sections at the start of track sections with ATB-NG. As a result, vehicles with ATB-EG or ATB-E can no longer exceed 40km/h on these track sections. Pending the implementation of these technical measures, ProRail prohibited railway contractors from deactivating the trainborne ATB systems in maintenance machines on ATB-NG track sections.
- ProRail prohibited its rail traffic controllers and all contractors working on its behalf from diverging from Workplace Safety Instructions without applying the mandatory escalation procedure.[78]
- At the Railway Companies Safety Consultation,[79] ProRail called on railway companies and IVW to limit the number of people allowed in the cabins of self-propelled maintenance machines as much as possible. ProRail does not feel it is in a position to push through such measures in its capacity as infrastructure manager.[80]
- In 2011, ProRail will replace the marker at Stavoren with a light signal. This decision was made in connection with a modification of the railway track configuration at Stavoren station in order to allow a historic steam train to use the Leeuwarden-Stavoren line.
- ProRail has corrected the track layout plans of the Leeuwarden- Stavoren track section. A random check was conducted to establish to which extent other track layout plans also contain comparable mistakes. The check revealed similar errors in multiple track layout plans, prompting ProRail to launch a process to check all track layout plans and make corrections where necessary.
- In early 2011, ProRail initiated a project to assess the use of 'outdated signs and signals'.

c) Measures taken by Speno

The accident at Stavoren promoted Speno to take the following additional measures:

- Speno has agreed to ensure that all transfer journeys with rail grinding trains are operated by BAM Rail train drivers (as of early December 2010).
- The rail grinding train cabins have been fitted with more advanced equipment to record various data, including conversations during the journey.

d) Measures taken by BAM Rail

Partly on the basis of its own investigation into the Stavoren accident (report published on 24 August 2010), BAM Rail implemented/announced the following measures:

- BAM Rail will no longer hire external staff to perform the train driver function on rail grinding trains carrying out transfer journeys but now deploys its own staff. Incidentally, this also is a requirement stipulated by Speno and BAM Rail.
- The practice of piloting during transfer journeys was abolished. As of 1 December 2010, all rail grinding trains are operated by BAM Rail train drivers.
- During preparations for rail grinding activities, targeted checks will be conducted to assess whether the track layout plans are up-to-date.
- All activities will be conducted on the basis of the relevant documentation (including the Workplace Safety Instructions). In the event of any divergences from existing plans, staff must adhere to the mandatory escalation procedure.

78 In respect of the Stavoren accident, the Workplace Safety Instructions (WBI) were not deviated from; The work plan was changed within the framework of the relevant WBI.

79 The Railway Companies Safety Consultation facilitates active participation, harmonisation and consultation between infrastructure managers, transport operators, IVW and the policy department of the Ministry of Infrastructure and the Environment (previously the Ministry of Transport, Public Works and Water Management). The participating parties also exchange information and assess proposals for new railway safety legislation.

80 In the opinion of the Safety Board, ProRail is in a position to push through such changes in its capacity as commissioning party.

- Rail grinding trains on transfer journeys along ATB-NG track sections will be towed by locomotives fitted with ATB-NG systems. If this is not possible, the maximum speed will be limited to 40km/h.
- Additional measures will be taken to ensure that all train drivers have sufficient route knowledge.
- BAM Rail will prohibit more than three people from travelling in the cabin of a maintenance machine during transfer journeys.

e) Adjustment of sector regulations
The railAlert Foundation will assess the need to further elaborate the Safety at Work Standards Framework (NVW) in the area of staff and equipment transportation (this will include an assessment to determine whether these activities should be a mandatory part of the Health & Safety Plan).

5.9.2 Legislative changes
The Railways Act and the Railway Personnel Decree (*Besluit Spoorwegpersoneel*, BSP) are set to be amended over the course of 2011.[81] The new legislation will enter into force in autumn 2011.

Among other provisions, the amended Railways Act stipulates that:
- Maintenance machines and historic locomotives/trains are subject to the same ATB requirements as passenger and freight trains (thus bringing an end to their current exceptional status);
- In the event of incompatibility between trainborne and trackside ATB systems, vehicles will be subjected to a 40km/h speed limit.

The Ministry has requested that ProRail deactivate the ATB switch off sections at the start of ATB-NG track sections. The Ministry has also indicated that tailor-made exemptions will be needed in incidental situations where a vehicle with ATB-EG or ATB-E equipment travels over an ATB-NG track section.

The amended Railway Personnel Decree includes changed requirements relating to the route knowledge of train drivers. These are based on European requirements, incorporated into Directive 2007/59 EC on the certification of train drivers. The new decree includes more stringent requirements on the route knowledge of train drivers and prescribes that their knowledge be tested based on a mandatory government test rather than a test by the company itself.

5.9.3 Controlling the safety risks identified
The above means that additional measures have meanwhile been taken, which have helped to remove or reduce a significant proportion of the underlying risks.

However, the Safety Board has concluded that ambiguous legislation relating to passengers travelling in the cabin during transfer journeys carried out by self-propelled maintenance machines has not yet been dealt with. It is also unclear to which extent the transfer journeys are actually incorporated in the companies' risk analyses and project Health & Safety plans. The Safety Board would like to point out that companies are obliged to reduce the risks of transfer journeys to ALARP level. This implies that all potential control measures must be implemented, unless there are valid arguments against doing so.

81 The amendment to the Railways Act was published in the Bulletin of Acts, Orders and Decrees 2011-218 and the amended Railway Personnel Decree in issue 2011-240 of the same publication.

5.9.4 Subconclusions

Subconclusions regarding the measures taken following the accident:

- The companies involved, the Ministry and IVW have implemented various measures to control the safety risks that played a role in the Stavoren accident. An issue that has not yet been dealt with is structurally preventing several people from travelling in the cabin during transfer journeys carried out by self-propelled maintenance machines.
- It is unclear whether the companies involved are actually incorporating the transfer journeys in their risk analyses and Health & Safety Plans. In the Safety Board's view, it is desirable that they do so.

6 CONCLUSIONS

This investigation focused on the question: *what lessons can be learned from the accident in Stavoren in terms of risk management during transfer journeys carried out by rail grinding trains, the relevant regulations and supervision thereof?* This key question was elaborated in five research questions (see section 5.1), the answers to which are given below:

Conclusion 1. The immediate cause of the accident in Stavoren on 25 July 2010 was that the rail grinding train braked too late when approaching the end of the line. This is because the train driver did not comply with the indicated signal and the ATB system was inoperative.

The fact that the indicated signal was not obeyed, and the ATB system was inoperative is attributable to a number of underlying causes:
The signal was not obeyed on account of the following:

a. the expectations of the train driver in respect of the type of signalling system were incorrect on account of his poor route knowledge, an error on the track layout plan he was using and because the work plan was revised at a late stage;
b. an uncommon signal (an approach marker) was used, which was only visible for a relatively short period of time, and
c. the train driver's attention had been diverted from driving the vehicle because he was not operating the train himself (but was acting as a pilot) and was talking to a rail grinding train employee who was in the cabin;
d. the train driver had difficulty in determining the position of the train because a number of the location markers along the route were missing.

The ATB system was inoperative on account of the following:

a. the ATB equipment on the train was incompatible with that of the ATB equipment on the track section; and
b. the ATB equipment on the train automatically switched to offline mode by means of an ATB switch off section located at the start of the track section.

Conclusion 2. The factors underlying the accident at Stavoren are not unique to this accident nor are they unique to transfer journeys carried out by rail grinding trains.

Various risks that came into play during the Stavoren accident also came into play during transfer journeys carried out by other self-propelled maintenance machines (including video observation trains and other measurement trains). This applies mainly to driving without ATB protection on track sections equipped with ATB-NG, having several people in the cabin, a train driver piloting the train and having limited route knowledge. Errors in track layout plans, missing location markers and changing work plans also occur frequently. It was furthermore found that incidents in which self-propelled maintenance machines pass signals set at danger occur on average at least twice a year in which a number of the same risks come into play as those in the Stavoren accident.

Conclusion 3a. The companies involved did not properly define the specific risks involved in transfer journeys carried out by rail grinding trains. They were under the obligation to do so pursuant to both Railway legislation and Working Conditions legislation.

A risk analysis of the rail grinding project had been carried out – within the scope of the Health and Safety Plan – but this only focused on the risks involved in the rail grinding activities themselves and not on the transfer journey made by the rail grinding train. The companies involved regarded transfers journey carried out by rail grinding trains as normal train journeys and were insufficiently aware of the fact that transfer journeys involve other risks than normal train journeys. The safety at work sector regulations moreover did not stipulate that these particular journeys were to be included in the Health and Safety Plans in the event that work is carried out on the railway infrastructure.

One of the specific risks of which the railway sector was insufficiently aware was the fact that the majority of self-propelled maintenance machines are not equipped with ATB-NG, while these vehicles are in fact deployed on track sections featuring ATB-NG. Moreover, the relevant track sections featured ATB switch off sections which enabled maintenance machines not fitted with ATB for the purpose of monitoring compliance with signals to exceed a speed of 40km/h.

Conclusion 3b. The companies involved did not adequately control the risks involved in the transfer journeys carried out by the rail grinding trains. This is mainly attributable to the fact that they were unaware of some of these risks, and in respect of controlling the other risks, restricted themselves to the specific regulations stipulated in the Railways Act. This means that they inadequately fulfilled their own responsibility and duty of care (based on both the Railways Act and the Working Conditions Act). In the area of legislation, the Safety Board is of the opinion that the regulations particularly relating to the use of approach markers (*keperbaken*), the train driver's route knowledge and passengers travelling in the cabin must be made clearer and/or tightened.

The companies involved did not adequately control the various risks involved in the transfer journey made by the rail grinding train, namely: (a) instead of a light signal, an approach marker had been placed at Stavoren; (b) the requirements imposed on the train driver's route knowledge were lower than usual for drivers of passenger trains; (c) the rail grinding trains were piloted; (d) passengers were allowed to travel in the cabin while there was no urgent reason for doing so; (e) the rail grinding train was equipped with an ATB system which was incompatible with that of the ATB equipment on the track section; (f) the ATB switch off sections located at the start of the ATB-NG track sections had not been taken out of service; and (g) there were no measures in place to ensure that the mandatory escalation procedure was followed in the event of deviations from the work plans.

For a number of the risks the course of events did not contravene the current regulations, including those of the sector. However, this does apply to the train driver's route knowledge and failure to observe the escalation procedure. In the Safety Board's opinion, the regulations relating to these subjects provide leeway for parties to fulfil these requirements inadequately, and for that reason the regulations must be made clearer and/or tightened. In the Safety Board's opinion, the latter also applies to the regulations relating to the use of approach markers.

Conclusion 3c. The companies involved have only learned to a limited extent from comparable incidents in the past.

In the past ten years 18 incidents have occurred involving rail grinding trains and other self-propelled maintenance machines that did not comply with a signal (in time) during a transfer journey. Looking at the underlying causes, the Stavoren accident reflects many similarities with an incident in Zwolle in 2007. Even though a number of improvement measures were taken as a result of the incident in Zwolle, it has emerged from this investigation that adequate risk control measures have not yet been taken for a number of the safety risks established at that time. The Safety Board had primarily expected ProRail (as the infrastructure manager and the party commissioning the rail grinding project) and Speno (as the principal contractor for the rail grinding project) respectively to take a more pro-active approach on this point.

Conclusion 3d. In the structure selected for contracting out the project, it would have been possible to control the risks adequately during the transfer journeys provided the companies had made proper agreements on the risks. Since the companies failed to do so, the situation arose in which risk control had been entrusted to a company (the subcontractor) which did not feel obliged to take adequate control measures of its own accord. In addition, the consultation among the companies failed to produce a joint approach.

The selected structure would not necessarily have been a problem in controlling the safety risks provided the relevant parties had made proper agreements on these risks and had checked whether these agreements had been fulfilled. This was not the case, however. On account of the above, the situation arose in which a company, BAM Rail, as the subcontractor did not feel obliged

to take far-reaching measures of its own accord to control the safety risks involved in the transfer journeys. The lack of proper agreements was caused by the fact that the relevant companies did not fully understand the specific risks involved in the transfer journeys.

Conclusion 4. Supervision of risk control relating to transfer journeys carried out by rail grinding trains was not performed to ensure compliance with the Working Conditions Act. Supervision was indeed performed to ensure compliance with the Railways Act, however this focused mainly on the specific requirements with too little focus placed on the railway companies fulfilling their own responsibility or duty of care.

Based on previous incidents IVW was aware of the specific risks involved in carrying out transfer journeys. However, prior to the Stavoren accident the relevant companies had not been held accountable for their duty of care to ensure that they would take further measures supplementing the specific requirements (particularly for situations where the ATB equipment installed on trains does not lead to effective ATB monitoring). On account of the absence of these measures, prior to the accident the companies involved had no incentive to improve control of the safety risks and this was also not enforced. In the event of work carried out on the railways, the supervision of safety at work focused only on the work itself, and not or hardly on the associated transfer journeys.

Conclusion 5. As a result of the Stavoren accident, the companies involved and IVW have initiated a number of measures designed to tackle the underlying causes. In addition to finalising these measures, the Safety Board deems additional measures essential.

The Safety Board has established that the underlying causes will partially be removed based on the measures initiated following the accident. However, this does not mean that all safety risks will be adequately controlled. The Safety Board deems additional measures essential in respect of 'the use of approach markers', 'passengers travelling in the cabin' and 'structurally pre-assessing the risks that could arise during transfer journeys carried out by maintenance machines'.

7 RECOMMENDATIONS

On the basis of the investigation, the Safety Board has formulated the following recommendations:

Following the Stavoren accident, the companies involved, the Ministry of Infrastructure and the Environment and the Transport, Public Works and Water Management Inspectorate have taken a range of measures to ensure improved control of the safety risks that played a role during the accident. The Safety Board believes that it is vital to actively implement these measures and any other necessary measures. The Safety Board furthermore believes that the improvements should not only relate to transfer journeys carried out by rail grinding trains but also to other maintenance machines, to the extent applicable. The Safety Board believes ProRail should assume a central role because of its position as the railway infrastructure manager and the party commissioning the outsourced maintenance work.

Recommendation 1: ProRail
Take full responsibility for the safety of your own projects, including work that has been outsourced. This implies inter alia to implementing the required measures to adequately control the safety risks relating to transfer journeys carried out by rail grinding trains and other self-propelled maintenance machines.

Furthermore, the Safety Board deems it necessary that a number of the aspects of the general and sector-specific regulations be clarified/tightened.

Recommendation 2a: Netherlands Association for Railway Regulations and Documentation (VSD)
Ensure that the sector regulations concerning passengers travelling in the cabin are tightened.

Recommendation 2b: railAlert Foundation
Ensure that the issue of 'transporting staff/material/equipment' becomes an integral part of sector regulations for safety at work when working on the railways (Safety at Work Standards Framework, NVW, and the Safety at Work Regulations, VVW).

Recommendation 2c: ProRail
Ensure that the rules relating to the application of uncommon signals and signs (such as the approach markers) are tightened.

Administrative bodies to which a recommendation is addressed should state their position in respect of compliance with this recommendation to the relevant minister within six months of the date of publication of this report. Non-administrative bodies or persons to whom a recommendation has been addressed should state their position in respect of compliance with this recommendation to the relevant minister within one year of the date of publication of this report. A copy of the response should at the same time be sent to the Chairman of the Dutch Safety Board and the Minister of Safety and Justice.

After the response term has elapsed the Dutch Safety Board will publish the responses received on the report on its website www.onderzoeksraad.nl/en. In the event no responses are received, this will also be stated on the above website.

APPENDIX 1: EXPLANATION OF THE INVESTIGATION

Dutch Safety Board investigations

The Dutch Safety Board independently investigates the causes or probable causes of incidents. Investigations undertaken by the Safety Board not only seek to identify the actual causes of incidents but are mainly aimed at bringing to light the underlying causes and any shortcomings at system level. If structural safety shortcomings come to light during an investigation, the Safety Board can formulate recommendations to resolve these shortcomings. The purpose of this investigation is consistent with the above: by investigating the accident at Stavoren the Safety Board aims to learn lessons in order to prevent such accidents in the future or limit the consequences thereof.

Reason for the investigation

On account of the scale and the damage incurred, this particular accident is subject to a mandatory investigation by the Safety Board (as stated in Article 8a of the Dutch Safety Board Decree). Moreover, based on the information collected at the site of the accident, there are reasons to suspect that the accident was probably caused by a combination of factors that were inadequately controlled.

Research questions

The key question in this investigation is: *what lessons can be learned from the accident at Stavoren in terms of risk management during transfer journeys carried out by rail grinding trains, the relevant regulations and supervision thereof?*

This key question was elaborated in the following five research questions:

1. What were the immediate causes of the accident and what are the underlying factors that played a role in this context?
2. To what extent are the underlying factors unique to this accident?
3. What procedures did the companies follow in managing the safety risks during transfer journeys carried out by rail grinding trains, and to what extent have the companies fulfilled their own responsibilities in this respect?
    a. To what extent have the companies involved predefined the safety risks relating to transfer journeys carried out by rail grinding trains?
    b. How did the companies involved deal with the risks, and what role has current legislation played in this context?
    c. To what extent have the companies involved learned lessons from comparable incidents that have occurred in the past?
    d. How was risk management dealt with in respect of the transfer journeys in the context of contracting out work, and to what extent did that approach play a role in the failure of risk management?
4. To what extent has the government monitored compliance with the relevant legislation?
5. What measures have the companies involved and the government taken as a result of the accident in Stavoren?

Other investigations

In addition to the Safety Board's investigation, the parties involved (ProRail, Speno International, BAM Rail and Spoorflex), the National Police Services Agency (KLPD) and the Transport, Public Works and Water Management Inspectorate (IVW) conducted investigations at the site of the accident. Delta Rail conducted a further investigation into the possible technical cause of the train accident in Stavoren, on behalf of, and under the direction of the Safety Board. Additional expertise

was provided on a number of aspects by specialists at the National Police Services Agency (KLPD) and Intergo[82] respectively.

The Public Prosecutor conducted a criminal investigation, while IVW conducted an investigation into enforcement. Among the companies involved, ProRail, BAM Rail and Spoorflex drew up their own investigation report.
The findings of the above investigations were communicated to the Safety Board.

Investigation method

The investigation consisted of an on-site investigation, studying documents and interviews. The interviews were conducted with staff members from the various parties involved, in this case ProRail, Speno International, BAM Rail, Spoorflex, IVW, the Health and Safety Inspectorate, the Ministry of Transport, Public Works and Water Management, and the railAlert Foundation. The purpose of these interviews was to gain an insight into the cause of the accident and the manner in which the various parties fulfilled their own responsibility for controlling the risks involved in transfer journeys carried out by maintenance machines.

Tripod analysis

An analysis based on Tripod Beta (referred to as Tripod) was performed as part of this investigation. Tripod provides a framework within which findings about the relevant facts behind an incident can be systematically collected and analysed. The basic principle of the Tripod model is that accidents can normally be prevented by safety barriers but could occur if these barriers are not present or fail. Tripod furthermore assumes that barriers fail on account of the fact that active errors are made, and supports the investigator in identifying the causes of such errors. In this respect, a distinction is made between facts and circumstances underlying the active errors (called preconditions) and structural safety failings underlying the preconditions (called the underlying factors).[83]

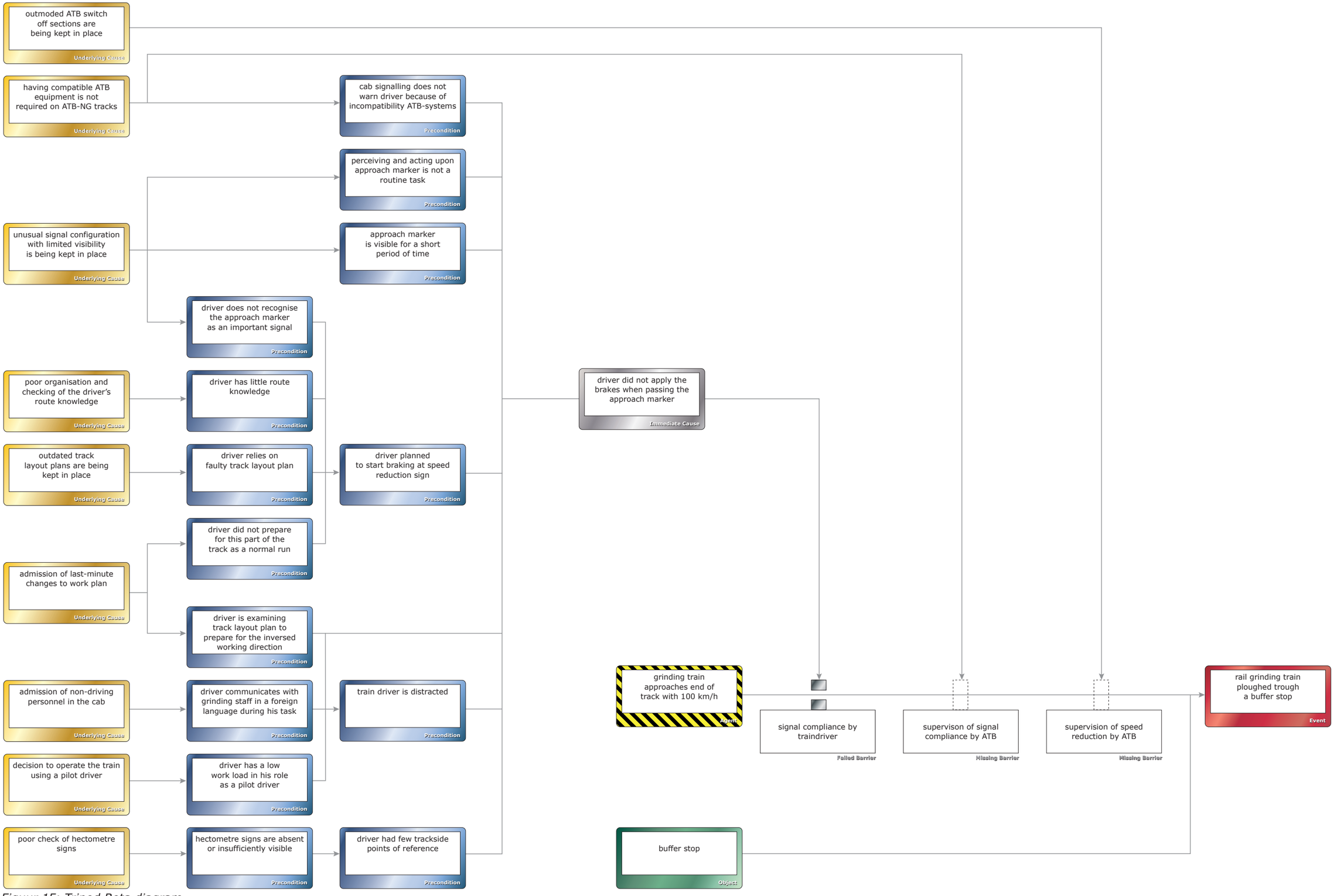
The Tripod Beta diagram is shown on the next page. In respect of the barriers, only the control measures which the Safety Board views as relevant to this particular accident have been included. These are as follows: 'the train driver obeying the signalling system', 'ATB monitoring of compliance with the signals' and 'ATB monitoring of the 40km/h speed restriction'. The diagram also shows the identified preconditions and underlying factors, more information on which is provided in Chapter 5.2.

Project team

The project team comprised the following people:	
J.J.G. Bovens	Investigation manager
R.J.H. Damstra	Project manager
A. Sloetjes	Investigator
R.D. Damstra	Investigator (external)
M. van het Loo	Process Support Department
N. Smit	Investigation advisor

The following people made a significant contribution to this report:	
J.M. Schuite	Legal assistance
M. van Zuijlen	Legal advisor
D.W. de Bruijn	Ergonomist and psychologist

82 Ergonomics consultancy firm.
83 For further information on the system of notation, see the Tripod Beta User Guide, http://www.tripodfoundation.com



Figuur 15: Tripod Beta diagram.

APPENDIX 2: RESPONSES RECEIVED FOLLOWING REVIEW OF THE REPORT

In accordance with the Safety Investigation Board Act *(Rijkswet Onderzoeksraad voor Veiligheid) a* copy of this report was submitted for review to the parties involved. The parties were asked to check the report for errors or ambiguities. The review version of the report was submitted to the following parties:

- Train driver
- Workplace Safety Leader
- ProRail
- Speno International S.A.
- BAM Rail
- railAlert Foundation
- Netherlands Association for Railway Regulations and Documentation (V*ereniging voor Spoorwegregelgeving en Documentatie*, VSD)
- Ministry of Infrastructure and the Environment and the Transport, Public Works and Water Management Inspectorate
- Ministry of Social Affairs and Employment, and the Health and Safety Inspectorate

All of the parties approach responded to the report, except for railAlert. The VSD stated that it did not have any comments on the content of the report. The responses received from the other parties have been included in a table that can be found of the Dutch Safety Board's website: www.onderzoeksraad.nl/en. The table shows to which section each response relates and the party providing the response. The table also states whether or not each response has led to amendment of the report. Wher e responses have resulted in amending the report (shown in the green fields), a general statement has been provided on how this has been carried out; where responses have not resulted in amending the report (shown in the yellow fields), the Safety Board's response is included.

APPENDIX 3: EXPLANATORY NOTES ON THE FACTS RELEVANT TO THE INVESTIGATION

This appendix describes a number of aspects of the investigation into the relevant facts behind the Stavoren accident. The following aspects have been examined one by one: 1) the rail grinding train specifications, 2) the tachograph investigation, 3) the investigation into the condition of the braking system and 4) the investigation into the condition of the railway infrastructure.

1. Rail grinding train specifications

Vehicle class	Special vehicle – rail grinding train
Type	RR48 M
Machinery number	99 B7 9 127 507-1
Serial number	RR48M5 – 56023
Date of construction	2006
Manufacturer	Speno International S.A.
Owner	Speno International S.A.

Information/restrictions based on the deployment certificate	
Deployment certificate	VENW/IVW-2010/54834/K72.413.353, issued on 12 July 2010
Permitted deployment	Self-propelled, the entire Dutch railway network, except for ERTMS track sections
ATB	ATB-E, including ATB-VV functionality
Train detection system	Suitable for all train detection systems
Load category (pursuant to the deployment certificate)	C2 with empty water tanks, D with full water tanks. If the vehicle is driven with full water tanks on track sections specified as C2 load class, ProRail B&I must be contacted about any possible vehicle deployment restrictions.

2. Tachograph investigation

The rail grinding train was not equipped with a an automatic trip registration system (*Automatische Rit Registratie,* ARR) as is usual in the Netherlands, but with a tachograph. This recording method complies with the statutory requirements. The tachograph records the speed and the distance covered by the vehicle on a strip of paper. Unlike the train event recorder, a tachograph does not record the operational actions taken by the train driver.

At the Safety Board's request the strip of paper was analysed by Delta Rail and by the National Traffic Assistance Team (LVBT), a department of the National Police Services Agency (KLPD). They answered the following questions:

- At what speed was the train driving when it passed the approach marker?
- To what extent did the train brake prior to the crash?
- At what speed was the train driving when it crashed into the buffer stop?

The KLPD first investigated whether the tachograph was sufficiently reliable. By comparing the record of the journey between Workum and Hindeloopen with the actual distance between these stations, the KLPD concluded that the records are reliable and do not need to be adjusted.

The tachograph records show the following:

- When the train passed the approach marker it was driving at a speed between 94-95 km/h.
- At about 154 metres from the buffer stop, when the train was travelling at a speed of around 95 km/h, it initially decelerated slightly to around 91km/h. It then decelerated even more and after that – from a speed of around 81km/h – decelerated abnormally/erratically. The initial

slight deceleration probably relates to the time at which the braking system was applied and the abnormal/erratic deceleration at the end was probably caused by the crash.
- The collision speed (at the buffer stop) is likely to have been around 81km/h.

Based on the course of deceleration described above, the Safety Board deems it likely that the braking system was operated when the rail grinding train was still about 154 metres away from the buffer stop.

3. Braking system

During the technical investigation of the train, the following three questions relating to the train's braking system were looked at:
- Were the brake levers in the correct position?
- What was the technical condition and maintenance level of the braking system?
- Was there anything unusual about the wheel treads of the train?

Position of the brake levers
The braking system on the rail grinding train is fitted with two brake levers per train unit (see figure below). One lever can be used to switch the braking system 'on' or 'off'; the other lever must be in set in position P in self-propelled mode (as was the case at the time of the accident), and in position G when towed (as part of a long goods train).

Figure 16: This photograph shows the two brake levers that feature on the units of the rail grinding train (in their correct position).

After the accident, all nine units of the rail grinding train were examined to find out whether the brake levers were in the correct position. The levers on five train units were found to be in the correct position. The levers on three train units were found to have broken off after the accident, making it impossible to determine their position; the remaining part of one of the levers was found in position G, whereby it should be noted that the position of this particular lever is likely to have changed during or as a result of the accident. The front unit of the train had sustained such severe damage that it was not possible to determine the position of the brake levers.

Condition of the brakes
The two rear units of the rail grinding train were virtually undamaged, which allowed the Safety Board to perform a thorough inspection of these units. It was established that the brakes on two of these units were in good condition. As a result of the damage sustained by the train it was difficult to inspect the brakes on the other units, however there was no evidence to suggest that the brakes on these particular units were not in good condition.

It was established that the brakes on the wheel sets that had not sustained damage or had sustained limited damage had been 'pulled' (see figure 17).

Figure 17: This photograph shows that the brakes on the front train unit had been 'pulled'.

Wheel treads

Skid marks were found on the wheel treads. There were hotspots on a number of wheels (see figure 18); these are created by excessive overheating and indicate that the train braked heavily.

Figure 18: Hotspots on the wheel treads

4. Railway infrastructure

The following two aspects of the infrastructure were investigated:
- the skid resistance of the rails;
- the presence and readability of the location markers and speed restriction signs.

Skid resistance of the rails
The remains of leaves were found on and alongside the rails (see figure 19). These leaves were from trees (which had shed their leaves because of the dry weather) in the surrounding area, and from trees that had been pruned near the platform. The remains of the leaves on top of the rails were found to have been compacted; they were partly charred, which was caused by the high temperatures that occurred during braking.

Figure 19: This photograph shows part of the skid marks and the remains of leaves found.

The skid resistance level of the rails on the last part of the track section – the length of which is 850 metres – was determined by a Rail Tribometer (RTM). Figure 20 shows the result of the RTM measurement.

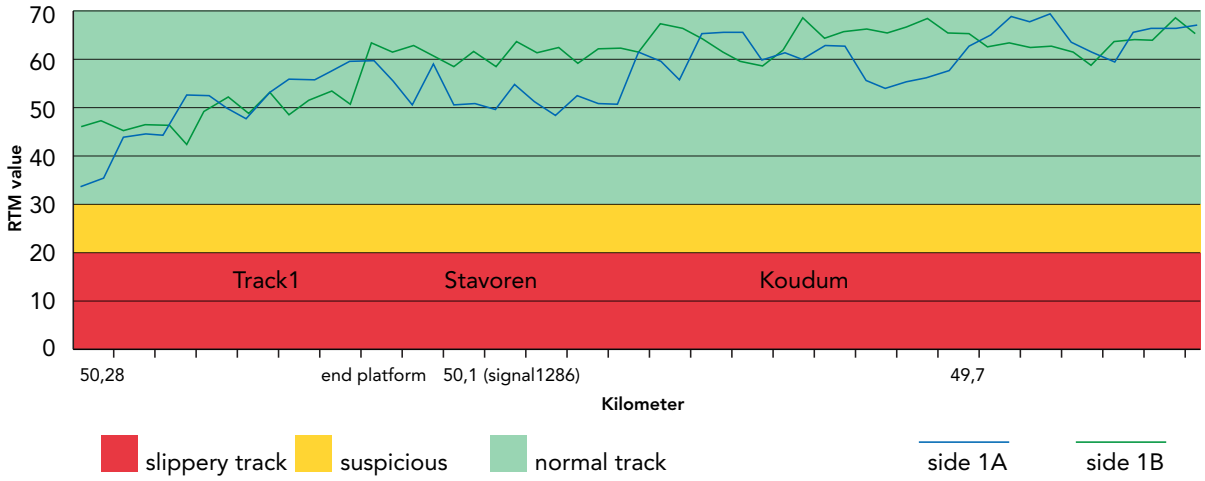


Figure 20: Results of the skid measurement

The measurements revealed that level of skid resistance of the rails was normal and that the rails were not 'slippery'. The skid resistance level of the rails on the last 20 metres of the track section was also measured in wet conditions; normal values were also established on this section.

Location signs and speed restriction signs
The signs on the track section were indicated on the visual instructions (track layout plan) available on board the rail grinding train. This track layout plan also shows (by means of kilometre values) the location of certain objects, including the platform and the buffer stop at Stavoren. The track layout plan also showed that there were two speed restriction signs at Stavoren Station: first sign 313 (slow down to 40km/h) and then sign 314 (maximum speed 40km/h).

Location signs (kilometre and hectometre signs) were placed alongside the railway track serving as orientation points for the train driver. Kilometre signs are normally placed at 'whole' and 'half' kilometres; these are usually mounted to catenary portals and in the absence of these portals (as was the case on this particular track section) the signs are mounted on 'long' poles. The hectometre signs are generally mounted to 'short' poles and are usually located near important objects (such as level crossings).

It was investigated to what extent the speed restriction and location markers were present and readable[84]. The findings revealed that:
- The speed restriction signs (313 and 314) indicated on the track layout plan were not present.
- Location markers:
  - A kilometre sign mounted on a high post was located at 49.0km; the sign was placed a short distance after the first approach marker and was turned at an angle of 45 degrees (see figure 21). No kilometre sign was present at 49.5km. However, a kilometre sign was present at 50.0km but had been turned at an angle of 90 degrees (as a result of which it was not readable from the train cabin).
  - A hectometre sign (49.2) was located at 49.343km (at the level crossing shortly before Stavoren), and another hectometre sign (50.3) was located next to the platform.

Figure 21: This photograph shows the small 49.0 km sign.

84 The investigation conducted by BAM Rail at the site was also used in respect of the location markers.

APPENDIX 4: EXPLANATORY NOTES ON SELF-PROPELLED MAINTENANCE MACHINES PASSING SIGNALS SET AT DANGER

The Stavoren accident involved a rail grinding train that was driving on a railway track that was in service to the deployment area. These vehicles are classified in the vehicle category 'self-propelled maintenance equipment'. Examples of such machines include tamping machines (which are used for maintenance work on the ballast bed) and the Eurail scout measurement train (which collects diagnostic data about the condition of the railway infrastructure as it travels along the track).

A number of risk factors that played a role in the Stavoren accident can also occur during transfer journeys carried out by other types of maintenance equipment. These factors are: driving trains featuring ATB-E train equipment on track sections with ATB-NG, driving with several people in the cabin and deploying train drivers who only drive the relevant track section very infrequently.

The Safety Board investigated to what extent in the recent past self-propelled maintenance machines carrying out transfer journeys have been involved in safety incidents similar to the course of events in the Stavoren accident. To that end, all self-propelled maintenance machines carrying out transfer journeys[85] that passed signals set at danger (*STS-passage*)[86] were selected from IVW incident database.[87] The period examined was 1 January 2001 to 1 July 2010.[88] The selection was limited to incidents in which signals set at danger were passed mainly because incidents of this type show similarities with the course of events in the Stavoren accident. The following incidents were not taken into account: incidents in which the maintenance machine was not self-propelled but was towed, and incidents in which the machine was leaving an area that had been taken out of service (which is not classified as a transfer journey).

The results of the selected incidents are shown in the table below:

	Speno rail grinding trains	Other self-propelled maintenance machines	Total
Signal passed at danger in which no damage was sustained	4	12	16
Signal passed at danger in which damage was sustained	1	1	2
Total	5	13	18

Overview of signals passed danger involving self-propelled maintenance machines

The above overview shows that in the period examined (almost 10 years) a total of18 incidents occurred in which self-propelled maintenance machines carrying out transfer journeys passed a signal set at danger, five of which were Speno rail grinding trains. This equates to around two incidents in which signals set at danger were passed per year, involving a Speno rail grinding train in around one third of the cases.

It was found that the 'ATB gap' that applied in the Stavoren accident (meaning that the accident occurred on an ATB-NG track section whereas the maintenance machine was equipped with ATB-E train equipment that had switched to offline mode) did not apply to any of the above 18 incidents during which a signal set at danger had been passed.

85 IVW databases do not explicitly state whether an incident occurred on a track that is in service or that is out of service. In this context, an interpretation was made based on the contextual information relating to the accident.
86 STS-passage is the Dutch term referring to signals passed at danger.
87 This was Misos until 1 January 2006, and thereafter the Hazard database.
88 1 July 2010 was chosen as the date because it is uncertain whether all incidents that occurred at a later date had already been included in the database. The Stavoren accident has therefore not been included in the overview.

APPENDIX 5: EXPLANATORY NOTES ON THE COMPATIBILITY OF ATB VERSIONS

ATB versions

ATB stands for Automatic Train Protection (*Automatische Trein Beïnvloeding,* Dutch abbreviation ATB), a technical system for improving and monitoring compliance with the speed restrictions the train driver receives en route. If a speed restriction is not complied with in time the train driver first receives a warning signal and if he then fails to start operating the braking system, automatic brake intervention occurs. In this context, an ATB system forms a technical safety net to prevent a train from 'driving through a red light' (also referred to as passing a signal set at danger).

In the Netherlands, apart from a few border track sections, three ATB systems are used as follows:
- two national systems: First Generation ATB (ATB-EG) and New Generation ATB (ATB-NG) respectively.
- A European system, known as the European Railway Traffic Management System (ERTMS).

Compatibility

An ATB system generally consists of two components:
- first, the trackside equipment, which transmits information to the train about the locally permitted speed and – for some systems – the distance along which the train is permitted to continue driving;
- second, the train equipment which controls the speed/distance and performs brake intervention if necessary.

The functional features of the above ATB systems differ in terms of information exchange between the trackside and trainborne equipment. As a result, the trainborne equipment only functions if it is compatible with the trackside equipment on the relevant track section. Generally speaking the following applies:
- ATB-EG trainborne equipment is only compatible with ATB-EG trackside equipment;
- ATB-NG trainborne equipment is compatible with both ATB-NG and ATB-EG trackside equipment;
- ERTMS trainborne equipment is only compatible with ERTMS trackside equipment.

ATB versions in the infrastructure

ATB was introduced in the Netherlands in the 1960s. ATB-EG was first installed on main lines and part of the secondary lines (the trunk network). The process was carried out up to around 1995 and over 2,000km of railway track (largely multi-track) was equipped with ATB-EG.

Around 1995, advanced ATB-NG became operational and the decision was taken to install that system on track sections that had not yet been equipped with ATB-EG. These track sections were a number of non-electrified secondary lines and a number of border track sections. That process was largely completed in 2005.[89] In total around 700km of railway track (single-track routes, operated by regional transport operators) was equipped with ATB-NG. The Leeuwarden-Stavoren track section falls within this category and was one of the last tracks to be converted (in 2005).

ERTMS was installed on two recently constructed track sections designated for international train traffic (the HSL-zuid for high-speed trains travelling to Belgium/France and the Betuweroute for goods trains travelling to Germany), and the new track section between Utrecht and Amsterdam.

89 At the end of 2005 only route sections bordering Belgium had not been equipped with ATB; a Belgian ATB system (MEMOR) was installed on these sections in 2010.

ATB versions installed on vehicles

In general, vehicles deployed along track sections carry the same ATB version(s) featured on that particular track section. For instance, this means that trains that are only deployed on track sections with ATB-EG are, or need only be, equipped with ATB-EG while trains that are also deployed on the Betuweroute (must) also carry ERTMS on board in addition to ATB-EG.

An exception to the above is made for self-propelled maintenance machines and historic trains (such as steam locomotives). Under the 'old' Railways Act, these trains were originally not required to carry ATB. When the current Railways Act entered into force in 2005, mandatory ATB entered into force for all vehicles capable of travelling faster than 40km/h, which also applies to this vehicle category (at least to the extent they were put into operation after 1 January 2005). In view of the relatively extensive investments needed for inbuilt ATB-EG or ATB-NG, exemptions were granted up to 2008. Basic ATB (ATB-E) was then made available, a simplified and less expensive version of ATB-EG. Since that time exemptions are no longer granted for self-propelled maintenance machines and historic vehicles. Although ATB-E (just as ATB-EG) trainborne equipment is only compatible with ATB-EG trackside equipment, the deployment certificate of maintenance machines equipped with ATB-E does not stipulate that these machines can only be deployed on track sections equipped with ATB-EG trackside equipment.

Switch off sections

During the period in which the main lines already featured ATB and secondary lines did not, switching sections were installed at the start of the secondary lines. When a train fitted with ATB-EG trainborne equipment passes a switch off section, depending on the direction of the train, that equipment is automatically switched to offline or online mode. The switch off sections were installed at that time because ATB-EG trainborne equipment restricts the speed of the train to 40km/h on a track section that does not carry ATB-EG; switching the trainborne equipment to the offline mode nonetheless enabled trains – that were meanwhile equipped with ATB-EG for the purpose of deployment on main lines - to be driven at the permissible line speed.

The above reason was actually rendered obsolete when the secondary lines were equipped with ATB-NG (between 1995-2005). This is because since then, the permissible line speed may be driven on these particular secondary lines using inbuilt ATB-NG trainborne equipment. However, the switch off sections have not been removed or deactivated, and as a result vehicles carrying ATB-EG or ATB-E trainborne equipment may still exceed a speed of 40km/h on secondary lines without ATB monitoring.

In 2011 the Ministry of Infrastructure and the Environment asked ProRail to take the ATB switch off sections out of service in the short term.

APPENDIX 6: EXPLANATORY NOTES ON THE USE OF APPROACH MARKERS

Warning signals

In order to enable a train to brake in time, the brakes must be applied no later than at a braking distance before the point at which the reduced speed must be reached. Since the braking distance (which may extend to approximately one kilometre) may be longer than the distance of the track that the train driver can see (because of fog and rail track curvatures, for instance), it is essential that the train driver at least receives braking instructions at braking distance. This is carried out by means of a *warning signal*. Virtually all signalling systems worldwide apply this principle in one way or another, which in a nutshell means that both the starting point and end point of braking is indicated (by using a warning signal and a main signal respectively).

Markers serving to announce warning signals

Over the course of time various measures have been taken to draw attention to warning signals. One of the measures includes announcing the warning signal by using a marker placed at some distance from the warning signal alongside the route. In this case, the marker serves to announce a warning signal. From before 1930 until around 1990, a 'dual marker warning signal' was used comprising two black and white striped signboards positioned diagonally alongside the railway track. Not only were the dual marker boards very conspicuous visually, but as they were positioned diagonally had they also caused a whooshing sound when the train passed them so that the train driver could also hear the marker.

From 1970 the 'dual marker boards' were replaced with perpendicular triple marker board warning signals comprising a series of three consecutive white signboards displaying 3, 2, 1 ascending black stripes in that order. These types of perpendicular marker board warning signals have meanwhile completely taken over the role of the 'dual marker boards' but the acoustic warning has been eliminated.

Figure 22: Dual marker board warning signals (left) and perpendicular triple marker board warning signals (right) (Source: www.klassiekebeveiliging.nl).

Markers serving to announce a warning signal placed at a distance which is shorter than the braking distance

In certain cases a warning signal cannot be placed at the required braking distance before the main signal. There may be various reasons for this. For instance, the mechanical signals commonly used in the past were operated by pulling wires to which a maximum length applied. A further reason may lie in the fact that a warning signal would otherwise need to be placed in front of the preceding main signal (which would be illogical in terms of obeying the signals because it would not be clear to the train driver to which main signal the warning signal referred). The latter situation (with the distance between two main signals being shorter than the braking distance) can, for instance, be found at small stations located along single-track route sections.

In these situations insufficient braking distance is therefore available between the warning signal and the main signal. In order to instruct the train to brake in time nonetheless, a marker containing a triangular sign painted with black and white zigzag stripes is placed at braking distance from the main signal. This may apply to both 'dual marker boards' and from 1969 also to the perpendicular approach marker boards containing a herringbone pattern instead of diagonal stripes (the Dutch

word *keper* means 'herringbone' from which the Dutch name for the approach marker derives its name, i.e. *keperbaken.* Literally translated this means herringbone approach marker*)*.

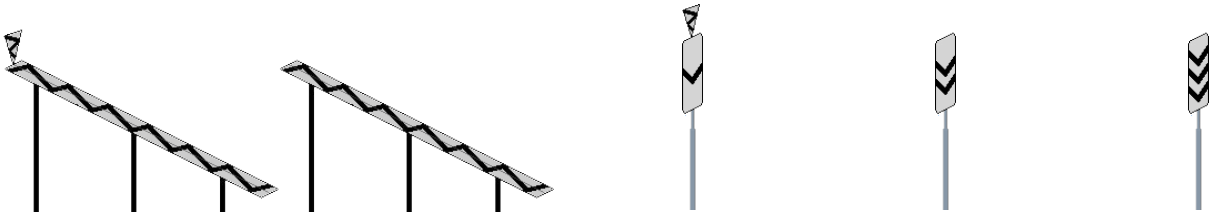


Figure 23: 'dual zigzag marker board' (left) and 'herringbone' approach marker (right). (Source: www.klassiekebeveiliging.nl).

The zigzag or herringbone pattern shows the train driver that he has approached a main signal at braking distance. If the train driver cannot read the position of the accompanying warning signal (located at a distance which is shorter than braking distance from the main signal), for safety reasons he must apply the brakes at the location of the marker.

Situation at Stavoren

In Stavoren there was a main signal (in the form of the stop sign on the buffer stop) and an approach marker (located at a distance of approximately 1200 metres before the buffer stop) respectively. The unusual aspect of this situation is that there is no warning signal between the approach marker and the main signal.

In the past, situations have however occurred in which a main signal was not preceded by a warning signal. The Safety Board was unable to locate a document containing the criteria based on which this was permitted. However, the known examples of such situations show that these were exceptions: for instance, 'driving along a wrong track' (in an exceptional case a regular train was using the track designated for trains driving in the opposite direction due to a failure on the regular railway track) and exit signals on branch lines at small stations (where the train speed had already been restricted by an entry signal with an accompanying warning signal).

It was established that these particular exceptional situations do not apply to Stavoren: 'driving along a wrong track' does not apply, nor does the fact that speed had already been restricted by a previous sign. The Safety Board was unable to find a comparable situation in which during regular use of the railway, it was required to reduce speed from the permissible line speed to stationary without the relevant main signal being preceded by a warning signal (whether or not placed at a distance which is shorter than braking distance).

Based on the historic material found, the Safety Board is of the opinion that a warning signal should have been placed in Stavoren in the form of a light signal displaying 'amber' (as in the case of a comparable situation near Rhenen, for instance). An amber light signal has the same meaning as an approach marker but is 'common' however (and as a result familiar to train drivers), and visible for a longer period of time during darkness.

In this connection the Safety Board refers to the manner in which the approach marker is incorporated in current legislation: Appendix 4 of the Rail Traffic Regulations contains information on the nature, execution and meaning of the different signals/signs, with information on the approach marker provided in the chapter on 'Additional signals for light signals'.

Locations using approach markers

At present, there still are 20 locations, including Stavoren, where approach markers have been placed (see the table below).

- Stavoren (case 1) is the only location where the approach marker is located on the main railway network and applies to regular use of the railways.
- However, the main railway network does have approach markers in five (2-6) of the other 19 locations, but these only apply to 'wrong direction running', i.e. situations in which trains are driving against the normal current of traffic.
- In the other 14 cases (7-20) these are industry tracks, which tracks do not form part of the main railway network; they have not been incorporated in the safety control system (which means that the train must be driven with caution) and the maximum speed is 40km/h. In these situations the approach marker serves as an advance warning of a stop sign (S sign).

1	Sneek – Stavoren	Regular track
2	Utrecht Maliebaan	Wrong direction running
3 + 4	Olst – Zwolle	Wrong direction running
5	Belgian border – Roosendaal	Wrong direction running + border track section
6	German border – Oldenzaal	Wrong direction running + border track section
7	Belgian border – Budel	Industry track / border track section
8	Belgian border – Maastricht	Industry track / border track section
9	German border – Coevorden	Industry track / border track section
10 + 11	Nieuw Amsterdam – Schoonebeek	Industry track
12 + 13	Roodeschool – Eemhaven	Industry track
14	Velsen Zeeweg – Driehuis Westerveld	Industry track
15	Veghel – Boxtel	Industry track
16	Sittard – Born	Industry track
17	Veendam – Wildervank	Industry track
18	Amersfoort – Amersfoort PON	Industry track
19 + 20	Weert – Budel	Industry track

Locations using approach markers (as at 2010)

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