THE DUTCH
SAFETY BOARD

Train collision at Barendrecht,

24 September 2009

TRAIN COLLISION AT BARENDRECHT,
24 SEPTEMBER 2009

The Hague, January 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.

Visiting address:	Anna van Saksenlaan 50 2593 HT The Hague, The Netherlands	Correspondence address:	PO Box 95404 2509 CK The Hague
Telephone:	+31 (0)70 333 7000	Fax:	+31 (0)70 333 7077
Internet:	www.onderzoeksraad.nl/en		

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LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
ARI	Automatic route-setting system
ARR	Automatic trip registration
ATP	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
ECG	Electrocardiogram
EC	European Community
ERTMS	European Rail Traffic Management System
ERA	European Railway Agency
ETCS	European Train Control System
EU	European Union
GSM-R	GSM Rail - Global System for Mobile communication
HSL	High-speed line
IVW	Inspectorate for Transport, Public Works and Water Management
NSA	National Safety Authority
OVS	Rail Company Safety Consultations
RI&E	Risk inventory and evaluation
RvTV	Transport Safety Board
SOR	Railway Accident Board
SPAD	Signal passed at danger
TNTS	Train Number Tracking System
VenW	Ministry of Transport, Public Works and Water Management
SMS	Safety Management System
VPT	Planning and traffic management system

Explanation of (technical) terms
Annex 3 contains an explanation of a number of technical terms used in this report.

CONSIDERATION

The first Dutch train travelled from Amsterdam to Haarlem on 20 September 1839. In 2010, some 170 years later, more than one million passengers travel on Dutch trains every day. Many goods trains also travel daily on the railways, some of which carry hazardous materials. It will require little imagination to realise that the consequences of passing a red signal can be disastrous.

Two goods trains collided head-on at Barendrecht on 24 September 2009. The collision occurred because one of the trains involved had passed a signal set at danger ('drove through a red light'). This indicates that a critical railway traffic safety measure had failed, since signals constitute the backbone of the railway safety system and are binding on the drivers. Trains, unlike cars and trams, are not driven under visual rules: they are driven under signal rules. This is because the braking distance of trains (at high speeds) is too long to permit them to be driven under visual rules. For this reason the instructions given by signals must be unconditionally observed, since this is essential for the safety of railway traffic. Train drivers regard passing a signal set at danger as 'sacrilege'. Nevertheless, every year more than 200 trains pass a signal set at danger. This in turn results in a few accidents each year. For this reason the current investigation is not focused solely on the collision at Barendrecht, but also extends to the Signal passed at danger (SPAD) issue in the broader sense. In view of the potentially extremely serious consequences of SPADS the Dutch Safety Board expects both the authorities and railway companies to put safety high on their agenda.

Facts, consequences and cause of the collision at Barendrecht

The two trains that collided at Barendrecht[1] on 24 September 2009 were a mixed goods train and a container train. The mixed goods train[2] was underway from Onnen (in the Province of Groningen) to Kijfhoek (a shunting yard between Barendrecht and Zwijndrecht). The container train was underway from the Maasvlakte (Rotterdam) to Warsaw. The mixed cargo train passed a signal set at danger at Barendrecht. At that moment the container train was approaching from the opposite direction on the same track. The trains collided head-on under the A15 motorway viaduct. Shortly afterwards an international passenger train approaching Barendrecht on another track collided at low speed with a wagon from the mixed goods train which had come to rest on the international passenger train's track following the collision. An express train travelling in the direction of Barendrecht stopped near the scene of the accident to offer assistance.

The collision resulted in the death of the driver of the mixed goods train. The driver of the container train was severely injured. Both the trains involved and the railway infrastructure were severely damaged. The A15 motorway viaduct was also damaged. The hazardous materials carried in the wagons of both trains were not released in the collision. Road traffic was closed for several hours after the collision, and no railway traffic was possible between Kijfhoek and the Port of Rotterdam for four days.

The train collision at Barendrecht occurred because the mixed goods train passed a signal set at danger without authorisation. The reason why the train passed a signal set at danger cannot be established with complete certainty. However, on the basis of its investigation the Dutch Safety Board finds it plausible that the train driver had become unwell.. There are several indications that this was the case. Firstly, during its journey the train had been stopped twice by an intervention of the dead man's system, a system that applies the brake should the train driver fail to respond to warning signals. An intervention of this nature twice during a train's journey is highly unusual and may suggest that the driver had become unwell. Secondly, the train driver applied the brakes

1 The actual collision occurred at the Barendrecht Connection. This location is abbreviated to Barendrecht to promote the readability of this report.

2 A mixed goods train is a train comprised of separate wagons loaded with goods from various carriers which are coupled together in a shunting yard. Mixed goods trains are also known as unit cargo trains and freight cargo trains.

only two to three seconds before the collision whilst the train had passed a highly visible signal set at danger shortly before the collision and had passed over points that were not set to the correct position for the train. Train drivers then usually respond by applying the brakes. In this instance there are no indications that the driver of the mixed goods train responded to the situation. In conclusion, the autopsy revealed that the train driver suffered from an hereditary heart disorder that can result in sudden death and can be associated with cardiac arrhythmia, dizziness and/or fainting. Complaints of this nature could explain both the two interventions of the dead man's system and the SPAD.

Measures to control the SPAD issue

The Dutch Safety Board has investigated which options are available for the control of the SPAD issue. These measures can be classified into three categories. The first category relates to measures to reduce the number of situations in which signals at danger are required, since the number of SPADs will decrease when trains encounter fewer signals set at danger during their journey. The second category relates to measures to prevent SPADs when trains do encounter any danger signals during their journey. The third and last category relates to measures to prevent a SPAD resulting in a collision or, when this is not feasible, to reduce the consequences of the collision. The Board has investigated both the extent to which these measures were utilised at Barendrecht and are utilised in a general sense. The three categories of measures are reviewed below.

Reducing the number of signals at danger. Not all options to prevent signals at danger were utilised at Barendrecht. The train driver of the mixed goods train encountered a signal set at danger because of a conflict in the schedules, since pursuant to the design of the schedules the mixed goods train and the container train would in fact need to travel over the same section of track in opposite directions. As a result of this conflict one of the two trains would need to stop at a signal set at danger to allow the other train to pass.

A situation of this nature can be avoided by segregating routes either physically or in time.[3] The routes at Barendrecht could have been segregated in time by designing the schedules in a manner which ensured that the trains were not required to use the same section of track after each other. The routes could also have been segregated physically, for example by assigning either the mixed goods train or the container train to an adjacent track.

Both the planning department and the rail traffic management[4] could have observed that the schedules at Barendrecht contained two conflicting train paths[5]. Moreover, it was possible to correct this situation, but this did not take place. Scheduling conflicts of this nature can also go undetected in other areas of the Netherlands, largely due to the unavailability of technical support for schedulers and rail traffic controllers who need to identify scheduling conflicts. The schedulers and rail traffic managers assume that the technical protection system will respond to a conflict by setting the signal for one of the trains at danger and that the train driver will stop at the signal. However, although the signal was set at danger at Barendrecht the train did not stop at the signal.

Prevention of SPADs. Although the mixed goods train's signal was set at danger this need not have resulted in the train passing the signal. The measures that could have prevented the SPAD at Barendrecht are reviewed below.

Firstly, SPADs can be prevented by an automatic train protection system (ATP), a technical system which checks that train drivers comply with the commands they receive from the signals along the track. If the train driver does not comply then the system initiates an automatic emergency braking action. The track and the locomotive of the mixed goods train were equipped with automatic train

3 A route is the section of the infrastructure released for the passage of a specific train.
4 The planning department is responsible for the preparation of the schedule. The rail traffic management can subsequently amend the schedule in the event that, for example, the schedule contains an error or trains do not travel according to schedule.
5 A train path is the section of the planning that specifies the tracks the train will use during its journey and the times at which it will use those tracks.

protection - first generation (ATB-EG) systems. This type of automatic train protection system has a number of functional limitations that prevented the system from avoiding the collision: when the train is approaching a signal set at danger. ATB-EG intervenes solely if the train driver does not apply the brakes or the train is travelling faster than 40 km/hour. The system does not intervene in the event that the train driver applies the brakes but with insufficient braking force or the train is travelling slower than 40 km/hour. A system (such as ATB-NG, automatic train protection - new generation) that does not have this functional limitation would have prevented the collision. However, neither the relevant signal nor the locomotive were equipped with this system at the time of the accident. The majority of the Dutch railway network is equipped with the limited ATP protection that was applied at Barendrecht. More details about the development and implementation of the various types of ATP systems in the Netherlands are enclosed later in this analysis.

Secondly, the train driver of the mixed goods train did not receive an explicit reminder that he was approaching a signal that could be set at danger. This could have been possible, since a system was available for this purpose in the past, what is referred to as the ‘cancel function’. This was a technical warning system that could not only draw the driver’s attention to the possibility that the train was approaching a signal that could be set at danger (in a 40 km/hour area) but could also stop the train if the driver failed to respond. In the mid-nineteen-nineties, the cancel function was disabled in existing rolling stock and was no longer fitted to rolling stock. This was due to reasons. Firstly, a new type of dead man’s system was introduced which had a different objective[6] from the cancel function but which needed to be operated in a similar manner. The second reason was that cancelling was a routine action that was assumed to be ineffective. The Board is of the opinion that the cancel function should not have been decommissioned until it could be replaced by a better warning system.

In conclusion, the probability of a SPAD can be lowered by reducing the risk that train drivers become unwell during the journey or continue the journey while they are unwell. The Board, as indicated earlier, considers that it is plausible that the mixed goods train passed the signal set at danger at Barendrecht because the driver had become unwell. The following options to reduce this risk were available at Barendrecht:

- Medical examinations: the objective of medical examinations is to minimise the risk that train drivers become unwell during their work. Although medical examinations cannot entirely preclude the risk that train drivers become unwell they, when performed correctly, reduce this risk. The driver of the mixed goods train had undergone eight medical examinations during the course of his career. The autopsy revealed that he suffered from an hereditary heart disorder. However, the medical examinations failed to reveal this disorder whilst a more in-depth examination could have identified it. In view of the train drivers’ safety function the Board is of the opinion that it is important to increase the stringency of train driver medical examinations.
- Dead man’s system: The investigation revealed that the mixed goods train had been stopped twice by interventions of the dead man’s system before the train reached Barendrecht. The dead man’s system applies the train’s emergency brakes if the train driver becomes unwell. When the train is moving the driver must press a pedal or button once every 60 seconds. If the driver fails to press the control in time then a warning lamp is lit and 2.5 seconds later an aural signal sounds if the driver still fails to press the control. If the driver still fails to press the control then 2.5 seconds later the system initiates an emergency stop. The carrier leaves the decision to continue the journey after an intervention by the dead man’s installation to the train driver’s discretion. No assessment of the suitability of the driver’s condition to continue the journey is made. The Board is of the opinion that it is necessary to assign the power to make a decision on the train driver’s continuation of the journey to an officer other than the driver.

Preventing an accident after a SPAD. A number of options are available to prevent a SPAD resulting in a collision or reduce the consequences of a collision:

6 The objective of the dead man’s system is to initiate an emergency stop in the event that the train driver becomes unwell or fails to respond for another reason, whilst the objective of the cancel function is to remind the driver that the train is approaching a signal that may be set at danger.

- Opposite signal[7] automatically set at danger: It is technically feasible to respond to a train passing a signal set at danger by immediately setting the relevant opposite signal at danger. Although this measure will not be effective in all situations, automatically setting an opposite signal at danger can result in the earlier initiation of an emergency stop and, in turn, prevent a collision or at least reduce the consequences of the collision. If this measure had been implemented at Barendrecht then the signal for the approaching container train could have been set at danger about 15 seconds earlier and the train driver could have braked about 15 seconds earlier. However, this was not the case: the relevant opposite signal was set at danger only once the mixed goods train had actually entered the path of the container train.
- Revocation of the signal: If the rail traffic manager had seen that the mixed goods train had passed a signal set at danger on his monitor then he could have tried to prevent the collision by revoking the signal for the container train (by setting the signal at danger). This measure cannot totally preclude the risk of an accident following a SPAD but can make a contribution to the limitation of the number of accidents. However, this option is not utilised to an optimum extent. According to ProRail, the train services managers' duty is to configure routes. The managers are not required to monitor them. Moreover, the rail traffic managers are often assigned a control zone of a size and/or complexity that precludes the feasibility of observing that a train is passing a signal set at danger without suitable technical support. Although a system of this nature was used in the past (train has passed through red alarm), this system was decommissioned because it generated too many false alarms and has not been replaced by an improved system.[8]
- Emergency call: If the rail traffic manager had seen that the mixed goods train had passed a signal set at danger then he could have sent an emergency call to the area in the vicinity of the two trains. All train drivers in that area would then have heard the emergency call immediately and would have been able to take the necessary action. Within this context it is also important to note that the driver of the international passenger train and the rail traffic manager both sent two emergency calls after the collision. However, due to a technical malfunction both calls were connected only after the second attempt. It is known that problems with connections with the Netherlands' GSM-R, the telephony network used for this purpose, are not uncommon.

Approach to the SPAD issue

32 train collisions related to SPADs have occurred in the past ten years (2000-2009). Moreover, this investigation has revealed the circumstances that allowed the incident at Barendrecht to happen are not unique. The Board is concerned about this. Not all the available options for the control of the SPAD issue are utilised. The Board has investigated the reasons and the parties that play a role.

Approach to the SPAD issue: responsibilities. The new Railways Act, which came into force in 2005, prescribes that the responsibility for the safety of railway traffic is vested in the railway companies (the carriers and the infrastructure manager). They are individually and jointly responsible for the implementation of suitable measures for the adequate control of the safety risks (the duty of care). The system responsibility for railway safety is assigned to the Minister of Infrastructure and the Environment (formerly the Minister of Transport, Public Works and Water Management).[9] The Minister's duties include the supervision of the railway companies' adequate fulfilment of their duty of care. The Minister fulfils this responsibility by

- granting the concession for the management of the main railway network infrastructure to one or more infrastructure managers[10]; and

7 An opposite signal is the last signal an approaching train encounters before the threat of a collision with a train that has passed a signal set at danger.

8 The Transport Safety Board raised the issue of the decommissioning of the 'train has passed a signal set at danger' alarm in its investigation of the train collision at Dordrecht on 28 November 1999.

9 The name of the portfolio was changed to 'Ministry of Infrastructure and the Environment' when the Rutte government took office on 14 October 2010. This report refers to the portfolio using the name prevailing at the time of the incident, namely: Ministry of Transport, Public Works and Water Management.

10 The Railways Act lays down that the Minister can grant the concession for the management of the main railway network infrastructure to one or more infrastructure managers: in practice the Minister has opted for one infrastructure manager, namely ProRail.

- assigning the operation of the railway traffic to railway companies that comply with requirements including the possession of the relevant safety certificate.

The management concession is granted by the Minister and the safety certificate is issued by the Inspectorate for Transport, Public Works and Water Management on the Minister's behalf. Both attach conditions to assure that trains can travel on the infrastructure in safety and that the railway companies are in a position to make safe use of the railways. The Inspectorate for Transport, Public Works and Water Management supervises compliance with these conditions on the Minister's behalf.

In view of the potentially serious consequences of SPADs the Dutch Safety Board expects the responsible parties to implement all the measures that are reasonably possible to control the SPAD issue, what is referred to as 'ALARP'[11]-principle. Pursuant to this principle the responsible parties are required to implement all possible measures to control the SPAD issue unless they can demonstrate that the costs of a measure are unreasonable and/or that a measure will have other detrimental consequences. Within this context the Board is supported by the Railways Act and by the Second and Third Railway Safety Framework Documents published in 2004 and 2010 respectively. The Railways Act prescribes that the safety risks must be adequately controlled by 'suitable measures' and the Second and Third Railway Safety Framework Documents adopt the ALARP principle as the criterion for suitable control of the safety risks. The Board has investigated the extent to which the Minister of Transport, Public Works and Water Management and the railway companies (in the case of the collision at Barendrecht these were ProRail, Keyrail, DB Schenker, ERS Railways, NS HiSpeed and NS Reizigers) have fulfilled their responsibilities for the control of the SPAD issue.

The actions the Minister of Transport, Public Works and Water Management and the railway companies have taken in the past decades to reduce the number of SPADs are reviewed below, together with an examination of the development and introduction of ATP systems and other control measures.

Approach to the SPAD issue: automatic train protection system. Passing signals set at danger is not a new problem: the SPAD issue has a long history. NS Dutch Railways carried out studies of various existing systems (in particular, German and US systems) to limit the consequences of passing signals in the nineteen-fifties. However, the decision to implement a protection system was made only after the extremely serious 1962 Harmelen train accident, when two trains collided head-on in thick fog with disastrous consequences. The then Railway Accident Board's investigation concluded that the collision was caused by a train passing a signal set at danger. Until this accident NS had always relied on the train drivers' compliance with the signals. The Railway Accident Board concluded that a technical safety net was necessary to eliminate the consequences of potential errors of this nature. The Railway Accident Board's investigation was in part the reason for NS Dutch Railway's decision to introduce the (US) ATP system.

However, the introduction of the ATP - first generation (ATB-EG) took a great deal of time: this took more than thirty years and, moreover, the system was not introduced on all railway lines. In the first instance ATB-EG was introduced solely on sections of the railway network where trains are permitted to travel faster than 100 km/hour. As stated earlier, this system suffers from two important functional limitations. The Railway Accident Board drew attention to these limitations. The Board's report of the investigation of the 1992 Eindhoven train collision, thirty years after the Harmelen accident, stated that the ATP system offered insufficient safety functionality to prevent accidents of the nature of the Eindhoven collision. The Railway Accident Board was of the opinion that the functional limitations of the system gave cause to the need for a new ATP system. During the public hearings the Railway Accident Board held on the accident it was stated, on behalf of NS Dutch Railways' Management Board, that NS was working on a ATP - new generation (ATB-NG) system that resolves the limitations of ATB-EG. It was stated that the introduction of this system, based on the current progress, would be completed on the tracks in 2017 and in the rolling stock in

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2027 but that, in the event of the accelerated introduction of the system, 2005 would be feasible.[12] The fact that NS Dutch Railways had been working on the development of ATB-NG for a number of years was apparent from documents including the Rail 21 report[13] in which NS Dutch Railways presented its perception of the future of the railways. This report was based on the underlying concept that the transport capacity of the railways would need to be doubled to offer an alternative to the continually increasing volume of road traffic. NS Dutch Railways' Rail 21 report contained the following statement about ATB-NG: 'The second generation automatic train protection system (ATP) will improve the quality of the train traffic process[14].' NS Dutch Railways' used 'second generation' to refer to ATB-NG.

However, the introduction of ATB-NG was postponed due to the expected arrival of a European safety system.[15] The European Union wished to make arrangements to ensure that trains travelling on a European railway network would have European safety system at their disposal. A number of questions remained unanswered on the decision to postpone the introduction of ATB-NG:

a. How long will this postponement last and what are the implications of this delay for the prevention of SPADs?;
b. Will the European safety system be installed on the entire Dutch railway network or solely on part of the network (as was also the case with ATB-EG and ATB-NG)? And if the European system is installed solely on part of the Dutch railway network, then what are the implications for the other parts of the network?

A further serious accident caused by a SPAD occurred in 1999, near Dordrecht. The Transport Safety Board (the successor to the Railway Accident Board and the predecessor of the Dutch Safety Board) published the report on its investigation in 2001. This report once again stated that the ATP system was obsolescent. The investigation revealed that the number of signals passed at danger had almost doubled in the space of five years (1995 to 2000) from 125 to 150 SPADs per annum in the years before 1995 to 250 to 275 per annum at the beginning of this century. The response of the then Minister of Transport, Public Works and Water Management to the recommendations in the report was that the European safety system was too expensive to introduce solely for safety reasons: '… You can conclude from this that the replacement will not be made solely on the basis of safety reasons …. In view of the cost of the replacement (several million euros for the introduction throughout the Netherlands) and the low benefits to safety other arguments such as quality improvement, capacity management and interoperability should be decisive …' The Minister did not provide an insight into the specific scheduling.

A following serious train collision occurred in 2004, near Amsterdam. Once again, all the evidence immediately indicated that a signal set at danger had been passed. One week after the accident the Transport Safety Board sent a letter to the House of Representatives of the States-General stating that the Board would 'certainly instigate an investigation' but noted that the question arose whether the Board should continue its work in the event that the investigation revealed that the collision was due to shortcomings in the current ATP system. The Board had already had doubts for some time about conducting repeated in-depth investigations of the SPAD issue, both since the parties involved were sufficiently aware of the limitations of the ATP system and in view of the Minister's response to the report on the Dordrecht accident limitations. The train collision at Amsterdam gave cause to the Board's statement of its standpoint. [16]

Following a debate with the House of Representatives of the States-General the Minister decided to allocate 40 million euros to deal with the problem. This resulted in the Minister's appointment

12 Railway Accident Board, Botsing tussen intercity 846 en stoptrein 15243 te Eindhoven op 31 oktober 1992 ('Collision between Express train 846 and slow train 15243 at Eindhoven on 31 October 1992'), July 1993, p. 7.
13 NS Dutch Railways, Rail 21 – sporen naar een nieuwe eeuw ('Rail 21 – tracks towards a new century'), Utrecht, 1988.
14 'Train traffic process' refers to the train movements.
15 This is apparent from documents including a letter from the Ministry of Transport, Public Works and Water Management to NS Dutch Railways of 18 May 1993.
16 The investigation of this collision, 'Passing a red sign at Amsterdam Central Station', was published in June 2005.

of a SPAD steering group comprised of representatives from the largest railway companies and observers from the Ministry of Transport, Public Works and Water Management and the Inspectorate for Transport, Public Works and Water Management. This steering group drew up a plan for the reduction of SPADs which contained measures for the control of the SPAD issue. The target was to complete the plan before the end of 2008, whereby it was estimated that the number of SPADs would be reduced by 50% and the risk of SPADs by 75%. The Minister of Transport, Public Works and Water Management adopted the plan's measures and targets, which since then have served as the basis of the government's policy for the SPAD issue. Pursuant to the most important measure in the plan 1,000 signals would be equipped with 'extra' protection in the form of the automatic train protection - improved version (ATB-VV). ATB-VV is a supplement to a signal equipped with ATB-EG which can automatically bring a train that is also equipped with ATB-VV to a stand still in the event of the threat of a SPAD. It was then assumed that equipping 20% of the signals posing the greatest risk (1,000 of the 5,000[17] with ATB-VV would reduce the risk of SPADs by 80%. Consequently, this would achieve the risk-reduction target.

However, at the end of 2008 it became clear that the targets of the SPAD reduction plan would not be achieved by the implementation of the measures laid down in the plan, since the decision to equip 1,000 signals with ATB-VV was based on the assumption that the majority of SPADs occurred at a limited number of signals - an assumption that was found to be incorrect. It was then decided to equip a further approximately 260 signals in addition to the original 1,000 signals with ATB-VV. In 2010, the Minister of Transport, Public Works and Water Management also decided, in part on the basis of an investigation the Minister had carried out into the accident at Barendrecht, to equip an additional 350 signals in the basic hazardous materials railway network[18] with ATB-VV. This was because the initial selection of the signals to be equipped with ATB-VV had not taken account of the risks associated with the transport of hazardous materials (external safety). The Minister promised to make a decision on an additional number of signs to be equipped with ATB-VV on the basis of the number of SPADs that occurred in 2010.

As stated earlier, the general introduction of ATB-NG was postponed due to the expected arrival of a European safety system (ERTMS[19]). ERTMS was developed and implemented in around 2007. However, at the present time the system is operational solely on Betuweroute goods and HSL-Zuid high-speed railway lines. It is still unclear when ERTMS will be introduced on other parts of the Dutch railway network and on which scale. The railway companies will submit a proposal for the further implementation of ERTMS to the Minister in 2013. However, the Board is of the opinion that the Minister should provide clarification about the introduction of ERTMS as soon as possible (and not wait until the submission of the proposal in 2013). This is necessary to enable the railway sector to make decisions on the implementation of alternative control measures on other parts of the railway network that will not be equipped with ERTMS or will not be equipped with the system in the near future. This is because the Board is concerned about the long period of time required to introduce ERTMS on the majority of the Dutch railway network, since experience acquired in the past has revealed that several decades are required for the development and introduction of new protection systems on the majority of the railway network. Moreover there is uncertainty about the precise costs and benefits of ERTMS in the Netherlands, there is uncertainty about the financing of ERTMS and there is not as yet a specific plan for the introduction of the system. In conclusion, the Minister has stated that he intends to wait for the initial experiences in other member states and the availability of a new functionality. Consequently, the Board is of the opinion that with the current policy ERTMS will not make a great contribution to the reduction of SPADs on the Dutch railway network within the near future.

Approach to the SPAD issue: other control measures. The large majority of the signals in the Dutch railway network are not equipped with an ATP system that can effectively prevent trains

17 This relates to the about 5,000 operated signals at yards that were all equipped with ATB-EG at that time. At the time a further approximately 1,000 operated signals were equipped with a more effective ATP system, such as ATB-NG or ERTMS.

18 The basic hazardous materials railway network is comprised of a limited number of railway lines that have been designated for the railway transport of hazardous materials to and from the Betuweroute goods railway line.

19 European Rail Traffic Management System.

passing signals set at danger. It is expected that this situation will continue for years. For this reason the Board has investigated the extent to which other measures have been implemented to control SPADs. It is striking to note that work on the development and implementation of these measures began only in around 2004, as is demonstrated by the SPAD reduction plan formulated in 2004, which supplements the development and introduction of ATB-VV with measures focused on the improvement of (a) train-driver alertness; (b) the visibility of signals at yards; and (c) the safety systems of signals that have been passed when set at danger more than twice in the past five years.

As stated earlier, in 2008 it became clear that the targets of the SPAD reduction plan would not be achieved. The SPAD steering group then announced additional measures including supplementary investigations of signals passed when set at danger more than twice in the past five years. In addition, the railway companies are working on the development and introduction of new functionality for the design of schedules and for the identification of conflicts in schedules. However, unfortunately the railway companies have not indicated when this new functionality will be completed. In conclusion, in 2010 the Minister of Transport, Public Works and Water Management requested the railway companies to carry out further studies of new supplementary measures, including an alternative for the decommissioned cancel function.

Conclusions on the approach to the SPAD issue

The worst train disaster in Dutch history occurred at Harmelen in 1962. This collision between two passenger trains, caused by a SPAD, resulted in 91 fatalities and 54 injuries. The accident resulted in great social unease about railway safety and was the direct reason for the government's decision to develop an ATP system that would prevent recurrences of this type of accident. However, SPADs continue to cause accidents in 2010 since the plans for the implementation of a suitable protection system have still not been completed. In addition, other measures that have been implemented have also proven to be inadequate. One measure regarded as particularly promising is the European ERTMS system, although to date this system has been introduced solely on the high-speed passenger and the Betuweroute goods railway lines.

The reasons for this limited introduction are the complexity and the high costs of the system. Moreover, the system is being introduced in phases rather than in one operation. The long lead time of several decades required for the installation of a new system justifies the question as to the actions that are required in the intervening period, since other measures are needed for the adequate control of the safety risks in this intervening period. The Board observes that this need was overlooked when the decision was made to implement (and, in so doing, wait for) the European ERTMS system.

This investigation reviews a variety of measures, such as the design and modification of the schedules and the automatic setting of opposite signals at danger. These measures have not all been implemented to date. In retrospective, the Board observes that the wish for and expectation of a better ATP system has distracted attention from the need for and opportunities to implement other measures in the intervening period. Each major accident results in a review of the performance of the ATP system and the progress in its development or modernisation, but does not result in a structural solution. This was the case at the time of the 1992 Eindhoven train collision, and is still the case now.

Every system, including ERTMS, has its limitations. For example, the ERTMS offers no protection in the event of defective brakes or trains skidding on slippery rails. For this reason every type of system will need to be accompanied by additional measures and it will always be necessary to give comprehensive consideration to all the feasible options and the available financial resources for those options. However, many measures can be implemented solely when the various railway parties cooperate and impose requirements on each other, whereby they are not only dependent on each other but also - when measures have major financial consequences - on the government. Moreover, conflicts of interests can play a role in decisions to implement specific measures: for example, preparing a schedule is a process which involves critical success factors for both the manager and carriers, namely capacity and availability.

During the past decades the focus was placed on the ATP system, and work began on the joint development and introduction of other measures - such as a programme to improve train-driver alertness - only in around 2004. This work was begun following yet another serious accident in that same year (the train collision at Amsterdam Central Station referred to earlier). At the time the solution was sought in the formation of the SPAD steering group, a collaborative arrangement involving the various railway parties. The SPAD steering group drew up a 'SPAD reduction plan' containing measures designed to control the SPAD issue. However, in general the measures laid down in this plan devote virtually no attention to the reduction of situations in which signals set at danger are necessary or to the limitation of the consequences of SPADs: they are concentrated on the prevention of SPADs, in particular by equipping a number of existing signals with ATB-VV. Solely a rough estimate has been made of the effects of the measures laid down in the SPAD reduction plan and no precise calculations have been carried out. As reviewed earlier in this analysis, it was assumed that equipping 20% of the signals with ATB-VV would result in an 80% reduction of the SPAD risk, an assumption that was found to be incorrect. Moreover, no consideration has been given to the reasonable measures that could be implemented to control the SPAD issue. Measures that could make a contribution to this control - such as the reduction of conflicts in the schedules, the rail traffic manager's revocation of a signal (train has passed a signal set at danger alarm) and automatically setting the opposite signal at danger - were omitted from the reduction plan without adequate substantiation for their omission. Nor has the SPAD steering group provided an insight into which measures are feasible at acceptable costs. The steering group's activities have not resolved the aforementioned problem of the lack of a structural planning.

Close

The privatisation and division of the former NS Dutch Railways state-controlled company in the nineteen-nineties changed the mutual relationships in the railway sector. Whilst the Minister had previously dealt solely with NS Dutch Railways, which was responsible for both the infrastructure and railway transport, a number of different parties are now active on the railways. The management of the infrastructure is vested in ProRail: the transport operations, including the use of the rolling stock, is vested in the carriers. The government is responsible for the system.

The various parties involved bear their individual responsibilities in the different phases of the protection and use of the railways, each to the extent that they can exert an influence on safety. For this reason the Board expects that all parties give consideration to the level of safety which, in their opinion, is sufficient for the responsible use of the railways and when the safety level is no longer sufficient. This principle is also anchored in the railways legislation.

The infrastructure manager, ProRail, is assigned a special duty since this party serves as a node within the chain for all information about the condition and safety of the railways. In this position ProRail can identify bottlenecks and implement changes. In addition to the management of the railways, ProRail is also responsible for the rail traffic management. ProRail may be expected to make use of this position to collate and analyse existing and new railway safety risks and, on the basis of these analyses, give consideration to the measures required to guarantee the safe use of the railways. When the available resources are not sufficient to reduce the risks to an acceptable level then ProRail must give consideration to the reprioritisation of these resources. When the measures that need to be implemented are of a nature that reprioritisation does not suffice then ProRail should warn the Minister so that the latter can give consideration to the needs and, where relevant, can decide to make additional resources available. This is the personal responsibility of ProRail, a responsibility that is not dependent on complaints from the carriers. ProRail should also call the users of the railways to account for the implementation of the necessary measures.

In addition, the carriers must assume their personal responsibility in deciding whether the deployment of a train for the carriage of passengers or goods is or is not safe.[20] NS Reizigers' decisions to carry passengers by rail should ideally be preceded by an assessment as to whether the risks are controlled to an adequate extent. This is also applicable, for example, to carriers making the decision to carry hazardous materials on the railways. When they are of the opinion that the risks are not controlled to an adequate extent then they may be expected to act accordingly. These parties also primarily depend on their available resources.

Moreover, the infrastructure manager and carriers must - each for their part jointly - provide an insight into the costs associated with each of all the potential measures and the safety level that can be achieved with each of those measures. The Board then expects the infrastructure manager to play the leading role. The Minister, who bears the system responsibility for the railways, should assess the proposed measures in terms of the required safety level. When agreement is reached on the proposed measures the Minister must, where relevant, make the financial resources required to implement the measures if so required by reprioritisation within the policy field. When agreement cannot be reached then all parties are under the obligation to provide an insight into the resultant consequences for the safety of the users of the railways and to act accordingly. Once again, the infrastructure manager, in view of the manager's role as railway expert, may be expected to have a clearer insight into the consequences than the carriers.

These considerations have not been made to date: The railway parties and the Minister conduct a 'ritual dance' in which the focus is placed on the measures that are relatively simple rather than on the measures that are actually necessary. ProRail fails to make the level of ambition required for the safe use of the infrastructure sufficiently clear, the carriers fail to make the preconditions attached to the safe use of the railways sufficiently clear and the Minister does not require the railway companies to reduce the SPAD issue to an acceptable level but merely adopts the targets specified in the SPAD reduction plan. Railway safety receives most attention following a serious incident.

The Dutch Safety Board reached a similar conclusion in a recent investigation of the derailment of a goods train at Amsterdam Muiderpoort: this investigation revealed that the railway companies have not reduced the goods train derailment risk to ALARP level and that the Minister of Transport, Public Works and Water Management has failed to called the railway companies to sufficient account.

In view of the plans in the coalition agreement[21] to introduce timetable-less services as part of the High Frequency Rail Programme and allow more goods trains to travel on the railways the Board is of the opinion that it is essential that the Minister and railway companies do not delay the fulfilment of their responsibilities for railway safety any longer.

RECOMMENDATIONS

To the railway companies

The essence of the Railways Act is that the infrastructure manager and carriers bear the full responsibility for safety, each for their part. They must cooperate as necessary. They must then make use of all the measures available to control risks unless specific measures have demonstrably unreasonable consequences (the ALARP principle).

1. Undertake joint adequate actions for the suitable control of the SPAD issue in both the short and long term. Begin by identifying all potential measures focused on the reduction of the number of signals set at danger, the prevention of SPADs and the prevention of collisions due to SPADs. Then implement these measures unless specific measures have demonstrably unreasonable consequences.

20 The Board made a similar statement in the 'Derailment at Amsterdam Central Station' report of December 2007 in relation to the fulfilment of responsibilities on the application of new concepts. The Board also stated that: 'The carriers bear the primary responsibility of ensuring that passengers, in particular, are carried in safety. The infrastructure managers bear the personal responsibility for clarifying the preconditions the infrastructure attaches to the introduction of new rolling stock.'

21 Freedom and Responsibility Coalition Agreement VVD-CDA, 30 September 2010.

Explanatory note: In the Board's view the appropriate manner to adopt this recommendation is to draw up a specific plan of action for the implementation of all these measures. It is desirable that one party should take the lead in preparing this plan: in the Board's view this should be ProRail, since this party fulfils the role of node for all information about the safety of the railways. When specific measures are demonstrably infeasible for the railway companies then the Board expects the railway companies to enter into consultations with the Minister of Infrastructure and the Environment to examine the opportunities available to resolve these problems.

2. Develop a (technical or organisational) system within the near future which assigns the power to make a decision on the train driver's continuation of the journey following an intervention by the dead man's system to a functionary other than the driver.

To the Minister of Infrastructure and the Environment

Pursuant to the Railways Act the Minister bears the responsibility for the system, a responsibility which includes the exercise of the supervision and enforcement required to ensure that the parties actually fulfil the responsibilities assigned to them. The railway companies have not succeeded in reducing the SPAD issue to ALARP level since the Railways Acts came into force and the Minister has not required them to do so. Consequently, the essence of the Railways Act has not been implemented in practice to date. The Dutch Safety Board is of the opinion that this implementation is essential.

3. Make sure, as the party bearing the responsibility for the system, that the railway companies assume their responsibility for the adequate control of the SPAD issue in the short and long term.

Explanatory note: the Board expects that in adopting this recommendation the Minister plays the coordinating role explicitly assigned to the Minister in the Railways Act and increases the stringency of the supervision of the railway companies to provide for the joint approach as referred to in the Railways Act.

4. Within the next twelve months, specify which blocks of tracks, yards and rolling stock shall be equipped with ERTMS together with the associated timeframes, and specify which measures shall be implemented on blocks of track and yards that will not be equipped with ERTMS. Make sure that all parties involved invest in the necessary interim measures to be implemented before the actual introduction of ERTMS.

Professor Pieter van Vollenhoven (mr.)
Chairman of the Dutch Safety Board

M. Visser (mr.)
General Secretary

1 INTRODUCTION

1.1 Reason for this report

Two goods trains collided head-on at Barendrecht on 24 September 2009. The driver of one of the goods trains was killed and the driver of the other train was severely injured. In addition to the two goods trains, an international passenger train was also involved in the accident. This train, with about 150 passengers on board, collided with a derailed wagon. This resulted in one slight injury. The collision caused severe damage to the trains that were involved and to the infrastructure. A motorway viaduct was also slightly damaged. During the four days after the accident virtually no railway traffic was possible between the Port of Rotterdam and Kijfhoek, a major railway yard used to assemble goods trains. The two goods train carried freight including hazardous materials. The hazardous materials were not released as a result of the collision.

The Dutch Safety Board's investigation revealed that the collision was caused by one of the trains passing a signal set at danger without authorisation. The railway sector refers to passing a signal set at danger as a 'SPAD'. The Dutch Safety Board investigated how a SPAD could have occurred at Barendrecht. The Board has also established that the accident at Barendrecht was not an isolated incident and that trains regularly pass a signal set at danger in the Netherlands. The number of SPAD increased from 150 to 287 per annum in the years between 1991 and 2006 and has since declined to 214 in 2009.

The Dutch Safety Board decided to carry out the investigation in view of the consequences of the train collision (one fatality, one serious injury and major material, infrastructural and economic damage) and in view of the fact that more than 200 SPADs have occurred each year since 1997. In addition, this accident falls within the Board's obligation to conduct an investigation.[22]

1.2 Objective of the investigation and the questions to be answered

Passing a signal set at danger without authorisation can have serious consequences. For this reason the objective of the Board's investigation is to: 'Make a contribution to railway safety by providing an insight into the SPAD issue and by issuing recommendations for the prevention of SPADs or the limitation of their consequences.'

This investigation focused on the question as to how the relevant parties control the risk of a collision caused by a SPAD and the measures that can be implemented to improve the control of the SPAD issue.

This question is broken down into the following five questions to be answered by the investigation:
1. What caused the SPAD accompanying the accident at Barendrecht?
2. To what extent were the available control measures for the prevention of the accident and/or limitation of the consequences deployed at Barendrecht?
3. If any control measures were not deployed at Barendrecht then was this unique to this case or was this structural?
4. How was the current approach to the SPAD issue developed and on which considerations is the approach based?
5. To what extent have the parties involved fulfilled their responsibility for the control of the SPAD issue?

Annex 1 to this report contains information about the approach to the investigation.

22 Article 8, under a, of the Besluit Onderzoeksraad voor veiligheid ('Decree establishing the Dutch Safety Board').

1.3 Scope of the investigation

The train collision at Barendrecht gave cause to the Board's decision to carry out an investigation of the safety shortcomings that resulted in the SPAD at Barendrecht and the subsequent collision. Since more than 200 SPADs occur every year in the Netherlands and the consequences of those SPADs can be extremely serious the Board also decided to devote attention to the SPAD issue in general. The Board has investigated whether the safety shortcomings that played a role in the train collision at Barendrecht are unique to the collision or whether the established shortcomings also play a role in the SPAD issue in general. The safety shortcomings that did not play a role in the collision at Barendrecht are not addressed by this report.

1.4 Reader's guide

Section 2 reviews the facts of the collision at Barendrecht and contains factual information about the SPAD issue in the Netherlands. Section 3 explains the reference framework, the framework the Board uses to review its findings. This reference framework is comprised of the relevant legislation and regulations, the relevant company regulations and the principles the Dutch Safety Board has adopted for adequate safety management. Section 4 reviews the parties involved and their responsibilities. Section 5 contains an analysis of the circumstances that allowed the train collision at Barendrecht to occur as well as the options that were available to prevent the accident and the extent to which use was made of them. This Section also establishes whether the circumstances in which the collision occurred are also encountered at other locations in the Dutch railway network. Section 6 contains an analysis of the reasons why any options for the control of the SPAD issue are not used, where relevant, and the extent to which the parties involved fulfil their responsibilities in an adequate manner. Section 7 lists the conclusions from the investigation. The report concludes with Section 8, in which the Board issues recommendations for the control of the SPAD issue and, ultimately, the improvement of railway safety.

2 FACTUAL INFORMATION: THE COLLISION AT BARENDRECHT AND THE SPAD ISSUE IN THE NETHERLANDS

This Section contains factual information about the train collision at Barendrecht and its consequences, as well as factual information about the SPAD issue in the Netherlands. Annex 3 contains an explanation of the various technical terms referred to in this Section.

Figure 1: Aerial photo of the train collision at Barendrecht (source: KLPD, the Dutch National Police Services Agency).

2.1 The train collision at Barendrecht

Two goods trains collided head-on near the Barendrecht Connection (hereinafter referred to as 'Barendrecht') at 22:32 on 24 September 2009.[23] The two trains involved were:

- Goods train No. 61300, operated by DB Schenker, which was underway from Onnen to the Kijfhoek shunting yard[24] at Barendrecht (hereinafter referred to as the 'mixed goods train'[25]);
- Goods train 42331, operated by ERS Railways, which was underway from the Kijfhoek goods yard to Warsaw in Poland (hereinafter referred to as the 'container train').

In addition to the two goods trains an international passenger train operated by NS HiSpeed[26] and an NS Reizigers express train were also involved in the incident. The following subsections give a brief description of the most significant events for each of the trains involved in the incident prior

23 The actual collision occurred about mid-way under the (southern) viaduct carrying the A15 motorway.
24 A goods yard is a site equipped with a number of tracks that can be used to shunt trains, load and unload goods and/or assemble trains.
25 A mixed goods train is a train comprised of separate wagons loaded with goods from various carriers which are coupled together in a shunting yard. Mixed goods trains are also known as unit cargo trains and freight cargo trains.
26 NS HiSpeed is the brand name for international trains travelling under the NS Reizigers or High Speed Alliance (the operator of trains on the HSL-Zuid railway line) certificate.

to the collision. The subsections also review the occurrences at the relevant rail traffic managers in the period around the collision.[27] The routes followed by the trains are shown in Figure 2.

27 Rail traffic managers are officers who ensure that the trains on the section of the railway network for which they are responsible can travel safely and in accordance with the schedule for as far as is possible.

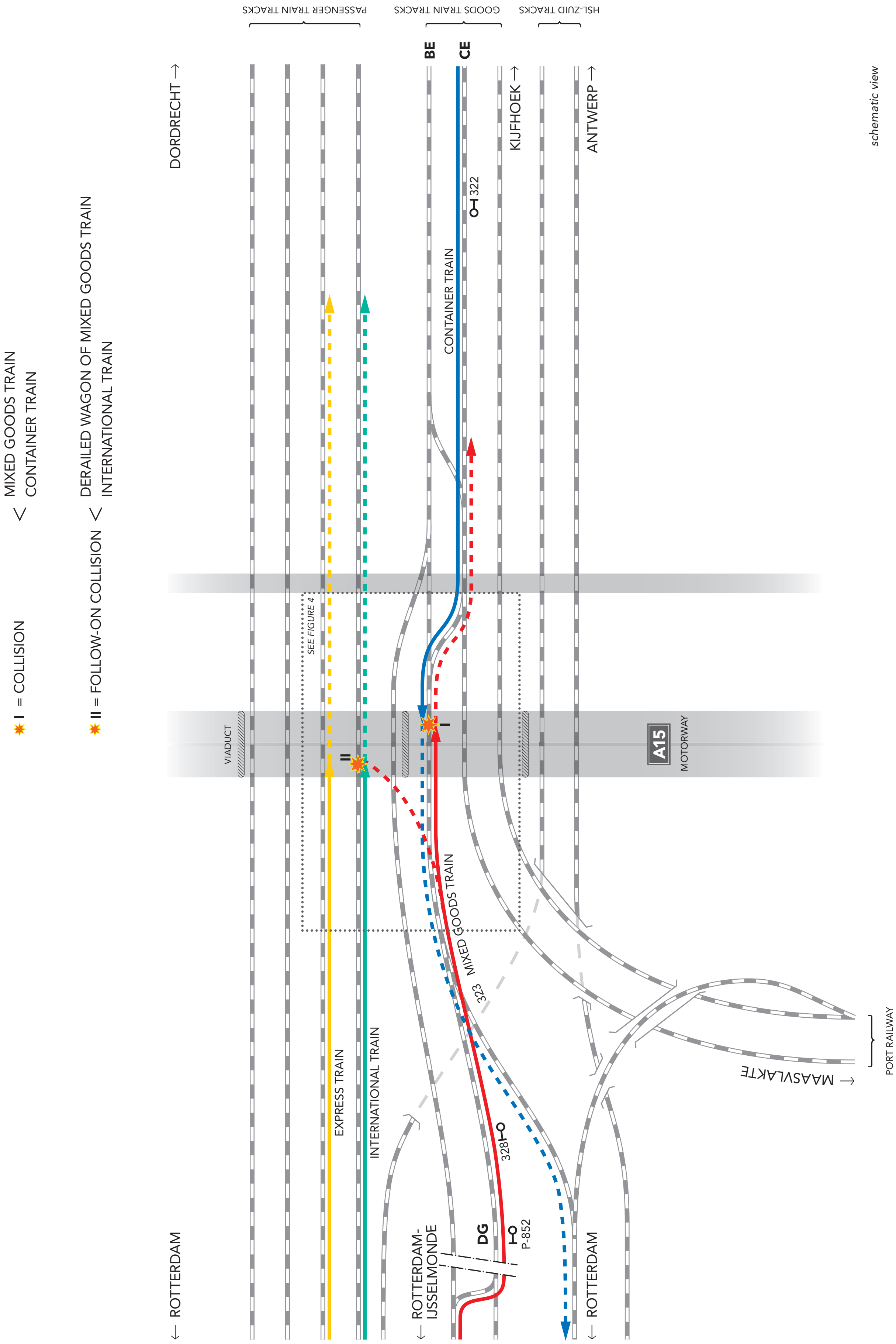

Figure 2: Diagram of the railway tracks at Barendrecht

2.1.1 The mixed goods train

The driver of the mixed goods train began his shift at his base at Onnen, near Groningen, at about 17:45 on 24 September 2009. The shift included driving the mixed goods train from Beilen to the Kijfhoek goods yard at Barendrecht. The driver met two colleagues when he reported for duty at Onnen. They had prepared the mixed goods train for departure. The driver, in consultation with a colleague, did not begin his shift at Beilen, which was further away, but from Onnen.

The mixed goods train left Onnen at 18:12. The train was comprised of two diesel-electric locomotives of the 6400 type and twelve wagons. The first two wagons were empty container wagons. The third to twelfth wagon inclusive were loaded with hazardous materials (natural gas condensate, hydrogen peroxide and chloroacetic acid). The goods train weighed 1088 tonnes and was 230 metres long.

At 19:48 the train came to a standstill near Nunspeet due to a braking action initiated by the train's system. As a result, the train incurred a two-minute delay. This was followed by a scheduled stop at Amersfoort from 20:16 to 20:40. At 21:07 the train once again came to a standstill near Keverdijk due to a braking action initiated by the train's system. Once again, the train incurred a two-minute delay. The Dutch Safety Board observes that these braking actions were due to an intervention by the dead man's system (see explanation in box 1).

Box 1: Intervention by the dead man's system

The Dutch Safety Board has established that the train came to a standstill near Nunspeet and near Keverdijk due to a braking action initiated by the train's system. This can be due to one of three possible reasons:

1. An intervention by the automatic train protection system: This is a system that intervenes with an automatic braking action in the event that the train travels in excess of the maximum permitted speed;
2. An intervention by the dead man's system: This is a system which applies the train's emergency brakes if the train driver becomes unwell. The general principle of this system is as follows: when the train is moving the driver must press a pedal or button once every 60 seconds. If the driver fails to press the control in time then a warning lamp is lit and 2.5 seconds later an aural signal sounds if the driver still fails to press the control. If the driver still fails to press the control within 2.5 seconds then the dead man's system initiates the automatic and full application of the brakes;
3. A technical defect.

The Dutch Safety Board is of the opinion, on the basis of an interpretation of the data stored by the automatic trip registration[28] and the logbook containing records of defects that it is plausible that the dead man's system intervened in both instances. This is because the automatic trip registration reveals that the two braking actions in question were not initiated by the operation of the brake lever and that the speed of the train was not in excess of the speed monitored by the ATP at the time of the intervention. These two facts reveal that the braking actions were not initiated by the train driver or the ATP. If there had been a technical defect then the train driver would probably have reported this via the customary channels. A report of this nature is not known. Nor does the logbook with records of defects contain information indicative of a technical defect. Annex 4 to this report contains more information about the findings from the technical inspection.

No other particulars were observed for the journey from Kijfhoek to Barendrecht. As it approached Barendrecht the train travelled at a fairly constant speed for a longer period of time from the IJsselmonde shunting yard. This speed was just under 40 km/hour, the maximum speed permitted by the prevailing signal aspects. At the time the train was running two minutes behind schedule.

28 Trains are equipped with automatic trip registration. This system, which is roughly comparable to the black box installed in aircraft, stores the most important data on recent train journeys. The data stored in the system can be read out following an accident and the data may provide an insight into the cause of the accident.

The fact that the dead man's system did not initiate a braking action reveals that the train driver must have operated the system one last time within the 65 seconds prior to the collision (60 seconds and then two successive periods of 2.5 seconds). Signal 328, the signal that was later observed to be set at danger (see box 2) and which was passed without authorisation, was readily visible.

Box 2: Signal set at danger
Signals are intended to make the speed at which trains may travel on the relevant track clear to the driver. The driver of the mixed goods train passed two signals prior to the collision at Barendrecht, the first of which was set at caution and the second of which was set at danger. A signal set at caution indicates that the driver must reduce the speed of the train to a maximum of 40 km/hour and must then continue at a speed low enough to stop the train at the next signal set at danger.

The Dutch Safety Board has observed that the last signal passed by the mixed goods train was set at danger. The records of the protection system[29] that gave the command to set the signal at danger establish that the signal must actually have been set at danger. A visual inspection of the signal immediately after the accident revealed that the signal was actually set at danger. The Board has also investigated whether electromagnetic interference could have played a role in the collision at Barendrecht. As is explained in Annex 4 to this report, the Board concludes that this was not the case.

The visibility of both signs was assessed during a reconstruction journey one week after the accident and in comparable circumstances. This revealed that signal 328 set at danger was visible at a distance of about 500 metres and that signal P852 set at caution was visible at a distance of about 750 metres. These signals were, in view of the speed of the mixed goods train (approximately 39 km/hour), visible at 47 and 72 seconds respectively before the train passed them. Consequently, there was sufficient reaction time and braking distance to bring the train to a standstill ahead of the signal set at danger. On the basis of the above the Board concludes that the visibility of the signals did not play a role in the collision.

Although the signal was set at danger the driver of the mixed goods train did not initiate a braking action and the train passed the signal set at danger at a speed of nearly 40 km/hour. The automatic trip registration does not contain any data which indicate that the train driver responded to the signal passed at danger. The train then passed over points that were not set to the correct position for the train. There are no indications that the train driver responded to this. Two seconds before the collision the train driver initiated an emergency brake which that then had virtually no effect. The speed of the mixed goods train at the time of the collision was 39 km/hour.

The driver of the mixed goods train
The driver of the mixed goods train, who was killed in the train accident at Barendrecht, was an experienced train driver with full authorisation.[30] The train driver's knowledge of the route and the rolling stock were also in order. The train driver underwent a medical and psychological examination at the time of his appointment and subsequently underwent seven further examinations. These established that he was completely fit for the duties of a train driver with full authorisation.

2.1.2 The container train
The driver of the container train began his shift at 20:45 on 24 September 2009 at the Rotterdam Waalhaven shunting yard. The shift, which continued until 06:15 the next morning, consisted of driving the container train from Kijfhoek to Bad Bentheim in Germany.

29 This is apparent from the analysis of the log file from the Vital Processor Interlocking (VPI) electronic protection system.
30 A train driver with full authorisation has been trained to drive trains and shunting units irrespective of speed and distances in the Netherlands. They distinguish themselves from train drivers with limited authorisation, who are trained to drive trains and shunting units at a maximum speed of 40 km/hour and within a radius of 25 kilometres from the point of departure.

After he had reported for duty the driver of the container train at the Rotterdam Waalhaven goods yard prepared the locomotive for departure, which included filling the fuel tanks and carrying out a technical inspection. The driver then drove the locomotive to the Kijfhoek goods yard where he coupled it to the container train ready for departure. The final destination of the container train, which had been driven from the Maasvlakte West departure station to Kijfhoek earlier that day, was Warsaw in Poland. On its departure from Kijfhoek the container train was comprised of a locomotive and 22 container wagons, the 21st of which was loaded with a dangerous compound (a corrosive alkaline liquid). The goods train weighed 1200 tonnes and was 600 metres long.

At 22:13 the driver of the contain train contacted the rail traffic manager by telephone to inform him that the train was ready for departure. The rail traffic manager released a route[31] for the container train, which then departed at 22:25. When the train approached Barendrecht it was one minute ahead of schedule.[32]

When the train driver approached Barendrecht he saw that signal 322 was set at proceed and that he could travel at the maximum speed of 80 km/hour permitted on that section of the track. The train's speed at that point was 73 km/hour. The train passed the signal and approached a viaduct carrying the A15 motorway. The driver suddenly saw the lamps of an approaching train on his track. At the same time the ATP system generated a signal indicating that his train's configured route was no longer unoccupied. The train driver immediately initiated an emergency braking action.

About six seconds later the two goods trains collided head-on, right underneath the viaduct carrying the A15 motorway. The speed of the container train at the time of the collision was 68 km/hour.

The driver of the container train
The driver of the container train was a driver with full authorisation. The driver had a zero-hour contract with ERS Railways and had last worked a shift for ERS Railways on Monday 21 September 2009. On the day of the accident the results from his examination established that he complied with all the relevant prevailing medical and psychological requirements governing train drivers in the Netherlands. The train driver's knowledge of the route and the rolling stock were also in order.

2.1.3 The international passenger train
At the time of the collision an international passenger train operated by NS Reizigers, which was travelling from Amsterdam to Brussels (under the NS HiSpeed brand name) was approaching the scene of the accident at the maximum speed of 140 km/hour permitted for the relevant section of track. The driver saw sparks coming from the overhead wire in the distance, at the location of the viaduct carrying the A15 motorway. The driver did not trust the situation and immediately applied the brakes, since the sparks gave him cause to presume that the power supply to the overhead wire would be interrupted. The driver then looked for a suitable location to bring the train to a standstill that would enable the passengers to alight safely from the train if necessary. However, when the train's speed had fallen to 40 km/hour the driver saw that the sparks were coming from a wagon on an adjacent goods railway line. The driver realised that this was not a suitable place to stop the train and interrupted the braking action. Immediately afterwards he saw a goods wagon lying in front of him on his track. The driver immediately initiated an emergency brake, but felt his train hit the goods wagon. The train came to a standstill a few seconds later. The train driver then sent an emergency call[33] and warned the rail traffic manager at Rotterdam.

2.1.4 The express train
At 22:31 an express train operated by NS Reizigers and travelling in the direction of Dordrecht was standing still at the platform at Rotterdam Lombardijen station. The international passenger train passed the express train on an adjacent track. During the departure procedure the driver of the express train saw two flashes of light shortly after each other. The guard also saw the

31 A route is the section of the railway infrastructure released for the passage of a specific train.
32 This is not an exceptional situation: variances from the schedule are permitted within specific margins.
33 An emergency call is a call received by all train drivers in the relevant area. On receiving an emergency call all drivers must immediately reduce the speed of the train to crawling speed and be ready to stop the train.

flashes of light and walked to the driver to report it to him. The driver and the guard suspected that the international passenger train had damaged the overhead wire. The driver departed from the station, but remained alert for possible problems. When the driver subsequently heard two unintelligible emergency calls shortly after each other he immediately applied the brakes. A little later the driver brought his train to a standstill with the driver's cabin right next to the cabin of the international passenger train.

The driver of the express train, seated in his cabin, discussed the situation briefly with the driver of the international passenger train. The driver of the express train then got out and went to investigate. He saw that two goods trains had collided head-on under the viaduct carrying the A15 motorway. He called to the drivers of the two trains but got a response solely from the locomotive of the container train. When the guard of the express train joined his driver he was informed that the driver of the container train was severely injured and was requested to warn the emergency services. The driver of the express train then saw that two small fires began under a tanker wagon close to the viaduct. He and the driver of the international passenger train then extinguished the fires. The driver of the express train then returned to the locomotive of the container train to talk to the injured driver. The police and fire brigade arrived at the scene of the accident shortly afterwards.

2.1.5 The rail traffic management

The tracks at Barendrecht fall under three separate rail traffic management zones:

1. The 'IJsselmonde' rail traffic manager, at the Kijfhoek the rail traffic management centre, who is responsible for the rail traffic management on the goods railway lines at the Barendrecht goods yard. Keyrail carries out the rail traffic management of this zone;
2. The 'Rotterdam-Oost' rail traffic manager, at the Rotterdam the rail traffic management centre, who is responsible for the rail traffic management on the passenger railway lines between Dordrecht and Rotterdam. ProRail carries out the rail traffic management of this zone;
3. The 'HSL Zuid' rail traffic manager, at the Rotterdam the rail traffic management centre, who is responsible for the rail traffic management on the southern section of the high-speed railway line (HSL), the HSL Zuid route. This route begins at Barendrecht and ends at the Belgian border. ProRail carries out the rail traffic management of this zone.

The 'IJsselmonde' rail traffic manager was responsible for the rail traffic management on the goods railway lines at Barendrecht where the collision occurred. He began his shift at about 22:30. In line with the customary practice the routes were configured automatically by the automatic route-setting system (hereinafter referred to as the 'ARI system"). Box 3 contains an explanation of this system.

Box 3: Automatic route-setting system (ARI)

Following the introduction of the ARI system in the mid nineteen-nineties rail traffic managers no longer need to configure the block of track: this is now carried out automatically on the basis of the predefined process schedule. The process schedule contains a schedule line for each train that will travel in the zone. Each schedule line contains information including the train number, the 'from' track, the 'to' track, the scheduled time and a setting time. The rail traffic manager's duty is to amend the process schedule in the event of delays and disruptions.

The rail traffic manager saw on his monitor that only a few trains were travelling at the time. These trains included the mixed goods train and the container train. The rail traffic manager then left his station. When the rail traffic manager returned after about two minutes he looked at his monitor and saw a track occupied message displayed downstream of signal 328 on the Barendrecht shunting yard that should not have been transmitted. In addition, the monitor also displayed malfunction alarms for points 323 and 317B. The rail traffic manager immediately suspected that an accident had occurred. He then tried to contact the drivers of the two goods trains via GSM-R[34]. Neither train driver responded. The rail traffic manager then sent an emergency call to the Barendrecht zone.

34 GSM-R is the communication system between the rail traffic management and the train drivers.

The ‘Rotterdam-Oost’ rail traffic manager at the Rotterdam rail traffic management centre began his night shift at about 22:30. Shortly after 22:30 the rail traffic manager’s entire control zone[35] displayed track occupied messages.[36] Immediately afterwards, the rail traffic management centre received two emergency calls. One emergency call came from the driver of the international passenger train, who reported a collision with a goods wagon, and the other came from the ‘IJsselmonde’ rail traffic manager.

2.1.6 The location of the collision

The location of the train collision is a busy and complex junction that was designed in its current form in the nineteen-nineties. The construction of the Betuweroute goods railway line and the HSL-Zuid high-speed passenger railway lines gave cause to the modernisation of the node, which included the construction of a number of connecting tracks and fly-overs[37]. This location accommodates three tracks for goods trains from and to the Port of Rotterdam and four tracks for passenger trains. At the point where the collision occurred the HSL-Zuid high-speed passenger railway crosses the goods railway lines and the A15 motorway passes overhead on a viaduct.

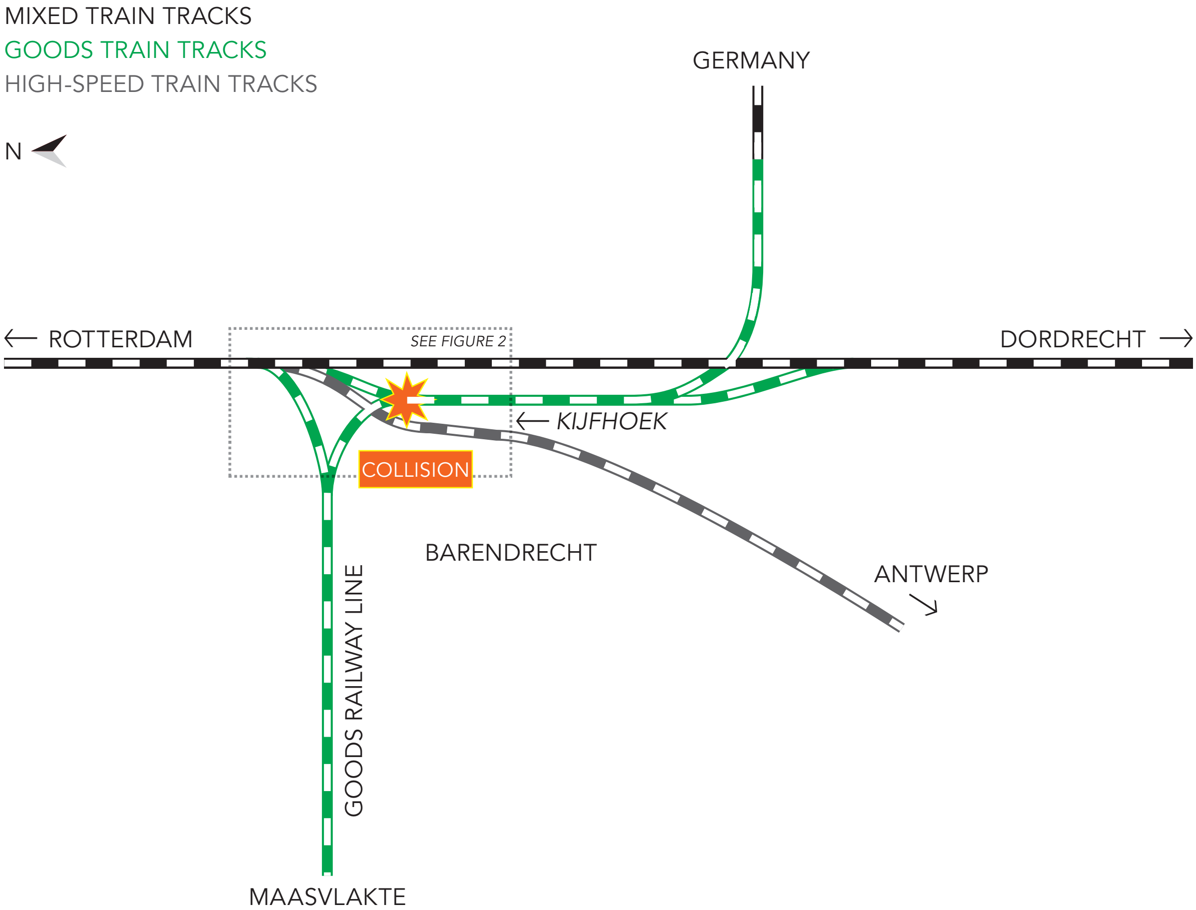

Figure 3: The railway tracks at the location of the collision

35 The control zone is the area under the rail traffic manager’s command.

36 A track occupied message is a signal displayed on the screen to inform the rail traffic manager that a block of track is occupied. This normally relates to a train on the block of track. However, track occupied messages can be generated for other reasons in the event of a malfunction: the safety system ensures that all signals on tracks leading to an occupied track are set at danger.

37 A fly-over is a viaduct for road or rail traffic which is designed to prevent two vehicles from unintentionally encountering each other (‘rendering two more more conflicting directions of travel free of conflicts’).

2.2 The consequences of the train collision at Barendrecht

After the collision the two goods train continued about fifty metres in the direction in which the container train had been travelling. The collision forced the locomotive of the container partly over the front locomotive of the mixed goods train, as a result of which the two locomotives of the mixed goods train (see Figure 5) and the locomotive of the container train suffered extremely severe damage. The driver of the mixed goods train was killed in the collision and the driver of the container train was severely injured.

Three wagons of the container train derailed to the left and ended up on the adjacent tracks. The two locomotives of the mixed goods train were derailed together with the first three wagons (two empty container wagons and a tanker wagon filled with a flammable compound). The derailed tanker wagon came to rest a few metres from a pillar of the viaduct carrying the A15 motorway. One of the empty container wagons of the mixed goods train came to rest on the adjacent passenger train track and was hit at low speed by the international passenger train. One of the 150 passengers in this train was slightly injured. Two small fires burnt briefly, probably due to natural gas condensate residues in the filling pipe of the front taker wagon. Although this filling pipe was torn off in the collision the valve was not damaged (in accordance with the design). The integrity of the tank was not impaired by the collision.

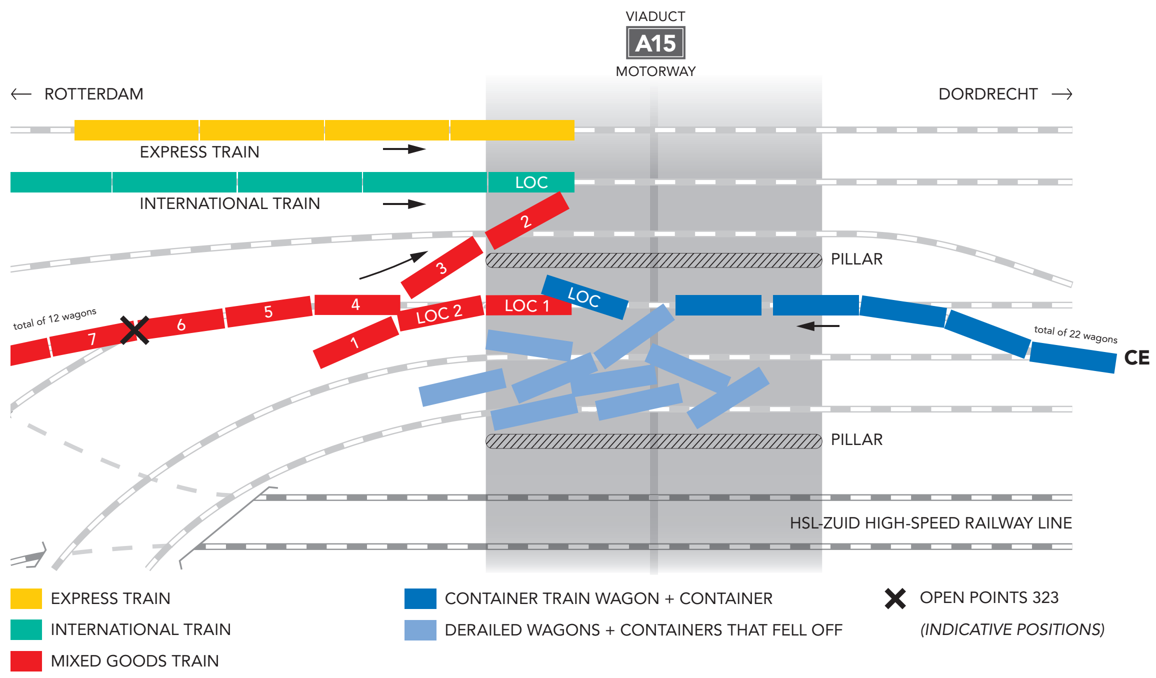

Figure 4: Diagram of the situation after the collision

In addition to the considerable damage to the track, the overhead wire and the freight carried by one of the goods train the viaduct carrying the A15 motorway was also damaged. Since the consequences of this damage were initially unclear, road traffic over the viaduct was halted for a number of hours. After an assessment of the damage to the viaduct it was reopened to road traffic. Virtually no railway traffic was possible between Kijfhoek and the Port of Rotterdam during the four days after the accident. This had serious consequences for international goods transport, but passenger traffic suffered virtually no hindrance.

Figure 5: The damage to the locomotives of the two goods trains (in daylight)

2.3 The SPAD issue in the Netherlands

The signal passed at danger without authorisation at Barendrecht was not a unique incident: this occurs more often in the Netherlands. This subsection contains information about the SPAD issue in the Netherlands, namely information about the number of SPADs, the consequences and the causes, as well as the locations of these SPADs. The following is known about these issues:[38]

- **Number:** The number of SPADs fluctuated in the period from 2004 to 2008[39] at around 250 per annum. There were 287 SPADs in 2006, the highest number ever. Since 2006 the number of SPADs has decreased to 240 in 2008 and 214 in 2009. There were about 135 SPADs in the first ten months of 2010: if this trend continues then it is expected that there will be about 160 to 170 SPADs in the whole of 2010.
- **Consequences:** The large majority of SPADs did not have any detrimental consequences. However, about 17% of the SPADs, more than 40 incidents a year, did have consequences. In the majority of these incidents (more than 30 a year) the damage was restricted to damage to the infrastructure, such as damage to a set of points. In a number of incidents the SPAD resulted in the train passing an open level crossing and in a number of incidents to an accident, i.e. a collision or derailment. 32 train collisions related to SPADs have occurred in the past ten years (2000-2009) (see Annex 8).
- **Causes:** About 87% of the SPADs were due to the train driver failing to brake or braking too late. In slightly more than half of these incidents the train passed the signal set at danger and in slightly less than half the incidents the train driver braked too late to stop the train before the signal. The other SPADs (about 13%) were caused by trains sliding past a signal set at danger due to slippery rails or 'parked' trains that 'rolled' past a signal set at danger because the handbrake had not been applied to an adequate degree.
- **Locations:** More than 80% of the SPADs occurred at a yard. The large majority of the other incidents occurred at an entry signal, the signal at the beginning of a yard. About 1% of the

38 The Transport, Public Works and Water Management Inspectorate's MISOS database.
39 The numbers cited in this report relate to the total number of SPADs, namely not solely the operated light signals but also the other signal S signs.

registered SPADs occurred at a signal on the open line, a block of track or through section of track, usually between two stations.[40]

SPADs occur at some signals more than at others. A repeated SPAD signal is a signal which is passed at danger three or more times within a period of five years.[41] There are more than eighty repeated SPAD signals. The composition of this group varies to some extent over the course of time. About three-quarters of the SPADs involved a non-repeated SPAD signal. One-half of the one-quarter of the SPADs involving a repeated SPAD signal involved signals with three SPADs in five years and the other half signals with four or more SPADs in five years.

Figure 16 shows the movement in the number of SPADs since 1981. No reliable data are available for the period before 1981. The figure reveals that the number of registered SPADs increased during the second half of the nineteen-nineties from between 125 and 150 per annum before 1995 to between 250 and 275 per annum at the beginning of the current century. When examining these figures it is important to note that the number of train movements has changed over the years and that there may be changes in the degree to which SPADs are reported and in the number of signals set at danger train drivers encounter during their journeys. Consequently, although the figures do give an indication of the number of SPADs they need to be interpreted with due care. Moreover, no automatic records are made of interventions by ATP systems and, consequently, these are not included in the statistics. These latter figures relate to the number of SPADs that would have occurred if the ATP systems had not intervened.

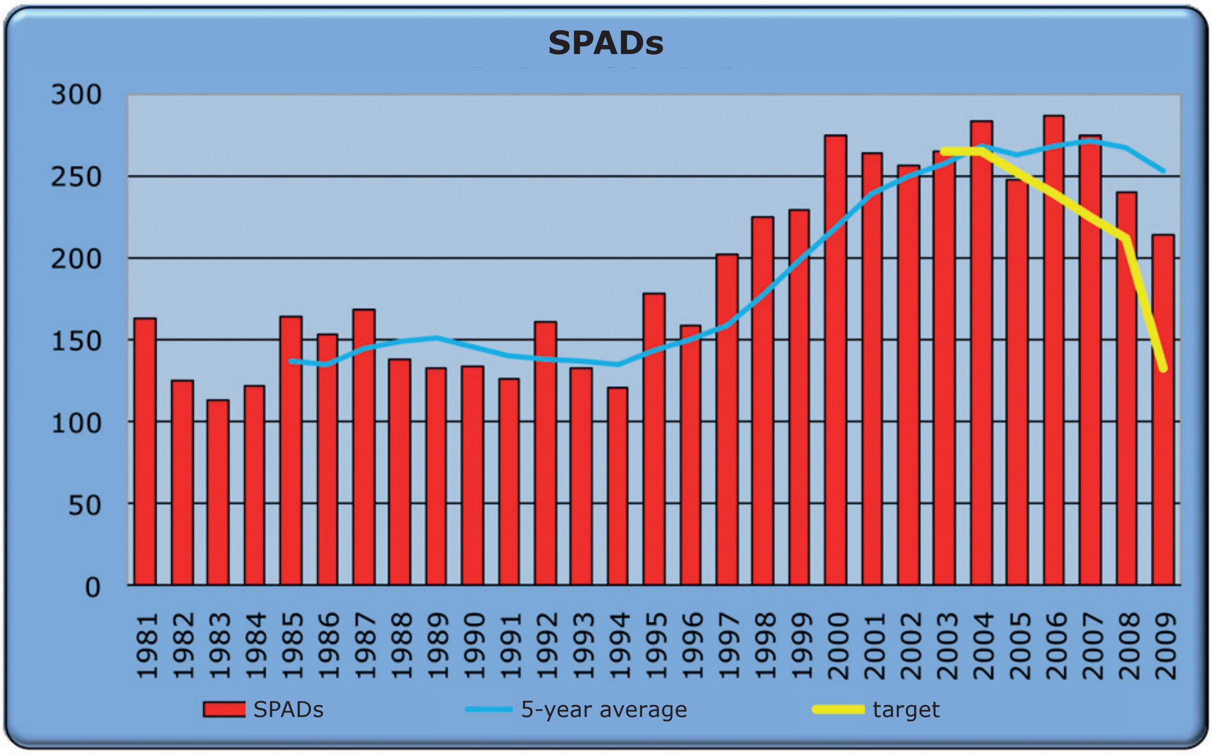

Figure 6: Number of SPADs in the period 1981 to 2009

40 It is then important to note that SPADs involving automatic signals (P signals) on the open line are not registered automatically and that it can be assumed that not all these SPADs are reported or otherwise known. The risk of passing an automatic signal on the open line is usually lower than at a yard since there are no points downstream of these signs and the trains travel in the same direction.

41 In view of the number of signals (approximately 10,000) and the average number of SPADs each year (approximately 250) 'two SPADs in a period of five years' involving the same signal can, from a statistical perspective, be explained in terms of 'chance'.

Figure 7 shows that the number of SPADs resulting in fatalities has decreased sharply since 1980:

- During the period from 1950 to 1980 there was a collision resulting in a fatality on an average of once every two years and there was a collision resulting in five or more fatalities on an average of once every five years;
- During the past twenty years (1990-2010) there were two accidents which each caused one fatality, namely on 20 March 2003 at Roermond and on 24 September 2009 at Barendrecht. In both instances the victim was one of the drivers of the trains involved in the collision.

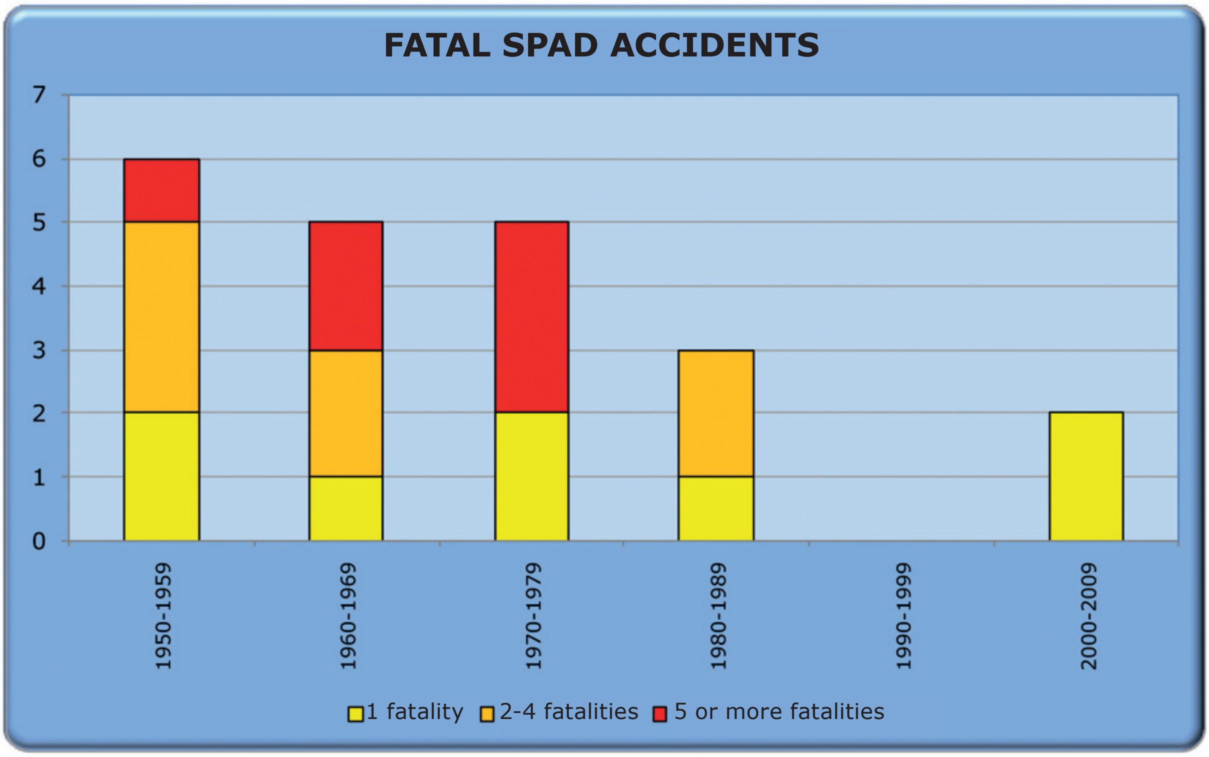

Figure 7: SPADs resulting in fatal accidents (number of collisions in ten years)

Figure 8 shows the movement in the number of accidents (collisions and derailments) involving SPADs in the past twenty years. The figure clearly reveals that twenty years ago the five-year average fluctuated at around one to two accidents a year and then doubled in the nineteen-nineties to around three to four accidents a year.

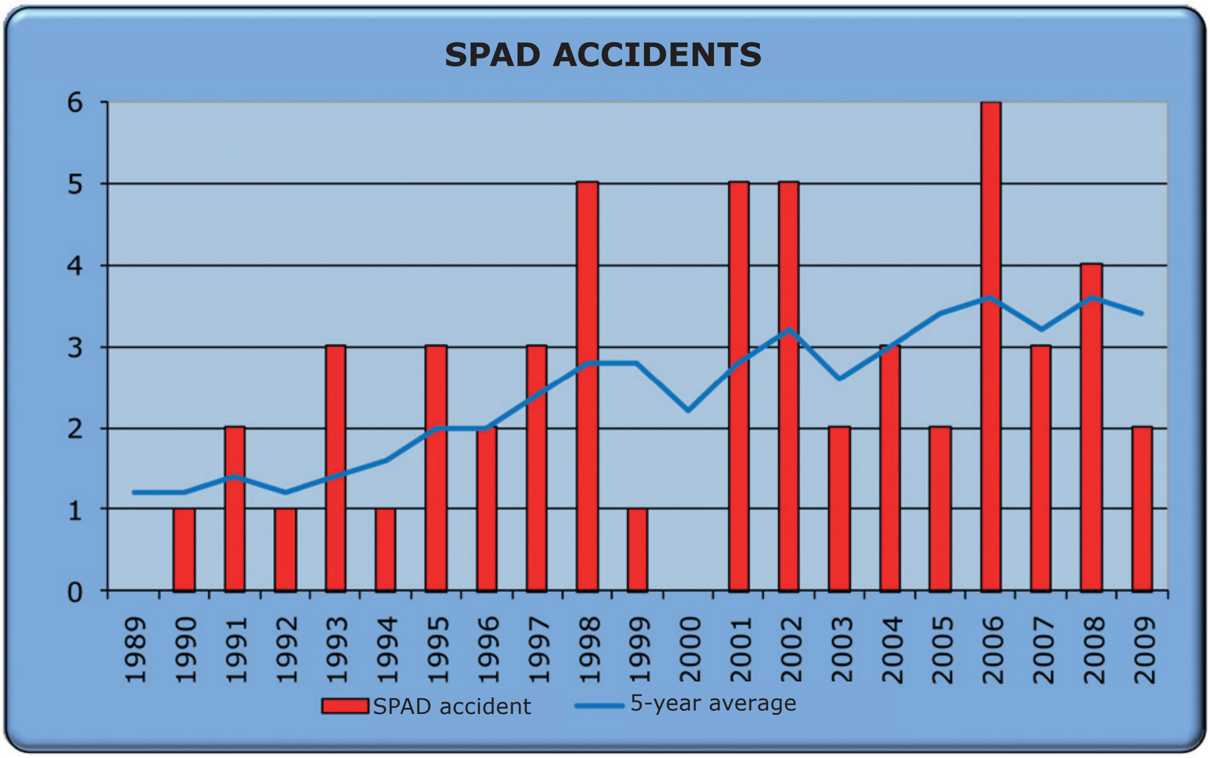

Figure 8: Accidents related to SPADs

3 REFERENCE FRAMEWORK

The reference framework for this investigation is comprised of three sections. The first section reviews the legislation and regulations that are intended to promote railway safety. The second section contains a brief review of the standards and instructions drawn up by the railway parties. The third section explains the Board's expectations of the manner in which the parties involved fulfil their personal responsibility for safety.

3.1 Legislation and regulations

Legislation and regulations have been drawn up at both a national and European level with the objective of promoting railway safety. The European Union has drawn up a number of directives focused on this issue, the most relevant of which is the Railway Safety Directive. The member states are required to implement the European directives in their national legislation and regulations. The Netherlands has arranged for the safety of the Dutch main railway network in the Railways Act. This Act has been implemented by the adoption of a range of decrees and regulations. The statutory framework governing the Dutch railway sector is summarised in Figure 9. The figure is followed by an explanation of the relevant legislation and regulations.

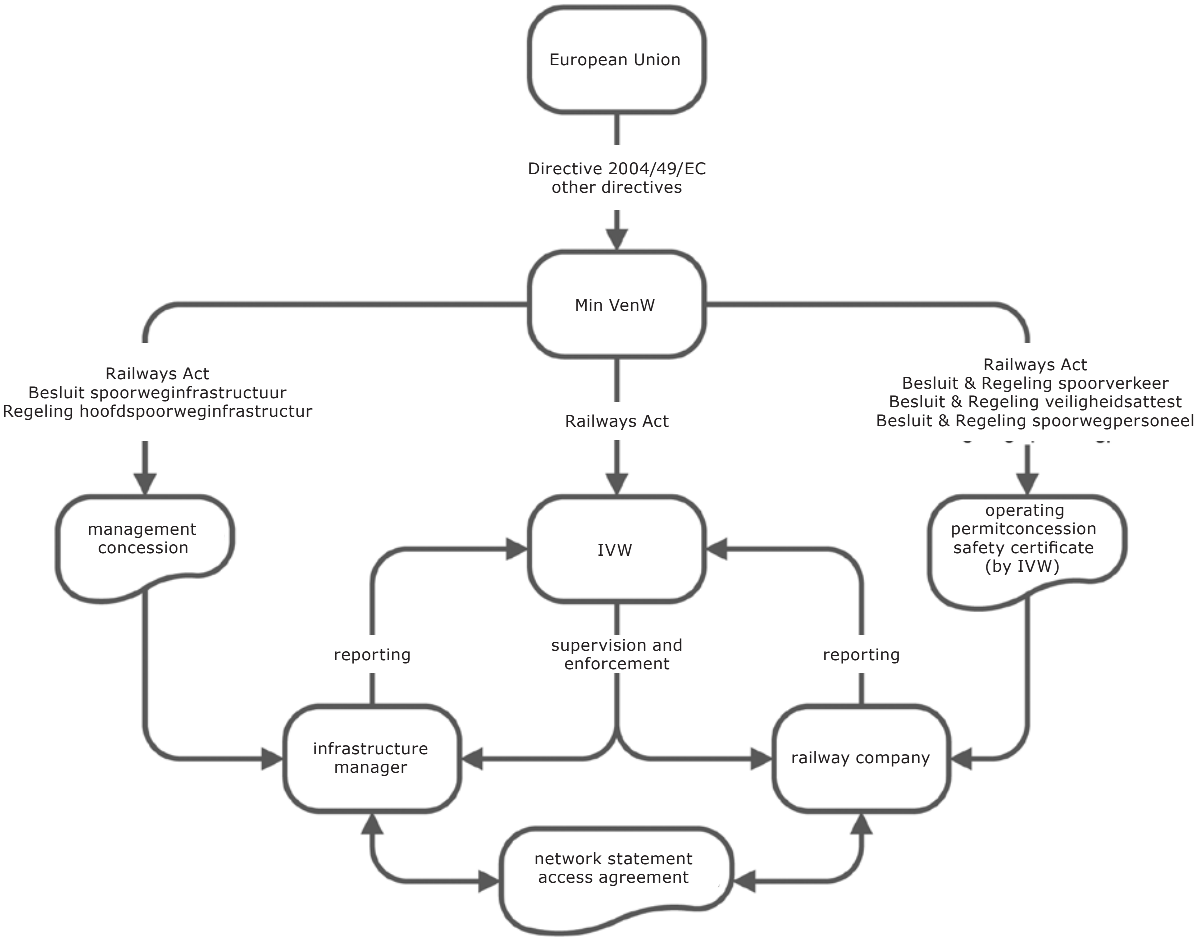

Figure 9: Relevant legislation and regulations

3.1.1 European directives

The objective of the European Railway Safety Directive 2004/49/EC (hereinafter referred to as the 'Directive') is to promote the safety of the railway system in its entirety.[42] The Directive specifies the safety targets the member states of the European Union shall endeavour to achieve and the safety indicators and measurement methods which they shall employ to determine whether those targets are also achieved.

Pursuant to the Directive the member states of the European Union are also assigned the following duties with respect to the development and improvement of railway safety:

- To ensure that the responsibility for the safe operation of the railway system and the control of risks associated with the system is assigned to the infrastructure managers and railway undertakings;
- To impose the obligation on them to implement necessary risk control measures, where appropriate in cooperation with each other, to apply national safety rules and standards, and to establish safety management systems.[43] [44]

In conclusion, the Directive specifies the following about the responsibilities of the various parties involved in railway safety:[45] '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.'

3.1.2 Railways Act

The Railways Act, which came into force on 1 January 2005, lays down provisions governing the construction, management, accessibility and use of the railways as well as the traffic on the railways. This Act makes a distinction between the responsibility for the infrastructure and the responsibility for railway traffic.

The Minister grants a concession for the management of the main railway network to one or more infrastructure managers.[46] This management, in addition to the arrangements for the quality, reliability and availability also encompasses the division of capacity and the traffic management. The Minister attaches conditions to the concession to provide assurances that railway traffic can travel on the infrastructure in a safe and efficient manner, and that safety risks associated with the use and management of the infrastructure are analysed and controlled to an adequate extent by implementing suitable measures.[47] When doing so, account needs to be taken of the specific requirements that the operations may be expected to impose and the state of the art. The aforementioned conditions and requirements are incorporated in the management concession[48] which also stipulates that the manager must possess an adequate safety management system (SMS) that complies with specific requirements.[49]

The Minister of Transport, Public Works and Water Management assigns the operation of the railway traffic to the railway companies. The railway companies must be granted an operating permit to carry out their operations. This operating permit is issued by the Minister.[50] The railway companies must be issued a safety certificate[51] before they may make use of the main railway infrastructure. This safety certificate is issued by the Inspectorate for Transport, Public Works and

42 Since the interoperability directives 1996/48/EC and 2001/16/EC also address safety systems these directives are also of relevance to railway safety.

43 The European Directive refers to a 'safety management system' whilst the Dutch legislation and regulations refer to a 'safety assurance system'. Other documents issued by the government and the railway parties usually refer to a 'safety management system' (SMS). This report also uses the term 'safety management system'.

44 Article 4, paragraph 3 of the Railway Safety Directive (2004/49/EC).

45 Railway Safety Directive (2004/49/EC), whereas 7.

46 Article 16 of the Railways Act.

47 Article 17, paragraph 1, under b and c of the Railways Act.

48 ProRail has been granted the management concession for the main railway network for the period from 1-1-2005 to 1-1-2015.

49 Article 3 and Article 7 of the management concession for the main railway network.

50 Article 27, paragraph 2, under a, of the Railways Act.

51 Article 27, paragraph 2, under b, of the Railways Act.

Water Management (IVW). A condition attached to the issue of this safety certificate stipulates that the railway company must demonstrate that it is in a position - by means of the implementation of an adequate safety management system (SMS) - to make safe use of the railways.[52] The Act imposes a number of functional requirements on the railway companies SMSs.[53] The content of the SMS must include assurances that the railway company:

- 'does not cause damage and does not hinder others unnecessarily during its normal operations and foreseeable deviations from the normal operations and ensures that the railway traffic can be carried out without disruptions whenever possible;
- takes account of the specific requirements imposed when the normal operations have an impact on the operations of other users of the railways or of the infrastructure manager;
- recognises the risks associated with the operations and implement suitable measures to achieve adequate control of those risks, whereby account is taken of the state of the art and the sector's knowledge and guidelines relating to safe operations;
- adopts and maintains procedures for the implementation of corrective measures in response to anomalies and incidents, as well as for continual improvements to the safety level from the perspective of changing circumstances and newly-acquired experience;
- ensures that employees assigned safety duties follow the further or supplementary courses, training, studies and experience needed to maintain their suitability, knowledge and competences required for the performance of their safety.'

The Act imposes further training and suitability requirements on railway company employees with safety duties[54] and the rolling stock used on the railways.[55]

As stated above, the Railways Act prescribes that the infrastructure manager and carriers must have adequate control of the safety risks by the implementation of suitable measures. The Second and Third Railway Safety Framework Documents[56], which lay down the government's railway safety policy detail - in line with the Railways Act and the management concession - what is understood as adequate control of the safety risks by the implementation of suitable measures. The Framework Documents state that the ALARP[57] principle serves as the criterion for the adequate control of safety risks. Pursuant to this principle the responsible parties are required to implement the available measures unless they can demonstrate that the costs and/or other consequences of a measure are unreasonable.

3.1.3 Decrees and regulations derived from the Railways Act

The Railways Act has been implemented by the adoption of a range of decrees and regulations. The decrees and regulations of relevance to this investigation are reviewed briefly below. The decrees and regulations reviewed in this subsection all came into force on 1 January 2005.

Besluit spoorweginfrastructuur ('Railway infrastructure Decree') and Regeling hoofdspoorweg-infrastructuur ('Main railway infrastructure Regulations')

The Decree lays down provisions governing the inspection, maintenance and repair of the main railway infrastructure and the protection of the main railway network and its surroundings. The contents of the Regulation include the technical basic requirements to be met by the main railway infrastructure and the rolling stock.

52 Article 32, paragraph 1, under b, of the Railways Act.
53 Article 33, paragraph 2 of the Railways Act.
54 Article 49 and 50 of the Railways Act.
55 Article 36 of the Railways Act.
56 Ministry of Transport, Public Works and Water Management, Safety on the railways. Second Railway Safety Framework Document, November 2004 (House of Representatives of the States-General, sessions 2004-2005, 29 893, numbers 1 and 2); Ministry of Transport, Public Works and Water Management, The railways: safety of transport, safety of work and safety of life. Third Railway Safety Framework Document, June 2010 (House of Representatives of the States-General, sessions 2009-2010, 29 893, numbers 106).
57 As low as reasonably practicable.

The provisions of the Regulations include the stipulation that the protection system of the main railway infrastructure[58] must provide assurances for the segregation of the routes of the trains.[59] The Regulations also stipulate that the safe trafficability of the routes must be made known to the train drivers by means of signals or cabin signals.[60] The Regulations also stipulate that that the relevant part of the main railway network must be equipped with a train protection system that transmits the prevailing signal aspects to the rolling stock (divided into at least the speed increments of 40-60-80-130-140 km/hour).[61]

Decree keuring spoorvoertuigen ('Rolling stock inspection Decree') and Regeling keuring spoorvoertuigen ('Rolling stock inspection Regulations')
The regulations stipulate that self-propelled rolling stock must be equipped with an automatic train protection system (ATP). The functionality of this system must be equivalent to ATB-EG. The requirements (and the exceptions to the requirements) are specified in the relevant regulations.[62]

Besluit bedrijfsvergunning en veiligheidsattest hoofdspoorwegen ('Operating permit and safety certificate for the main railway lines Decree') and Regeling veiligheidsattest hoofdspoorwegen ('Safety certificate for main railway lines Regulations')
The Decree lays down further regulations governing the operating permit and the safety certificate. The operating permit governs access to the profession of railway company. However, this permit does not grant access to the main railway lines, since the Railways Act includes supplementary conditions which include the possession of a safety certificate. Both the operating permit and safety certificate impose safety requirements. whereby the safety requirements stipulated in the operating permit relate primarily to the railway company's internal organisation and the safety requirements stipulated in the safety certificate relate more to the safe participation in railway traffic in practice.

The regulations lay down a number of provisions governing the assessment and issue of the railway companies' mandatory safety certificate in more detail. The Regulations' requirements include the implementation of a safety management system (SMS):[63]
1. provides for the adoption of an adequate safety policy;
2. provides for the registration of anomalies, the manner in which an inventory is made of the potential risks, the manner in which this inventory is updated and the manner in which compliance with the SMS is supervised;
3. assures that the documented railway safety instructions are kept up to date;
4. assures that employees with safety duties are and remain adequately schooled and that the rolling stock continually complies with the statutory requirements;
5. provides for adequate internal communications on railway safety risks.

Besluit spoorverkeer ('Railway traffic Decree') and Regeling spoorverkeer ('Railway traffic Regulations')
The Decree and the Regulations stipulate further provisions governing the safe and undisrupted use of the main railway infrastructure, including issues such as the train formation, driving speeds and location of signals. The provisions governing the location of signals are of particular relevance to this investigation. The provisions govern the positioning and visibility of signals and stipulate that, in principle, trains must always stop at a signal set at danger.[64] Train drivers may pass a signal set at danger solely when the rail traffic manager issues what is referred to as a 'signal set at danger authorisation'.[65] Annex 4 to the Regeling spoorverkeer contains an explanation of the nature, design and significance of signs.

58 Article 7, paragraph 1, of the Railways Act stipulates that main railway lines that be used by trains travelling at speeds above 40 km/hour must be equipped with a protection system.
59 Article 13, paragraph 1 of the Regeling hoofdspoorweginfrastructuur.
60 Article 13, paragraph 2 of the Regeling hoofdspoorweginfrastructuur.
61 Article 14 of the Regeling hoofdspoorweginfrastructuur.
62 Article 26 of the Regeling keuring spoorvoertuigen.
63 Article 2-8 Regeling veiligheidsattest hoofdspoorwegen.
64 Annex 4 to Article 24, paragraph 1 of the Regeling spoorverkeer.
65 Article 3 of the Regeling spoorverkeer. Directions of this nature may be issued solely for operated signals.

Besluit spoorwegpersoneel ('Railway staff Decree') and Regeling spoorwegpersoneel ('Railway staff Regulations')
The Decree stipulates that train drivers must comply with a number of requirements for their general knowledge and competence.[66] The Decree also stipulates that employees with safety duties (including train drivers) must comply with medical and psychological fitness requirements.[67] They are required to undergo a medical examination and a psychological examination. Their medical and psychological fitness must be confirmed by statements to that effect. These statements are of a limited period of validity. The period of validity depends on the train driver's age.[68] In addition to acquiring the professional knowledge required for the performance of the relevant safety duties, this knowledge must be maintained at the same level and the professional performance of employees with safety duties must be appraised at regular intervals.[69]

The regulations specify four issues addressed by the Besluit spoorwegpersoneel Decree in detail, namely the examination procedure, the medical and psychological requirements and the training programme for trainee train drivers.

3.2 Company regulations

The railway companies have drawn up internal procedures and regulations to supplement the aforementioned legislation and regulations. The objective of these is to manage the risks associated with railway traffic and/or to provide for uniform processes. The scheduling standards for the design of schedules and the 'Handboek & werkwijze treindienstleider' ('Rail traffic manager manual and procedure') are of relevance to this investigation.

The scheduling standards are specified in a network statement to be drawn up by the railway manager once a year. This network statement contains information about the conditions attached to access to the railway infrastructure, such as the specification of scheduling standards to be met by the schedules. These requirements primarily relate to the logistics process, i.e. whether the infrastructure can be utilised in the scheduled manner without one of the trains encountering a signal set at danger.

ProRail's 'Handboek & werkwijze treindienstleider' lays down the procedures governing the rail traffic managers' performance of their duties.

The scheduling standards and the 'Handboek & werkwijze treindienstleider' are discussed in more detail in Section 5.

3.3 Safety management

The Dutch Safety Board has specified a reference framework for use in each of its investigations. This defines a number of issues that need to be addressed in the safety management systems of the organisations involved in the incident that gave cause to this investigation. The Board's assessment framework lists the following points for special interest:

1. **Insight into risks as the basis for the safety approach:** The achievement of the required safety level needs to begin with an exploration of the system followed by an inventory of the associated risks. This inventory serves as the basis for the specification of the risks to be controlled and the preventive and repressive measures that will need to be implemented to do so;
2. **Demonstrable and realistic safety approach:** The occurrence of undesirable incidents should be prevented and controlled by laying down a realistic, practicable safety policy together with the principles on which the policy is based. This safety approach must be defined and controlled at a management level. This safety approach is based on: (a) the relevant prevailing

66 Article 24 of the Besluit spoorwegpersoneel.
67 Chapter III of the Besluit spoorwegpersoneel.
68 Article 31 and Article 32 of the Besluit spoorwegpersoneel.
69 Article 39, paragraph 1, of the Besluit spoorwegpersoneel.

legislation and regulations and (b) the available standards, guidelines and best practices from the sector, the organisation's insights and experiences from the organisation and the safety targets defined specifically for the organisation;[70]

3. **Implementing and enforcing the safety approach:** The implementation and enforcement of the safety approach and the control of identified risks is carried out by:
   - A specification of the method used to implement the adopted safety approach, with attention to the specific targets and plans including the preventive and repressive measures based on the targets;
   - A transparent and unambiguous division of the responsibilities at the workplace for the implementation and enforcement of safety plans and measures, whereby information about this division of responsibilities is available to everyone in the organisation;
   - A clear specification of the staff deployment and expertise required for the various tasks;
   - A clear and active central coordination of the safety activities;
4. **Tightening the safety approach:** The safety approach must be updated continually on the basis of:
   - The proactive performance of (risk) analyses, observations, inspections and audits at periodic intervals and at least after every change in the principles;
   - A system for the monitoring and investigation of incidents, near-misses and accidents and their expert analysis (a reactive approach). These analyses serve as the basis for evaluations followed, where relevant, by the management's modification of the safety approach. This also reveals points for improvement that can then be addressed in an active manner;
5. **Management control, involvement and communication**: The management of the parties/organisations involved should:
   - Ensure that explicit and realistic expectations of the safety ambition are known within the organisation, ensure that the organisation's working climate is characterised by the wish to achieve continual improvements in safety at the workplace by at least setting a good example and, in conclusion, make sufficient staff and resources available to do so;
   - Provide for explicit communications on the general working methods, the procedures used to assess the methods and the procedures adopted in the event of variances to parties and persons outside the organisation as based on clear and specified agreements with the surroundings.

The Board appreciates that the assessment of the manner in which organisations implement safety management should take account of the nature and size of the organisation.[71] For this reason the formation of an opinion can vary between incidents, although the general approach remains unchanged and the aforementioned expectations remain in force together with, self-evidently, the applicable statutory obligations.

70 The Second Railway Safety Framework Document lays down the government's railway safety policy for the period from 2004 to 2010 (House of Representatives of the States-General, sessions 2004-2005, 29 893, numbers 1 and 2).

71 This issue is also addressed in the Railways Act: Article 33, paragraph 3, stipulates that the railway company's safety management system must be appropriate to the nature and size of the company.

4 THE PARTIES INVOLVED AND THEIR RESPONSIBILITIES

This Section reviews the parties involved in the SPAD issue in general and in the train collision at Barendrecht in particular.

A number of parties are involved in the achievement of railway safety. Following the enactment of the Railways Act the government's task has primarily been to specify the frameworks: the primary responsibility for the everyday implementation has been assigned to the railway parties, whereby the infrastructure manager and the railway carriers are equal parties. The Inspectorate for Transport, Public Works and Water Management (IVW) supervises the parties' compliance with the various provisions of the Railways Act.

Subsection 4.1 reviews the various government organisations involved and their responsibilities, subsection 4.2 reviews the various companies involved and their responsibilities whilst subsection 4.3, in conclusion, reviews the cooperation between the various parties involved.

4.1 The government organisations involved

This subsection reviews the government organisations involved in the SPAD issue: The Ministry of Transport, Public Works and Water Management[72] and the Inspectorate for Transport, Public Works and Water Management.

4.1.1 Minister of Transport, Public Works and Water Management

The Minister of Transport, Public Works and Water Management is responsible for the railway safety system and the railway companies are responsible for the day-to-day operations. Consequently, the Minister is responsible for the formulation of policy, the performance of the statutory framework, the initiation of new legislation and regulations and the institution, organisation and performance of the supervision of railway safety.[73]

This means that the Minister's role is to specify the frameworks, whilst the responsibility for the safety of the day-to-day operations rests with the railway parties (the railway companies and the infrastructure manager). They must operate within the stipulated frameworks.

The framework governing the infrastructure manager is specified in the concession the Minister grants for the management of the main railway infrastructure. The framework governing each railway company is specified in the safety certificate. A safety management system is mandatory for both the infrastructure manager and the railway companies.

The Railways Act stipulates that the Minister of Transport, Public Works and Water Management supervises compliance with the safety provisions laid down by or in accordance with the Railways Act. The Minister has designated the Inspectorate for Transport, Public Works and Water Management to carry out this supervision.

4.1.2 Inspectorate for Transport, Public Works and Water Management

The Inspectorate for Transport, Public Works and Water Management is, under the responsibility of the Minister, entrusted with the enforcement of the Ministry of Transport, Public Works and Water Management's legislation and regulations.[74] The Inspectorate enforces compliance with

72 This portfolio was renamed 'Infrastructure and the Environment' on 14 October 2010. This report refers to the portfolio using the name prevailing at the time of the incident, namely: Ministry of Transport, Public Works and Water Management.

73 Ministry of Transport, Public Works and Water Management, The railways: safety of transport, safety of work and safety of life. Third Railway Safety Framework Document, June 2010, page 24 (House of Representatives of the States-General, sessions 2009-2010, 29 893, number 106).

74 Article 2 of the Regeling Inspectie Verkeer en Waterstaat ('Inspectorate for Transport, Public Works and Water Management Regulations') 2002.

the legislation and regulations by means of three methods, namely the provision of services, supervision and investigations. The Inspectorate's supervisory duties are of particular relevance to this investigation. The Inspectorate for Transport, Public Works and Water Management bears the responsibility for the issue and renewal of safety certificates to the railway companies on the Minister of Transport, Public Works and Water Management's behalf. The Inspectorate also assesses whether the safety management systems of the railway companies and infrastructure manager are adequate. In conclusion, the Inspectorate also carries out investigations of accidents, incidents and irregularities.

4.2 The companies involved

The following companies were involved in the train collision at Barendrecht:

- The manager of the infrastructure that was also responsible for the traffic management, ProRail;
- The railway company operating the mixed goods train number 61300, DB Schenker Rail Nederland (formerly Railion);
- The railway company operating the container train number 42331, ERS Railways;
- The railway company operating the international passenger train number 9272, NS Reizigers;
- Other railway companies using the relevant route at the time.

The following subsections review the responsibilities borne by the infrastructure manager and railway companies for railway safety in general and for the control of the SPAD issue in particular.

4.2.1 Infrastructure manager

The infrastructure manager is the organisation bearing the responsibility for the management of the railways. The Minister of Transport, Public Works and Water Management has granted the management concession for the main railway lines to ProRail for the period from 1 January 2005 to 1 January 2015.[75] Within the context of this management concession KeyRail operates the Betuweroute, the goods railway line from the Rotterdam Maasvlakte via Kijfhoek to Zevenaar.[76] ProRail, as the holder of the management concession, bears the sole responsibility for compliance with the statutory management obligations imposed on the manager.

ProRail's duty is to operate, maintain and, when so decided by the central government, expand the railway network. Within the context of its operation of the railway network ProRail distributes the capacity between the various goods and passenger carriers. Consequently, ProRail is responsible for the traffic management.

ProRail, as the manager of the infrastructure, is responsible for ensuring that the rail traffic can travel on the infrastructure in a safe and efficient manner. This responsibility is detailed further in instructions in the management concession. Pursuant to the management concession ProRail must ensure that the risks associated with both the use and management of the main railway infrastructure are analysed and that suitable measures are implemented for the adequate control of those risks, whereby ProRail must take account of the specific requirements that the operations may be expected to impose and the state of the art.[77] This implies that ProRail also needs to take account of risks that arise for causes outside of ProRail's direct sphere of influence.

Pursuant to the management concession ProRail must be in the possession of a safety management system (SMS) (as from 1 January 2008) that complies with the requirements laid down in the

75 Ministerial Order by the Minister of Transport, Public Works and Water Management relating to the management concession for the main railway infrastructure; Ministerial Order by the Minister of Transport, Public Works and Water Management relating to the amendment of the management concession for the main railway infrastructure.

76 Keyrail was incorporated by the Port of Rotterdam Authority, the Port of Amsterdam and ProRail on 1 January 2007.

77 Article 3 of the management concession for the main railway network.

Railways Act.[78] These requirements stipulate that ProRail must make arrangements including the following:

- procedures and methods for the assessment and control of risks when changes in the operating conditions or new equipment result in new risks to the infrastructure or operations;
- procedures to ensure that accidents, incidents, near misses and other hazardous occurrences are reported, investigated and analysed and that the necessary preventive measures are implemented;
- provisions for periodic internal audits of the SMS.

Keyrail's role as the operator of the Betuweroute goods railway line relates in particular to a number of logistics operations including the design of the schedules and the traffic management. Although Keyrail provides the traffic management services for the Betuweroute goods railway line these, from an administrative perspective, fall under the full responsibility of ProRail.

4.2.2 Railway companies

The railway companies, also referred to as 'carriers', are engaged in the transport of passengers and goods. These transports must give due regard to safety. A railway company does not have access to the main railway lines when:[79]

- The company does not have a valid operating permit;
- The company does not have a valid safety certificate or test certificate;
- The company does not comply with the insurance obligations imposed on the company;
- The right to access does not arise directly from an access contract as referred to in Article 59 of the Railways Act; and
- The company is not otherwise authorised to make use of the main railway lines.

The Minister of Transport, Public Works and Water Management grants an operating permit when the railway company complies with the requirements of a sound reputation, sufficient financial resources and professional competence, and has taken out sufficient third-party insurance.[80] A railway company wishing to receive a safety certificate must demonstrate that:[81]

- The company has implemented adequate safety management as referred to in the Railways Act; and
- The company's implementation of safety management ensures that the company can make safe use of the railways, whereby the company complies with the safety certificate instructions laid down by or in accordance with the Railways Act.

When the above conditions are met the Inspectorate for Transport, Public Works and Water Management issues a safety certificate on the Minister of Transport, Public Works and Water Management's behalf.

The railway companies must have implemented a safety management system which provides assurances including the following:[82]

- The risks associated with the operations are recognised and suitable measures are implemented to achieve adequate control of those risks, whereby account is taken of the state of the art and the sector's knowledge and guidelines relating to safe operations;
- Procedures are adopted and implemented for the implementation of corrective measures in response to anomalies and incidents, as well as for continual improvements to the safety level from the perspective of changing circumstances and newly-acquired experience;
- Procedures have been drawn up which govern third-party supplies of services to the rail company and goods relating to rail safety.[83]

78 Article 17 of the Railways Act in conjunction with Article 7, paragraph 1, of the management concession for the main railway infrastructure.
79 Article 27, paragraph 2 of the Railways Act.
80 Article 28, paragraph 1 of the Railways Act.
81 Article 32, paragraph 1, of the Railways Act; Article 16, paragraph 4, of the Besluit bedrijfsvergunning en veiligheidsattest hoofdspoorwegen ('Operating permit and safety certificate for the main railway lines Decree').
82 Article 33, paragraph 2 of the Railways Act.
83 Article 7, Regeling veiligheidsattest hoofdspoorwegen ('Safety certificate for main railway lines Regulations')

Consequently, the Railways Act prescribes that the safety risks must be adequately controlled by suitable measures.[84] These risks can also relate to risks that arise for causes outside of the carrier's direct sphere of influence. The carrier must take account of these risks in the carrier's assessments and, where relevant, implement measures to reduce those risks.

The railway company must ensure that the drivers of railway vehicles comply with the stipulated requirements for their suitability, knowledge, competence and experience and that they have been issued a statement for their medical and psychological fitness. Employees with safety duties (including train drivers) must undergo medical and psychological examinations. Their medical and psychological fitness must be confirmed by statements to that effect. These statements are of a limited period of validity. The period of validity depends on the employee's age.[85]

4.3 Cooperation between the parties involved

The European Railway Safety Directive requires the parties to cooperate as required: '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.' The government position on the evaluation of the railways legislation refers to the above whereas in the Railway Safety Directive and adds: 'This is given shape with specific agreements and instruments such as the Integral Safety Plan. This cooperation is essential to railway safety.'[86] Two cooperative arrangements are of relevance to the SPAD issue.

Overleg Veiligheid Spoorwegondernemingen ('Rail Company Safety Consultations', OVS)
The Overleg Veiligheid Spoorwegondernemingen (OVS) is a platform in which the infrastructure manager, railway companies, the Ministry of Transport, Public Works and Water Management and the Inspectorate for Transport, Public Works and Water Management take part, harmonise their plans and hold consultations, exchange information and assess plans for railway safety regulations. The OVS discusses the SPAD issue, although the SPAD steering group referred to below makes the decisions on the SPAD issue.

SPAD steering group
The SPAD steering group is a temporary project organisation that monitors developments in the number of SPADs, initiates actions to reduce the number of SPADs and the concomitant risks and monitors progress in the implementation of the measures. The steering group drew up a plan of approach at the end of 2004, in which it discusses the possible causes of SPADs and lists measures for the prevention or the reduction of SPADs. The following parties cooperate in the steering group:
- ProRail;
- DB Schenker;
- NS Dutch Railways;
- Representative from the OVS on behalf of the other goods carriers;
- Representative from the OVS on behalf of the other passenger carriers;
- Representative from the OVS on behalf of the railway contractors with a transport certificate.

The following parties also attend the meetings of the steering group as observers and on the Minister's behalf:
- The Ministry of Transport, Public Works and Water Management's Railways Directorate;
- Inspectorate for Transport, Public Works and Water Management

More information about the steering group is enclosed in Annex 6.

84 The ALARP principle is once again adopted as the criterion for the suitable control of the risks.
85 Article 31 and Article 32 of the Besluit spoorwegpersoneel.
86 House of Representatives of the States-General, sessions 2008–2009, 31 987, number 1, part 6.3.

5 ANALYSIS: UTILISATION OF THE CONTROL MEASURES

Since SPADs can have extremely serious consequences the Dutch Safety Board is of the opinion that all reasonable measures must be implemented to reduce the number of SPADs and limit the consequences of those SPADs that nevertheless occur. This implies that the maximum possible use must be made of the available measures.

5.1 Introduction

The Board has investigated the measures that could have contributed to the SPAD issue at Barendrecht. These measures are classified into three categories:

a. **Reduction of the number of signals set at danger** The primary issue of importance to the control of the SPAD issue is the minimisation of situations in which a train driver is confronted with a signal set at danger during the journey.
b. **Prevention of signals passed at danger.** When a driver is nevertheless confronted with a signal set at danger during a journey then measures are conceivable which could prevent the train passing the signal set at danger.
c. **Preventing a collision after passing a signal set at danger.** A number of options are available to prevent a collision after a train has passed a signal set at danger, namely measures intended to prevent the relevant train reaching the danger point and measures intended to warn other trains in time. In the first instance these measures are intended to prevent a collision, but they can also make a contribution to the limitation of the consequences.

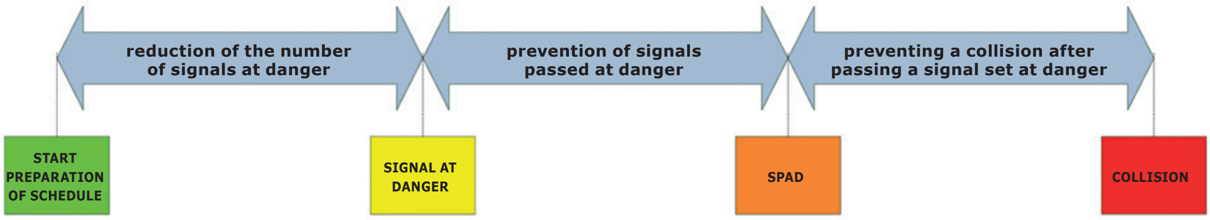

Figure 10: Three phases in the control of the SPAD issue

The following subsections review the available measures, whereby it is important to note that this report, as stated in subsection 1.3, addresses solely the control measures of relevance to the collision at Barendrecht. This report does not extent to a review of measures which focus on the control of the SPAD issue but did not play a role at Barendrecht (such as the visibility of the signals). Each subsection begins with a brief explanation of the measure, moves on to discuss the extent to which the failure to utilise the relevant measure played a role in the collision at Barendrecht and then assesses whether this situation is unique to Barendrecht or can occur more frequently in the Netherlands.

5.2 Reduction of the number of signals set at danger

The investigation revealed that the following measures which can prevent trains being confronted with a signal set at danger were of relevance to the train collision at Barendrecht:

- The design of the schedule by the scheduler (subsection 5.2.1);
- The modification of the schedule by the rail traffic manager (subsection 5.2.2);

5.2.1 The design of the schedule by the scheduler

Objective. The schedule, also referred to as the 'plan' specifies which train will make use of the railway network at which time. To this end the railway companies notify the infrastructure manager of the time at which they wish to carry out a specific train journey. The infrastructure manager and a number of major railway companies employ schedulers, whilst other railway companies, such as ERS Railways, request ProRail and Keyrail to schedule their trains. The infrastructure manager examines the feasibility of the schedule (for example, an assessment as to whether the submitted applications are in conflict) and then formalises the schedule. The schedulers endeavour to design the schedules in a manner that avoids the need for trains to use the same track at the same time and minimises the need for the trains to brake or stop during the journey. 'Schedule' refers to the timetable for one train and 'schedules' to the timetables for all trains.

Barendrecht. The Dutch Safety Board has examined the schedules of the relevant trains. Trains travelling from Rotterdam IJsselmonde to Kijfhoek, as was the case with the mixed goods train, must at some point cross the track used by trains travelling from Kijfhoek to the Havenspoorlijn goods railway line or to Rotterdam, as was the case with the container train (see Figure 2 in Section 2). Tables 1 and 2 list information about (part of) the schedules of the mixed goods train and container train.

Schedule of the mixed goods train travelling from IJsselmonde to Kijfhoek train number 61300, Mondays through Fridays				
IJsselmonde junction	through	track DG		22:28
Barendrecht junction	**through**	**track CE**	**22:30**	
Kijfhoek junction	**through**	**track LZ**		**22:32**
Kijfhoek North side	arrival	track 211	22:35	

Table 1: Schedule of the mixed goods train (from revision sheet 14-06-2009)

Schedule of the container train travelling from Kijfhoek to Rotterdam Lombardijen train number 42331, solely Thursdays				
Kijfhoek South side	departure	track 154	22:26	
Kijfhoek North side	through	track CD		22:31
Kijfhoek junction North	**through**	**track CE**	**22:31**	
Barendrecht junction	**through**	**track EF**		**22:33**
Barendrecht Fork junction	through	track EG		22:34
Rotterdam Lombardijen	through	track EH		22:35

Table 2: Schedule of the container train (from revision sheet 14-06-2009)

The schedule of the mixed goods train was drawn up by DB Schenker. ERS Railways requested Keyrail to reschedule the container train. Consequently, a number of parties worked on the schedule. The last party to amend the schedule must ensure that it complies with the scheduling standards.[87] The scheduling standards specify the minimum number of minutes to be allowed between the passage of two trains at one location. An element of the scheduling standards of relevance to Barendrecht is what is referred to as the 'crossover time' for goods trains at a junction: this amounts to a minimum of three minutes.

The data listed in tables 1 and 2 reveal that both trains would make use of the same track at the same time. Pursuant to the schedule for the mixed goods train it would travel on the track from 22:30 to 22:32, whilst pursuant to the schedule for the container train it would travel on the same track (with a length of about two kilometres) in the opposite direction from 22:31 to 22:33. Since the 'double-booked' track was released for the container train first the track could no longer be released for the mixed goods train. As a result, the mixed goods train was confronted with a signal set at danger. This scheduling conflict was not unique: this situation had occurred once a week for several months and, as a result, when both trains were running more or less on time then one of the trains was confronted with a signal set at danger.

87 These scheduling standards are included in the infrastructure manager's Network statement (Annex 23 to ProRail's Network statement and Annex 16 to Keyrail's Network statement).

The resolution of this conflict between the two trains would have required one of the two trains to be scheduled a number of minutes earlier or later so that the trains could use the same track after each other. In addition, either the mixed goods train or the container train could have been guided to an adjacent track to avoid the simultaneous use of the same track. In conclusion, the container train could have made use of a fly-over to travel directly from the Havenspoorlijn goods railway line to Rotterdam.[88] No scheduling standards are specified for the routing of the trains in a yard. The decision to proceed to the resolution of a conflict depends on the individual scheduler's perception of his duties.

The investigation has revealed that the various parties involved have different opinions on the use of the tracks between Kijfhoek and the junction at Barendrecht. These three tracks offer an opportunity for the flexible use of the tracks whereby trains can use all tracks in both directions and can switch between two of the three tracks at both Barendrecht and Kijfhoek at top speed. The schedulers could make use of this flexibility to reduce the probability of trains encountering signals set at danger.

The redesign of the tracks in around 2003 anticipated that crossing trains travelling from IJsselmonde to Kijfhoek would use the middle track (track CE) and trains travelling from Kijfhoek to the Havenspoorlijn would use the adjacent track BE.[89] The Dutch Safety Board has observed that this anticipated use of the tracks was unknown to the schedulers: the schedulers are not issued 'instructions for use' for their scheduling of trains in the yard. The flexibility integrated in the design offers scope for different ideas as to the best use of the tracks at Barendrecht.

The schedulers did not notice the conflict. Nor does their scheduling software offer them support to do so. Consequently, the options available to prevent the conflict in the schedules, the segregation of the train paths in location and/or time, were not utilised in the incident at Barendrecht. The signal set at danger was not consciously included in the schedules.

The Netherlands. The procedure used to prepare the schedules for Barendecht was no different from the procedure used in the rest of the Netherlands. The Inspectorate for Transport, Public Works and Water Management had already issued the following comment after a train collision in Gouda on 11 October 2008: The scheduling process lacks a final review of the feasibility and the consequences in practice, as well as an assessment of railway safety issues. This is, in particular, applicable to the potential risks associated with crossing routes. […] The various scheduling organisations fail to carry out insufficient coordination and harmonisation of and communications on the (consequences of) the scheduling.'

The Dutch Safety Board can understand that this comment, issued on 6 May 2009, had not yet resulted in the modification of the scheduling at Barendrecht. However, the Board is disappointed to note that the scheduling process is still unchanged more than one year later.

The investigation has revealed that the failure to design conflict-free schedules could be due to the following causes:

- **The scheduling standards do not offer any guarantee for the reduction of the number of signals set at danger in practice.** The carriers do not usually find it desirable that trains encounter signals set at danger during their journeys. For this reason the schedulers endeavour to draw up schedules that allow the trains to keep moving whenever possible, whereby they make use of the scheduling standards which stipulate that a train may not pass a specific point too soon after the previous train has passed that point. However, the scheduling standards specify solely a minimum time segregation of a duration such that a one-minute disruption of the schedule can result in the need for interim stops. As a result, although a schedule which complies with the scheduling does contribute to the reduction of the number of signals at danger

88 The container train came from the Rotterdam Maasvlakte and needed to travel in the direction of Rotterdam; without the detour to Kijfhoek the train could have travelled from Havenspoorlijn and in the direction of Rotterdam via the fly-over.

89 Programma van Eisen – Barendrecht eindplan goederensporen, railverkeerstechnisch ontwerp, versie 3.0, ('Schedule of Requirements – Final plan for goods tracks at Barendrecht, rail traffic design, version 3.0') July 2003.

the effectiveness of the measure is reduced in the event of delays. Interviews have revealed that many schedulers are of the opinion that their responsibility does not extend to designing schedules in a manner such that minor disruptions do not immediately result in unscheduled stops. As is illustrated above, this is certainly feasible in some instances.

- **The current scheduling system does not identify conflicts in the schedules.** The schedules are designed using the Vervoer Per Trein ('Transport by train', VPT) system. The VPT system does not generate a warning when two trains are simultaneously scheduled to use the same track. The identification and resolution of conflicts of this nature is left to the schedulers' expertise and perception of their duties.
- **The schedulers rely on the technical protection systems and are insufficiently aware that they themselves also play a role in assuring railway safety.** Errors in the scheduling or disruptions of the services, as reviewed above, can result in two carriers wishing to use the same section of the track at the same time. The schedulers then assume that the technical protection system will set signals at danger (as was also the case at Barendrecht) and rely on trains stopping at signals set at danger. However, as every train driver may make a mistake or become unwell and the automatic train protection system is not effective in all situations it is nevertheless possible that a train passes a signal set at danger. As illustrated above, the schedulers are also offered options for the prevention of conflicts and, consequently, signals set at danger: they could make use of these options as required to increase safety. At present, the use of these options usually depends on the individual scheduler. During an interview ProRail and Keyrail stated that there is no training programme for schedulers at present: the 'older' schedulers pass on their knowledge and experience to the next generation.

The result of the above three points is that the schedulers do not give structural consideration to the risks associated with crossing routes but instead rely totally on signals set at danger as the last barrier.

It should be noted that ProRail has also come to this conclusion following the accident at Barendrecht. ProRail and the other parties involved in the scheduling are now working on solutions for a number of problems that have been identified. ProRail and Keyrail are developing a new scheduling system, 'DONNA', which will be able to identify scheduling conflicts. Pursuant to this system the railway companies submit an application for a train which then needs approval from the infrastructure manager. This results in a technical aid for the final review of the schedules. However, it is not yet known when 'DONNA' will replace the current 'Vervoer Per Trein' (VPT) scheduling system. A scheduling course is also being developed that will prepare future schedulers better for their duties. However it is not clear whether, and, if so, when and to what extent the carriers are involved in this development.

5.2.2 The modification of the schedule by the rail traffic manager

Objective. Although the schedulers endeavour to prepare conflict-free schedules, it is nevertheless possible that two trains wish to make simultaneous use of the same section of track, for example due to an error in the schedules or due to a train not running to schedule. The rail traffic manager can then modify the schedule before implementing it, thereby keeping the trains moving and avoiding interim stops.

Barendrecht. ProRail has laid down the rail traffic managers procedures in the 'Handboek Treindienstleider' ('Rail traffic manager's manual') and 'Werkwijze Treindienstleider' ('Rail traffic manager procedures'). These documents also govern Keyrail's rail traffic managers. The Werkwijze Treindienstleider assumes that the schedules are supplied free of conflicts. However, this was not the case at Barendrecht. During interviews held with Keyrail's rail traffic managers they stated that they regularly observed that one of the trains had to stop. A rail traffic manager who discovers an error in a schedule line is required to report the error to his team manager. However, in this instance this did not result in a modification of the schedules, as a result of which the conflict remained unresolved.

The 'Werkwijze Treindienstleider' does not include a procedure for this specific situation, although it does include a procedure for the resolution of conflicts due to trains running behind schedule - which is a comparable situation, since the schedule is equally infeasible. The most important task in this procedure is stated as follows: 'A train running behind schedule can cause a conflict. You act as follows: 'Search for a solution that does justice to all interested parties, whenever possible within 15 minutes[90] before the performance time (…).'

In principle, rail traffic managers can opt for the same measures as the scheduler for the resolution of conflicts of this nature, such as rescheduling a train to another track or to another time (see subsection 5.2.1). The rail traffic managers, in analogy with the schedulers, do not possess support systems that visualise conflicts in advance. This limits the time available to resolve conflicts, as a result of which some measures (such as redirecting a train to another track) are no longer feasible when the train has already passed the relevant signal. The resolution of conflicts is also complicated by the involvement of more than one rail traffic manager. For example, if the Barendrecht rail traffic manager had wished to resolve the conflict by redirecting the container train to the adjacent track then the Kijfhoek rail traffic manager would have needed to implement this measure. However, the latter could not have seen the conflict at Barendrecht and would have allowed the train to depart over the scheduled track. Consequently, contact with the Kijfhoek rail traffic manager is required in the event that the scheduled track for one of the two goods trains is to be rescheduled.

The scheduling standards do not play a role in the rail traffic manager's duties: the sole safety criterion governing the performance of the schedule is that a block of track may not be released for more than one train simultaneously. This is assured by the fact that a signal (set at danger) is always present between two train movements. The Handboek Treindienstleider states that the rail traffic managers may rely on this: 'The safety of the railway infrastructure is assured by the protection system and procedures. (…). You may rely on the correct performance of the protection system.' Consequently, not only the schedulers but also the rail traffic managers rely on the prevention of conflicting routes by technical measures and the assurance of safety by signals set at danger.

The Netherlands. The methods available to the rail traffic managers for the resolution of conflicts at Barendrecht were no different from those in the rest of the Netherlands. It is then important to note that the risks associated with passing a signal set at danger are considerably greater for some signals than for others. However, the rail traffic manager can exert an influence on the location where the train is to stop by selecting which train of the two is to stop and by determining whether the this stop is to be made immediately before the conflict or at an earlier signal. However, there are no instructions governing the choice of the signal for an interim stop.[91] The rail traffic manager could also give consideration to stopping the trains earlier or have them reduce their speed so that they arrive at the location of the conflict only once the rail traffic manager has been able to configure a route and the signal is no longer set at danger.

The rail traffic managers do not, in analogy with the schedulers, possess technical support for the identification of situations in which two trains are scheduled simultaneously on the same block of track. Although the development of such a functionality of this nature began at the end of the nineteen-nineties it has never been implemented. This makes it difficult for rail traffic managers to prevent interim stops whenever possible, certainly on larger and often more complex yards.

90 The intention is: between now and 15 minutes before the performance time.

91 An exception is the signals with what is referred to as 'configuration instructions'. This is not a form of formal instructions, but a software configuration of the automatic route-setting system (ARI) that responds to a signal set at danger by setting the preceding signal at danger. This method is effective solely when the route is configured with ARI and has been installed solely on a limited number of signals.

5.2.3 Sub-conclusion:

The Dutch Safety Board has reached the following conclusions on the reduction of the number of signals set at danger:

- The signal of relevance to the accident at Barendrecht had been set at danger since both trains were scheduled on the same block of track at the same time. This scheduling conflict had not been identified either during the preparation of the schedules or the configuration of the routes. However, this scheduling conflict had occurred once a week for a number of months.
- Scheduling conflicts of this nature can occur more frequently. The following structural issues play a role in these conflicts:
  - The scheduling standards compel a minimum time segregation of trains. However, it is also necessary to make optimum use of the tracks to minimise the probability of signals being set at danger. The schedulers' selection of the tracks can further reduce the risks, although whether the appropriate tracks are actually selected depends on the expertise of the relevant schedulers and rail traffic managers and their perception of their duties.
  - Neither the software used to prepare the schedules nor the software used to execute the schedules includes functionality for the automatic identification of any conflicts in the schedules.
  - A number of parties are involved in the modification of the schedules. However, no final review is carried out to verify that the ultimate schedules are free of conflicts.
  - In practice, there is insufficient feedback from the rail traffic managers who implement the schedules to the schedulers who prepare the schedules, as a result of which scheduling conflicts can remain unresolved.

5.3 Prevention of signals passed at danger

The investigation of the facts of the accident at Barendrecht revealed that the following measures were of relevance to the prevention of signals passed at danger:

- Measures to reduce the risk of a train driver becoming unwell (subsection 5.3.1);
- The automatic train protection system (subsection 5.3.2);
- The cancel function (subsection 5.3.3).

5.3.1 Measures to reduce the risk of a train driver becoming unwell

Objective. One important factor in the prevention of signals passed at danger is ensuring train drivers are fit enough to carry out their duties. Measures can be implemented to reduce the probability of train drivers becoming unwell during their work or continuing their journey after they have become unwell.

Barendrecht. The Dutch Safety Board considers that it plausible is that the driver of the mixed goods train became unwell prior to the SPAD and the subsequent train collision. The Dutch Safety Board bases this on the following indications:

- The driver was confronted by two interventions of the dead man's system[92] earlier during the journey, as a result of which the train automatically came to a standstill. Interviews with train drivers and an analysis of automatic trip registrations carried out by DB Schenker[93] reveal that it is highly unusual for this to occur during a journey. The train driver continued his journey without any form of communication after each intervention: there are no instructions which state that train drivers must communicate an intervention. There is no mandatory or automatic

92 The mixed goods train was equipped with an intermittent dead man's system. This system ensures that the train initiates an emergency stop if the train driver becomes unwell or fails to respond for another reason, since the driver must press a pedal or button once every 60 seconds while the train is moving. When he fails to do so then the system automatically initiates an emergency stop.

93 DB Schenker has stated that from now on it will monitor the (repeated) activation of the dead man's system during its periodic analyses of the automatic trip registration of train speeds.

transmission of a message giving notification of an intervention by the dead man's system to, for example, the rail traffic manager. Consequently, the train driver is the only person who is aware of an intervention during the journey.

- The train driver who was killed in the accident initiated a braking action only two to three seconds before the collision. The train driver did not take any action whatsoever other than the initiation of this braking action during the last minute prior to the collision even though there were a number of indications that there was a threat of an accident. These indications were:
  - The train's approach to and subsequent passing of a highly-visible signal set at danger to the right of and above the relevant track;
  - The train passed over an open set of points.[94] Train drivers usually feel this as the train passes over the set of points;
- An autopsy revealed that the train driver suffered from an hereditary heart disorder. This heart disorder, which can result in sudden indisposition or even in death, can be accompanied by cardiac arrhythmia, dizziness and/or fainting. The two interventions of the dead man's system during the journey could have been due to complaints of this nature.

Pursuant to a requirement by law train drivers must undergo periodic examinations to verify their medical and psychological fitness for their duties.[95] The driver of the mixed goods train was 56. The train driver underwent a medical and psychological examination at the time of his appointment and subsequently underwent medical examinations every five or four years (in accordance with the statutory regulations) until he was 50[96] and then every two years from the age of 50. The driver of the mixed goods train underwent seven medical examinations after the examination on his appointment. These medical examinations were carried out by different examination organisations. All the (re)examinations carried out by these organisations, which included electrocardiograms (ECG), resulted in a declaration that the driver was fit to carry out the duties of a train driver with full authorisation.

The driver had a heart disorder which is included on a list of disorders that give cause to declare train drivers medically unfit to carry out their duties. This heart disorder was not observed during any of the examinations and the train driver was always declared medically fit. Although a symptom indicative of this disorder was observed during the train driver's last medical examination, this did not give cause to further medical examination. The Dutch Safety Board expects that the medical examinations preclude as many of the disorders included on this list as possible before train drivers are declared medically fit. This condition was not met: the symptom observed during the medical examination was not examined further whilst this should have taken place.

The Netherlands. Five train collisions have occurred in the Netherlands since 1996 which were caused by the train driver becoming unwell and failing to observe a signal aspect.[97] It is striking to note that all five incidents resulted in extremely serious material damage and, in a number of cases, in many injured:

- Amersfoort, 5 December 1996, several people injured;
- Roermond, 20 March 2003, one fatality and seven people injured;
- Maastricht, 24 June 2006, fourty people injured;
- Enkhuizen, 31 March 2008, twelve people injured;
- Barendrecht, 24 September 2009, one fatality and one person injured.

It is not possible to entirely preclude the risk that train drivers become unwell. However, measures are conceivable which can reduce the probability of train drivers becoming unwell during their work or continuing their journey after they have become unwell. The first of these measures relates to the introduction of more stringent periodic medical examinations of train drivers. The second of

94 'passed over an open set of points' refers to the train passing over a set of points that are not in the correct position for the train.
95 Article 49 and 50 of the Railways Act.
96 The Besluit spoorwegpersoneel stipulates that train drivers with full authorisation must undergo examinations once every five years until the age of 40, once every four years between the ages of 40 and 50, and once every two years from the age of 50.
97 The accidents at Maastricht and Enkhuizen were not caused by passing a signal at danger, but caused by the driver's non-observance of a signal aspect without authorisation.

these measures relates to the development of a (technical or organisation) system that makes it impossible for train drivers to continue their journey after a first or second intervention of the dead man's system. For example, train drivers can be placed under the obligation to give notification of an intervention of the dead man's system to, for example, the rail traffic management before continuing their journey. This notification could also be transmitted automatically.

5.3.2 The automatic train protection system

Objective. The automatic train protection system (ATP) checks that train drivers comply with the commands they receive from the signals along the track. If the driver does not obey a command then the system initiates an automatic emergency braking action.

Barendrecht. The Barendrecht yard and the Kijfhoek goods yard were equipped with automatic train protection - first generation (ATB-EG) systems. ATB-EG has the following two important functional limitations:

- When the train approaches a signal set at danger then ATB-EG checks whether its speed is more than 40 km/hour: when this condition is met the system does not initiate a braking action.
- When the driver of a train travelling at more than 40 km/hour does brake but fails to apply sufficient braking force to stop before the signal set at danger then ATB-EG does not intervene (no braking curve monitoring).

ATB-EG did not initiate a braking action in the Barendrecht incident because the train was travelling slower than 40 km/hour. Automatic train protection - improved version (ATB-VV), which is being fitted to an increasing number of signals to bring trains that could pass a signal set at danger to a standstill before the signal, could have initiated a braking action in the Barendrecht incident. However, the system was not fitted to the relevant signals. The relevant signal at Barendrecht was not one of the 1,260 signals scheduled to be equipped with ATB-VV.[98] Pursuant to the implementation plans the locomotives should also have been equipped with this supplementation at the time of the accident: however, as a result of delays in the workshops the two locomotives of the mixed goods train were not yet equipped with ATB-VV. If the signals and the front locomotive of the mixed goods train had been equipped with ATB-VV then this could have prevented the accident. This would also have been the case if the train and signal had been equipped with ERTMS, the new European protection system, which has been introduced on the Havenspoorlijn goods railway line.

An analysis of the automatic trip registration of the locomotive of the mixed goods train revealed that ATB-EG limited the train's speed to 40 km/hour, in accordance with the design. The ATP system was operational and no notifications of ATP malfunctions of the systems fitted to the relevant locomotive or the relevant block of track were received in the days prior to the accident. For this reason it may be assumed that the ATP was working correctly. The ATP system fitted to the locomotive of the container train also worked in accordance with the specifications.

The Netherlands. The current situation with respect to ATP in the prevention of signals passed at danger can be summarised as follows. The Dutch railway network is equipped with a total of approximately 10,000 signals, of which about 6,000 are operated signals in yards and the other about 4,000 are automatic signals on the open line (to protect the train headway). In 2010, about 2,000 of the approximately 6,000 operated signals had been fitted with a train protection system that does not allow trains to pass signals set at danger.[99] The other approximately 4,000 operated signals are equipped solely with ATB-EG. The large majority of the approximately 4,000 automatic signals along the open track are also equipped solely with ATB-EG.

In view of the functional limitations of ATB-EG the threat of a SPAD involving a signal fitted with this system does not result in the automatic initiation of a braking action when the train is travelling slower than 40 km/hour or when the driver has initiated a braking action.

98 More information about these plans is enclosed in subsection 6.1.2.
99 Approximately 500 with ATB-NG, approximately 300 with ERTMS and approximately 1,260 with ATB-VV.

Although ATB-VV does not have ATB-EG's functional limitations, the signals equipped with ATB-VV nevertheless do not offer full protection from SPADs: this is because ATB-VV can prevent a SPAD solely when the train approaches a signal set at danger at a speed not much higher than 40 km/hour as the longer braking distance required to bring trains travelling at higher speeds to a standstill is in excess of the available distance (120 metres). It is also possible that long goods trains travelling at speeds of 40 km/hour or less cannot be brought to a standstill in time due to these trains' low(er) braking power. Consequently, the design of ATB-VV - with a relatively short distance between the signal and the ATB-VV beacon - has not taken sufficient account of the braking distance required by long goods trains.[100]

5.3.3 The cancel function

Objective. What was referred to as a 'cancel function' was in use until the mid nineteen-nineties. The objective of this cancel function was to test the driver's alertness when the train was approaching a signal set at danger and to intervene if the driver did not exhibit an alert response. As explained above, ATB-EG cannot intervene when a train travelling slower than 40 km/hour is at risk of passing a signal set at danger. Consequently, it is even more important that the driver of a train travelling slower than 40 km/hour brings the train to a standstill in time. For this reason the original design of ATB-EG provides support for the driver since after having braked to 40 km/hour the driver must continue to brake to stop the train before the signal set at danger. The system checked that the driver was aware of the need to brake by requiring him to press a button once every 20 seconds. If he did not do so then a warning buzzer sounded and, if he still failed to respond, the system initiated an automatic braking action.

Barendrecht. Although it cannot be guaranteed that an operable cancel function or similar system could have prevented the Barendrecht collision, it could have increased the probability of a safe outcome since the cancel function would have been active during the 85 seconds between passing the signal set at caution until passing the signal set at danger and would, consequently, have requested a response from the driver on four occasions. Since the driver in the Barendrecht accident had failed to respond to various indications (a signal set at danger and the fact that the train forced open an set of points) it is plausible that the cancel function would have stopped the train before the collision.

The Netherlands. The cancel function was decommissioned in the Netherlands in the mid nineteen-nineties on the introduction of a new type of dead man's system. The decision to decommission the cancel function was based on the argument that the new type of dead man's system required the driver to take an action similar to that required for the cancel function. Moreover, experience had revealed that after a period of time drivers pressed the cancel function button automatically, as a result of which the system became increasingly ineffective. Consequently, the cancel function (and, in so doing, the intended additional attention given to signals set at danger) was decommissioned.

The Dutch Safety Board is of the opinion that a protection system of the nature of the cancel function may be decommissioned only once a satisfactory replacement has been introduced. An alternative means of warning the driver of an approaching a signal set at danger which was both reliable and compatible with the driver's work should have been found before the cancel function was decommissioned.

100 Long goods trains have a longer braking distance to avoid instability problems.

5.3.4 Sub-conclusion:

The Dutch Safety Board has reached the following conclusions on the reduction of the number of signals set at danger:

- It is plausible that the signal set at danger was passed at Barendrecht because the train driver had become unwell as a result of a hereditary heart disorder. It is possible that disorders are not identified by the current procedure for medical examinations.
- Since the power to make a decision on the train driver's continuation of the journey following an intervention by the dead man's system rests with the driver concerned the train driver was able to continue the journey without consultation or intervention.
- The absence of the automatic limitation of the braking action to prevent the train passing the signal at danger was due to the functional limitations of the ATP systems fitted to the train and the signal (ATB-EG). If the signal and the locomotive had been equipped with an ATP system without these functional limitations then the automatic initiation of a braking action would have brought the train to a standstill in time.
- It is possible that the accident would not have occurred if the locomotive had been equipped with the cancel function decommissioned in the nineteen-nineties or with a contemporary variant of that function.
- The failure to implement the aforementioned measures is not unique to the accident at Barendrecht: the situation observed with respect to the current medical examination procedure, the absence of a real-time dead man's system activation notification and the decommissioning of the cancel function are all applicable to the Netherlands. About 65% of operated signals and the large majority of the automatic signals are equipped with ATB-EG (with the associated functional limitations).

5.4 Prevention of a collision after passing a signal set at danger

Even though the train had passed the signal set at danger at Barendrecht, measures are nevertheless conceivable which could have prevented the collision or limited the consequences, namely:

- Opposite signal automatically set at danger (subsection 5.4.1);
- Revocation of the signal (subsection 5.4.2);
- Emergency call (subsection 5.4.3).

5.4.1 Opposite signal[101] automatically set at danger:

Objective. A train which passes a signal set at danger can enter the route released for another train. It is then necessary to recall the release of that other route as quickly as possible (i.e. by setting the opposite sign at danger) so that the approaching train can be stopped.

Barendrecht. Both trains involved in the incident at Barendrecht were required to pass over the same set of points shortly after each other. At the time the mixed goods train involved in the incident at Barendrecht passed the signal set at danger the container train was still 6 to 7 seconds upstream from the last signal that protected this set of points. This signal remained set at proceed at the time: only once the train that passed the signal set at danger had moved onto the shared set of points - a distance of a further 180 metres - did the protection system automatically set the signal for the container train at danger.

It is technically feasible to respond to a train passing a signal at danger by immediately setting the relevant opposite signal at danger. If this had been the case at Barendrecht then the signal for the approaching container train could have been set at danger about 15 seconds earlier and the train driver could have braked about 15 seconds earlier. Although this might not have prevented the collision, it could have limited the consequences.

101 An opposite signal is the last signal an approaching train encounters before the threat of a collision with a train that has passed a signal at danger.

The Netherlands. There are many locations in the Dutch railway network where, in analogy with Barendrecht, a train passing a signal set at danger does not result in the opposite signals for approaching trains immediately being set at danger. The design of the railways is such that the opposite signals are set at danger only once a train actually enters the path of another train.

5.4.2 Revocation of the signal

Objective. When a train passes a signal set at danger then the rail traffic manager can endeavour to prevent a collision or limit the consequences by revoking the route of another train approaching the danger point, as a result of which the relevant signals are set at danger and the train is not permitted to continue.

Barendrecht. The rail traffic manager could have seen on his monitor that the mixed goods train had passed a signal set at danger. If the rail traffic manager had seen this then he could have revoked the signal for the other goods train or sent an emergency call (see subsection 5.4.3). However, this was not possible at Barendrecht since the rail traffic manager was not at his workplace at the time of the collision.

The Netherlands. ProRail and Keyrail do not regard the continual monitoring of all train movements as part of the rail traffic managers' duties. In many instances the rail traffic manager's control zone is of a size and with a complexity of train movements that makes it impossible for one person to monitor all the movements. For this reason their duty is to configure routes. They are not required to monitor them and for this reason their working procedures are not designed to enable them to do so.

The rail traffic managers need a technical aid if they are to be able to intervene immediately in the event of a threat of danger caused by a train passing a signal set at danger. They had technical support of this nature in the past. This functionality, called 'train has passed a signal at danger' was available in two variants. The first variant responded to a 'train has passed a signal at danger' message by automatically setting all surrounding signals at danger. In the second variant the rail traffic manager received a warning and was under the obligation to take action. This functionality was, pending the introduction of a better version, decommissioned in about 2000 since it frequently incorrectly generated a message or made an intervention. Following an investigation by the Transport Safety Board of a collision at Dordrecht[102] the Board issued a recommendation in 2001 in which it stated the need to reintroduce a function of this nature. However, this functionality has not been implemented to date.

5.4.3 Emergency call

Objective. Both the rail traffic managers and the train drivers can send an emergency call to warn all trains in a certain area of approaching danger. These calls are made via the GSM-R mobile telephony network.

Barendrecht. The 'IJsselmonde' rail traffic manager did not send an emergency call after the train passed a signal at danger in Barendrecht because he was not at his workplace at the time. If he had sent an emergency call then all train drivers in the area would have immediately needed to reduce their speed and continue under 'visual rules'. When the rail traffic manager wished to send an emergency call a little later he was unable to make a connection on the first attempt. It is not known why this attempt failed. The connection was made on the second attempt.

The driver of the international passenger train also made an attempt to send an emergency call which was also unsuccessful on the first attempt. The second attempt to make a connection was successful, although the call was taken by another rail traffic manager in Rotterdam who thought that the train was still in his zone. The rail traffic managers cannot view each other's control zones.

102 Transport Safety Board, Botsing tussen twee reizigerstreinen in Dordrecht op 28 november 1999 ('Collision between two passenger trains in Dordrecht on 28 November 1999'), published in May 2001.

As a result, the 'Rotterdam-Oost' rail traffic manager could not see what was going on on the adjacent tracks in the 'IJsselmonde' rail traffic manager's control zone.

The Netherlands. It is known that there can be problems with making connections via the GSM-R network. Similar problems with GSM-R were encountered in another train incident (Barneveld, 12 February 2008), as a result of which the train driver concerned was connected to the wrong rail traffic manager. Valuable time can be lost in emergencies when train drivers are connected to the wrong rail traffic manager.

It should be noted that things can also go differently. A passenger train passed a signal set at danger near Amersfoort on Wednesday 23 June 2010. At the same time another passenger train was approaching on the same track in the opposite direction. A watchful rail traffic manager saw the train pass the signal at danger on his monitor and immediately sent a number of emergency calls with the hope that he could prevent a collision between the two trains. Both drivers responded to the emergency call and immediately applied the brakes. The trains came to a standstill at a distance of about 120 metres from each other, thereby avoiding an accident.

5.4.4 Sub-conclusion:

The Dutch Safety Board has reached the following conclusions on the prevention of a collision after a train has passed a signal set at danger:

- The following measures that could have limited the consequences of the SPAD in the Barendrecht accident were not utilised:
  - The opposite signal was not automatically set at danger immediately after the SPAD, but only about 15 seconds later (once the mixed goods train had reached the set of points about 180 metres further on).
  - The SPAD by the goods mixed train did not result in the rail traffic manager setting the opposite signal at danger.
  - The SPAD did not result in the transmission of an emergency call (either by the rail traffic manager or automatically).
- The aforementioned points are not unique to Barendrecht:
  - The Dutch protection system is designed in a manner such that opposite signals are not automatically set at danger immediately after a SPAD but only once the train that has passed a signal set at danger actually enters the path of another train.
  - Monitoring the train movements for SPADs is not part of the rail traffic managers' duties and they do not have the technical support required to do so.
  - Problems with making an emergency call - due to connection problems with the communication system (GSM-R) - are not uncommon.

6 ANALYSIS: EVALUATION OF THE SPAD REDUCTION POLICY

Section 5 revealed that some of the options available to control the SPAD issue are not utilised or are not utilised in full. This Section reviews why this situation has arisen and examines the extent to which the parties involved fulfil their responsibilities.

6.1 Approach to the SPAD issue

A distinction can be made between ATP systems and other control measures in the approach to the SPAD issue. This subsection begins with a review of the development and introduction of ATP systems, whereby a distinction can be made between the national systems (ATB-EG and ATB-NG) and the European system (ERTMS), continues with a discussion of the other measures that have been implemented to control the SPAD issue, and then reviews the recommendations issued by the Dutch Safety Board and its predecessors on the control of the SPAD issue and the extent to which these conditions have been adopted.

6.1.1 ATP systems

ATB-EG and ATB-NG

The 1962 Harmelen railway disaster resulted in the decision to equip the Dutch main railway network with the ATB-EG automatic train protection system. NS Dutch Railways had been working on the development of a system for the display of signal aspects in the train driver's cabin since the nineteen-fifties. This was developed further into an ATP system and was introduced from the end of the nineteen-sixties. it took about thirty years to equip the majority of the railway network and trains with this system. Although it was from the very beginning clear that the selected ATP system had its functional limitations, it was only in around 1990 that the parties realised that this system did not reduce the number of SPADs to a sufficient extent, in particular in yards.

NS Dutch Railways began work in the mid nineteen-eighties on the development of a second generation ATP system (ATB-NG) that did not suffer from ATB-EG's functional limitations. The objectives of this system were to enable the trains to travel at higher speeds and improve the control of the train movements, developments which were necessary in view of the more intensive railway traffic and the need to configure sections of routes. The intention was to install this system on both the regional railway lines (that had not yet been equipped with ATB-EG) and the main railway lines (to replace ATB-EG). However, in around 1993 it was decided to abandon the general migration from ATB-EG to ATB-NG and to terminate the further development of ATB-NG. Since then ATB-NG has been installed solely on the regional railway lines and the trains that use those lines (more information is enclosed in box 4).

The decision to abandon the plans for the migration to ATB-NG was largely based on the assumption that a new European ATP system (ERTMS) would be operational in around 2005. It has since become clear that this estimate was much too optimistic. In the Board's opinion, as based on the following explanation, the general replacement of ATB-EG by ERTMS is not to be expected earlier than at least 2025.

Annex 6 contains more information about the development and introduction of ATP systems.

ERTMS[103]

ERTMS is a railway control and signalling system developed at a European level. The system is based on the use of a cabin display to provide the driver detailed information about the configured route, as a result of which ERTMS obviates the need for signals along the track. In addition, ERTMS uses an automatic train protection system to monitor the driver's compliance with the signalled

103 ERTMS is the abbreviation of 'European Rail Traffic Management System'.

commands. The system makes use of full braking curve monitoring[104] that is configured for the specific train's braking power. For this reason ERTMS does not exhibit the functional limitations of the ATB system installed on the majority of the main railway lines (ATB-EG).

The Dutch Safety Board has observed that it is still unclear when ERTMS will be installed on the Dutch railway network and on which scale. In the Board's opinion, as based on current policy, it would be unrealistic to expect that ERTMS will be installed on large sections of the railway network before 2025. The Board bases this opinion on the following findings:

- It is still not clear to what extent ERTMS will contribute to the improvement of the railway system's performance, whilst it has been concluded in as early as 1999 that information about this contribution is of essential importance to the introduction of ERTMS.[105] Three studies of ERTMS carried out between 2000 and 2009[106] concluded that there is uncertain about the precise costs and benefits of ERTMS.
- It is not yet clear how ERTMS needs to be financed. The studies have revealed that the precise costs and benefits of ERTMS are unclear. In addition, correspondence[107] between the railway companies and the Ministry of Transport, Public Works and Water Management and the interviews the Board has conducted with the parties involved have revealed that the costs and benefits are not distributed evenly between the parties.[108]
- It is not clear which part of the railway network will be equipped with ERTMS. The aforementioned implementation studies refer solely to the main railway network and not to the regional railway lines. It is also unclear whether ERTMS can be implemented rapidly on existing yards, whilst these are the sections of the railway network where the risk of SPADs is greatest.
- The Minister of Transport, Public Works and Water Management has stated that the Netherlands is in the vanguard of the introduction of ERTMS[109] and prefers to wait with the introduction of ERTMS until the experiences of other countries are known. The Minister also intends to wait until equipment with the functionality of version 3.0.0 becomes available, which is expected to be released in 2015.[110]
- Experience acquired in the past[111] has revealed that several decades are required for the development and introduction of a new ATP system in the majority of the railway network and, in addition, that this always takes longer than expected.

104 Braking curve monitoring refers to the continual monitoring of a moving train's ability to reduce speed in time for a signal set at danger or other speed restriction.
105 Ministry of Transport, Public Works and Water Management, First Railway Safety Framework Document, 1999, Parliamentary Document 40132.
106 ProRail, Beleidstransitie treinbeveiliging en –beheersing ('Train protection and control policy transition'), March 2003; ProRail, NS and BRG, Implementatiestrategie ERTMS. ('ERTMS implementation strategy') Onderbouwing van de strategische keuzes met businesscase ('Substantiation of the strategic choices with a business case'), 24 August 2006; Decisio and SYSTRA S.A., Social Cost Benefit Analysis of implementation strategies for ERTMS in the Netherlands, 8 January 2010.
107 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 21 September 2007; Letter from NS Dutch Railways, ProRail and BRG to the Minister of Transport, Public Works and Water Management, 19 June 2008; Letter from NS Dutch Railways, ProRail and BRG to the Minister of Transport, Public Works and Water Management, 9 April 2010.
108 This portfolio was renamed 'Infrastructure and the Environment' on 14 October 2010. This report refers to the portfolio using the name prevailing at the time of the incident, namely: Ministry of Transport, Public Works and Water Management.
109 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 21 September 2007;
110 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 12 December 2008. The new functionality relates primarily to modifications of the ERTMS train equipment, such as the more accurate determination of the braking distance.
111 See Annex 6.

Box 4: ATB-NG versus ERTMS

At the beginning of the nineteen-nineties it was decided to replace ATB-EG by ATB-NG throughout the main railway network.[112] However, shortly afterwards ERTMS came into the picture and it was assumed that international European railway traffic could be a success solely when all member states introduced the same protection system. Since ERTMS is intended precisely for international railway traffic and high costs are incurred it is not logical to presume that ERTMS would be introduced throughout the entire railway network. The Ministry of Transport, Public Works and Water Management decided, in anticipation of the introduction of ERTMS, to terminate the investments in ATB-NG since investments in ATB-NG would constitute the destruction of capital when it was known that ERTMS was the system of the future. NS Dutch Railways decided to concentrate on ERTMS and install ATB-NG solely on a number of regional railway lines that had not yet been equipped with ATB-EG.

The Board finds it remarkable that NS Dutch Railways decided to abandon the plans for the national introduction of ATB-NG in the nineteen-nineties since the consequence was that in the period until the introduction of ERTMS the majority of the Dutch railway network would be equipped solely with ATB-EG. The Dutch Safety Board is of the opinion that the relevant parties involved should have implemented supplementary measures at the time to control the SPAD issue on those sections of the railway network that would not be equipped with ERTMS. However, this did not take place. Consequently, the Board concludes that at the time NS Dutch Railways and the Minister of Transport, Public Works and Water Management both failed to fulfil their responsibilities to an adequate extent.

The Dutch Safety Board has carried out an international comparison of the introduction of ERTMS on the basis of the implementation plans each member state submitted to the European Commission in 2007, and supplemented with some more recent information. This revealed that many other European countries have drawn up plans for the implementation of ERTMS that are more specific than those of the Netherlands. The Dutch Safety Board found the following issues striking:

- It is possible to prepare a specific plan for the implementation, whereby the countries can adopt for an dynamic approach or a more gradual approach. Some countries have decided to convert their entire network, such as Denmark (completion in 2021) and Luxembourg (completion in 2011). Austria, Italy and Switzerland have far-reaching and specific implementation plans for at least the most important sections of their networks. A number of large countries (Germany, France and the UK) have made a carefully-considered decision for slower implementation and solely the mandatory goods traffic corridors will be equipped with ERTMS within the short term. Germany and the UK combine the installation of ERTMS with the natural replacement of the existing protection systems.
- The commercial services of a number of countries use ERTMS: the commercial services in Spain, Switzerland and Luxembourg do so on a fairly large scale and are satisfied with the system's performance. A number of countries outside Europe (such as China and India) use the system.
- Germany, Denmark, Switzerland and Italy are of the opinion that ERTMS version 3.0.0 is required for the suitable application of the system in their railway networks, and believe that it is both feasible and necessary to begin work on the preparations now.

Annex 7 contains more information about ERTMS.

112 The fact that NS Dutch Railways' Board was of the intention to carry out a migration of this nature is apparent from the statement the relevant member of NS Dutch Railways' Board made during the hearings the Railway Accident Board held on the 1992 train collision in Eindhoven, as well as from the letter the NS Dutch Railways' Board sent to the Ministry of Transport, Public Works and Water Management at the end of 1993 which stated that the Board had decided to temporise the national introduction of ATB-NG (letter of 21-09-1993 from the Managing Director of NS Dutch Railways to the Ministry of Transport, Public Works and Water Management's Transport Directorate).

6.1.2 Other control measures

SPAD reduction plan

The Transport Safety Board, the predecessor of the Dutch Safety Board, observed in 2001 that the number of SPADs had almost doubled during the period from 1995 to 2000 and that there were two or three serious accidents related to SPADs each year.[113] The recommendation issued as a result of this observation, namely that supplementary measures be implemented at a rapid pace, initially had little effect. However, when a further serious train collision occurred in 2004[114] the political pressure increased to a level that resulted in the Minister of Transport, Public Works and Water Management's issue of an instruction to the railway companies in mid 2004 which required them to draw up a plan of approach for the control of the SPAD issue within the near future. This plan, the SPAD reduction plan, encompassed four measures:

- Train driver programme (to improve train-driver alertness);
- Analysis of the yards (to improve the visibility and recognisability of signals in yards);
- Introduction of configuration instructions[115] for approximately 25 specific signals involving a repeated SPAD;
- Installation of ATB-VV for approximately 1,000 signals in yards.

The cost of the SPAD reduction plan was estimated to amount to approximately 45 million euros and the leadtime to about five years. The results of the reduction plan were estimated to be a 50% reduction of the number of SPADs and a 75% reduction of the associated risk. The Minister of Transport, Public Works and Water Management adopted the SPAD reduction plan, including the targets and budget specified in the plan, at the end of 2004. The SPAD steering group was assigned the duty to implement the reduction plan.

The SPAD reduction plan was then implemented under the direction of the SPAD steering group. The first three measures (the train driver programme, analysis of the yards and configuration instructions) were implemented in the period from 2005 to 2007 inclusive. The implementation of the fourth measure (the development and introduction of ATB-VV for approximately 1,000 signals in yards) would take more time. The Ministry of Transport, Public Works and Water Management was of the opinion that ATB-VV could be implemented more rapidly than ERTMS. This was one of the reasons for the selection of ATB-VV. Pursuant to the original schedule the installation of ATB-VV would be completed at the end of 2008. However, this deadline was not met: the installation of the equipment for the relevant 1,000 signals was completed in 2009, but it was forecast that the installation of ATB-VV in the relevant trains would be completed only in the second half of 2010.

A study carried out by the Inspectorate for Transport, Public Works and Water Management in 2007-2008 revealed that the effect of the implemented measures would probably be less than was originally estimated. As a result, the SPAD steering group expanded the package of measures to include the following actions:

- increase the number of signals equipped with ATB-VV was increased from 1000 to 1164;
- carry out a further investigation of signals involving a repeated SPAD would be carried out;
- carry out a further investigation of SPADs by departing trains would be carried out;
- a further investigation of SPADs by rolling stock would be carried out (rolling stock in which the handbrake had not been applied);
- carry out a further investigation of the relatively large number of SPADs by shunting trains would be carried out;
- carry out a further investigation of the relatively large number of SPADs by goods trains would be carried out.

113 Transport Safety Board, Botsing tussen twee reizigerstreinen in Dordrecht op 28 november 1999 ('Collision between two passenger trains in Dordrecht on 28 November 1999'), May 2001.

114 Two passenger trains collided near Amsterdam on 21 May 2004 because one of the trains had passed a signal set at danger. The accident resulted in more than twenty injuries.

115 A signal equipped with configuration instructions has operating software installed that includes a link to the previous signal and ensures that when the relevant signal is set at danger then the previous signal is also set at danger. As a result, a SPAD involving the relevant signal is possible solely when the train has also passed the previous signal set at danger.

It was also decided in 2008-2009, that about 100 signals on the BrabantRoute railway line would equipped with ATB-VV in view of the transport of hazardous materials on this railway line (as a result of which the number of signals to be equipped with ATB-VV increased to about 1,260).

Measures as a result of the accident at Barendrecht
As a result of the accident at Barendrecht the Ministry of Transport, Public Works and Water Management requested Oranjewoud/SAVE to carry out a study which focused on the following issues:[116]

- An international benchmark study of measures for the control of the SPAD issue (a study of the measures implemented by comparable member states);
- A study of the number and selection of the signals to be equipped with ATB-VV required for the achievement of the reduction targets; and
- A study of measures to increase train-driver alertness in 40 km/hour zones (as an alternative for the decommissioned cancel function).

The study's results for ATB-VV and the alternatives for the cancel function are of relevance to the Board's investigation. The results from this study are summarised below:

- **Equipping signals with ATB-VV:** It is expected that equipping the signals as selected earlier on the basis of the greatest risk with ATB-VV will not achieve the target reductions of the number of SPADs and the risk of SPADs. It is estimated that about 640 additional signals will need to be equipped with ATB-VV to achieve the target reduction of the number of SPADs. The report also stated that about 1040 additional signals (as compared to the 1,260 already selected) would need to be equipped with ATB-VV to achieve the target reduction of the risk of SPADs. The report recommended that the selection of these additional signals should in any case include the signals along the basic hazardous materials railway network, i.e. the major routes for the transport of hazardous materials.[117] This was decided since the earlier selection of the signals to be equipped with ATB-VV had taken only partial account of the risks that the transport of hazardous materials poses to the surroundings (external safety). In addition, the report recommended waiting for the developments in the SPAD issue in 2010 and then using this information to determine the total number of extra signals and the specific signals that would need to be equipped with ATB-VV to achieve the reduction targets.
- **Alternatives for the cancel function:** Little effect is expected from the possible reintroduction of the original cancel function. However, a material effect is expected from the introduction of a special attention signal in the cabin in 40 km/hour zones (i.e. in yards) and from warnings in specific situations (such as a specific warning signal in the cabin when the train approaches a signal set at danger).

The Minister of Transport, Public Works and Water Management has stated that the results from the study have given cause to his decision to implement the following measures:[118]

- An additional 350 signals will be equipped with ATB-VV within the context of the basic hazardous materials railway network;
- The effectiveness of ATB-VV will be evaluated in 2011 and the results from this evaluation will be used to determine the number of additional signals and which additional signals shall also be equipped with ATB-VV;

116 Oranjewoud/Save, Onafhankelijk onderzoek STS-problematiek ('Independent study of the SPAD issue'), 17 May 2010 (carried out on the request of the Ministry of Transport, Public Works and Water Management's Mobility Directorate-General).
117 The basic hazardous materials railway network working party had already envisaged (in 2008) the expansion of the signals to be equipped with ATB-VV to include these approximately 350 signals.
118 Letter of 28 June 2010 from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General (ref. no. VenW/DGMo-2010/5266 and Parliamentary Document 29283, number 103).

- The railway parties shall be requested to carry out studies of: (a) the feasibility of introducing longer overshoot distances for new signals; and (b) the feasibility of increasing the effectiveness of ATB-VV by the modification of what is referred to as the 'braking criterion';[119]
- The railway companies will be requested to give the Minister information about the feasibility of implementing alternatives for the cancel function.

Analysis of the substantiation for the package of measures
As stated above, the essence of the current SPAD policy since 2004 is that the railway companies have been engaged on the implementation of the SPAD reduction plan under the direction of the SPAD steering group. The Board wishes to make the following comments about this policy:

a. The original reduction plan was restricted to the four measures that the then SPAD working group submitted to the Minister of Transport, Public Works and Water Management on the Minister's request as providing the most suitable means of controlling the SPAD issue within the relatively short term (of five years). The reduction plan is not, as should be the case, the result of a thorough analysis of the SPAD issue and an ALARP assessment of the available control measures. Although the original package of measures has been expanded to some extent over the course of the years some of the available control measures have not been implemented or implemented to only a limited extent. The measures that have or have not been implemented have not been selected on the basis of an ALARP assessment.
b. In addition, the expected effect of the measures specified by the reduction plan has been determined on the basis of an overall estimate rather than on the basis of a thorough analysis. Moreover since 'risk' and 'risk reduction' have not been defined in specific terms the significance of the promised improvements is not clear. The expectation (which has now been elevated to a formal target) that the selected measures can reduce the 'SPAD risk' by 75% was at the time based on the assumption that the majority of the SPAD accidents could be avoided by equipping the operated signals posing the greatest SPAD risk with a supplementary ATP system, whereby a reference was made to what is referred to as the '80/20 rule' in assuming that about 1,000 of the approximately 5,000 relevant operated signals would need to be equipped with a supplementary ATP system to achieve the target risk reduction of 75%. However, this assumption ignored the fact that the large majority of the SPADs occur with a limited number of signals[120], which is the reason why the '80/20 rule' is not applicable to this issue.
c. It has long been clear that the implementation of the reduction plan, in particular the introduction of ATB-VV, will take considerably longer than had originally been expected and that the effect will be less than the estimate made at the time. The Board observes that the lower than expected effect has resulted in only a limited response: as explained above, supplementary studies have been begun and the Minister has recently decided to equip 350 extra signals with ATB-VV, but no decision has been made to carry out an overall analysis of the SPAD issue or an ALARP assessment of all the available control measures. In addition, the Board finds it remarkable that the Minister decided to equip a further 350 signals with ATB-VV once this had been recommended by Oranjewoud/SAVE, whilst the basic hazardous materials railway network working party had already submitted this proposal in as early as 2008.[121]
d. The SPAD steering group is a project organisation and, consequently, is by very definition of a temporary nature. It is not clear how the parties will jointly tackle the SPAD issue once the steering group has been dissolved. The risk can be controlled by all the available measures

119 The design of ATB-VV assumes that the speed of a train approaching a signal set at danger will not be (very much) more than 40 km/hour: ATB-VV does not guarantee that trains travelling at higher speeds will be brought to a standstill before the signal set at danger. 'Modification of the braking criterion' refers to the initiation of an automatic braking action in the event that the driver applies only a low braking force after passing a signal set at caution. This modification increases the probability that the train's speed when it approaches the signal set at danger will not be (very much) higher than 40 km/hour and that the ATB-VV system will be able to bring the train to a standstill before the signal set at danger.

120 About one-quarter of the SPADs occur at a repeated SPAD signal, whereby a repeated SPAD signal is understood as a signal which is passed at danger three or more times within a space of five years. There are more than eighty repeated SPAD signals. The signals in this category vary somewhat from year to year since some signals no longer meet the criterion and other new signals meet the criterion.

121 This information was issued by the Ministry of Transport, Public Works and Water Management's Deputy Railway Director. According to the information issued to the Board the relevant working party had submitted this proposal in an internal Ministry of Transport, Public Works and Water Management document (Uitgangspunten Risicoberekeningen Basisnet Spoor per 1 juni 2008 ['Principles of the basic railway network calculations on 1 June 2008']).

only when continual assessments are made to determine whether new risks arise or whether new options for the control of the risk are available. Various parties stated during interviews that what is referred to as a 'Railway Centre of Expertise' is being set up that could fulfil this function. However, opinions on the duties of a centre of this nature vary greatly.

6.1.3 Earlier recommendations from the Board and its legal predecessors

The Dutch Safety Board has listed the recommendations the Board and its legal predecessors have issued in the past for the control of the SPAD issue and the response of the parties to whom those recommendations were issued. The Board's investigation of the collision at Barendrecht has also extended to an assessment of the extent to which these earlier recommendations have been adopted. This assessment is included in Annex 5.

Other control measures

Following the 1992 Eindhoven train collision the Railway Accident Board issued a recommendation to the then NS Dutch Railways to supplement the efforts for a technical safety net with the implementation of other measures for the control of the SPAD issue. However, this recommendation was not adopted. Following the train collision in Amsterdam on 21 May 2004 the Dutch Safety Board issued a recommendation to ProRail and the carriers to 'adopt an uninterrupted and creative approach to the resolution' of safety limitations in the railway system and that they should not preclude drastic measures (such as the reduction of the frequency of train movements). This recommendation was adopted to a limited extent: although other control measures were available, they were not utilised to a sufficient extent for a long time.

Period of the implementation of control measures

Following a collision between two passenger trains in Dordrecht on 28 November 1999, the Transport Safety Board issued a recommendation that the Minister of Transport, Public Works and Water Management should 'make an explicit statement on the phasing of the implementation of a modern ATP system based on modern computer technology in the Dutch railway network'. Although the Minister stated that he act along the line of the recommendation it was not possible for the Minister to issue a specific schedule within the stipulated period. Following the 2004 Amsterdam train collision the Dutch Safety Board issued a recommendation that the Minister of Transport, Public Works and Water Management should 'draw up a specific plan which stipulates the periods of time required for the implementation of the continuous automatic speed control system'. In response to this recommendation the Minister issued specific plans for a number of new construction projects but did not give information on the planning for the entire main railway network. The Board observes that a long period of time always lapses before clarity is obtained about the period involved in the implementation of control measures.

The reason for the implementation of control measures

The railway parties have usually implemented measures in response to serious incidents. The 1962 Harmelen train disaster gave cause to the accelerated implementation of ATP in the Netherlands, the 1992 Eindhoven train collision imparted an impetus to the further development of ATB-NG, and the 2004 Amsterdam train collision gave cause to the Minister of Transport, Public Works and Water Management's formalisation of the SPAD steering group and the specification of reduction targets for SPADs in the Netherlands. A review of the above indicates that the Ministry of Transport, Public Works and Water Management adopts a 'pragmatic approach' in which measures focused on the control of the SPAD issue are usually implemented after a serious incident and in response to the resultant commotion in the media and/or political arena. There is virtually no proactive policy based on a systematic inventory of the risks and the control of the identified risks.

6.1.4 *Sub-conclusion:*

The Dutch Safety Board has reached the following conclusions on the approach to the SPAD issue:

- During the past decades limited progress has been made in the control of the SPAD issue. This is due to the low priority assigned to the development and implementation of an effective ATP system and to the fact that work on the development and implementation of other control measures (the SPAD reduction plan) began only in around 2004. The measures implemented to date virtually ignore the reduction of the number of signals set at danger and the limitation of the consequences of SPADs: they are focused on the prevention of SPADs and, in particular, the ATP system.

The Dutch Safety Board has reached the following conclusions on the development and implementation of ATP systems:

- The majority of the Dutch railway network is equipped with ATB-EG, an ATP which exhibits functional limitations. The plans for the replacement of ATB-EG by ATB-NG were abandoned at the beginning of the nineteen-nineties, a decision primarily based on the argument that ERTMS could be implemented in around 2005.
- However, in 2010 solely the Dutch Betuweroute goods and HSL-Zuid high-speed railway lines have been equipped with ERTMS. The plans for the further implementation of ERTMS are not very specific. Other European countries have drawn up plans for the implementation of ERTMS which are more specific than those of the Netherlands.
- The Board is of the opinion that given the current policy ERTMS will not make a great contribution to the reduction of SPADs on the Dutch railway network before 2005.

The Dutch Safety Board has reached the following conclusions on the SPAD reduction plan:

- The SPAD reduction plan is not based on a thorough analysis of the SPAD issue and an ALARP assessment of the available control measures.
- The effect of the measures specified in the SPAD reduction plan has been determined on the basis of an overall estimate rather than on the basis of a thorough analysis.
- The implementation of the SPAD reduction plan is taking longer than had been foreseen (in particular, with respect to the introduction of ATB-VV) and the plan's targets have not been achieved to date.

6.2 Responsibilities

6.2.1 *Assignment of responsibilities*

Sections 3 and 4 discuss the requirements the Railways Act imposes on the parties involved with respect to the control of the safety risks posed to railway traffic (in which the control of the SPAD issue is a major element of the risk control). In essence, the Act prescribes that the railway companies must ensure that the safety risks must be adequately controlled by suitable measures and that the Minister of Transport, Public Works and Water Management must supervise the railway companies' adequate fulfilment of their duty of care. The Railways Act also prescribes that assurances for the adequate control of safety risks shall be provided by the rail companies' implementation of adequate company safety management systems (SMs).

The Board observes that the control of the SPAD issue requires both the implementation of measures relating to the operations of the individual railway companies measures that transcend the operations of the individual railway companies. Moreover, some of the measures have consequences for the capacity of the railway network, the punctuality of train movements and the investment burden borne by the government. For this reason it is necessary to supplement the individual railway companies' implementation of an adequate safety management system with a suitably-performing structure for consultations and joint decision-making on the control of the SPAD issue.

6.2.2 Fulfilment of responsibilities

Railway companies
Section 5 explained that railway companies have not utilised all the available measures to reduce the SPAD risks for as far as is reasonably possible. The Dutch Safety Board has also investigated the manner in which the control of the SPAD issue has been addressed in the safety management systems (SMSs) of the railway companies involved in the accident at Barendrecht (DB Schenker, ERS Railways, NS Reizigers and ProRail).

The Board observes that the SMSs of the aforementioned companies do not address all elements of the SPAD issue: the primary focus is placed on the prevention of passing signals set at danger, as a result of which inadequate attention is devoted to the reduction of the number of signals set at danger and the prevention of collisions following SPADs. The Board also observes that the railway companies adopt a 'reactive' approach to their SMSs, since the content of the SMSs is primarily determined by the specific requirements imposed by the Railways Act and not - as may be expected - by the underlying and ultimate objective (the adequate control of the safety risks). The Board notes that the criterion adopted by these systems is usually 'compliance with the standards'. This is not only applicable to the content of the SMSs, but also to operational areas such as the design of the train schedules and the duties of the rail traffic management. Without wishing to deny the importance of explicit standards, the Board is of the opinion that the adequate control of the risks requires not only 'do what must be done' but also 'do what can be done'. The Board expects the railway companies to implement all possible measures to control the SPAD issue unless they can demonstrate that the costs of a measure are unreasonable and/or that a measure will have other detrimental consequences (the ALARP principle).

SPAD steering group
The Board observes that the SPAD steering group, formed in 2004, to some extent functions as the consultative and decision-making structure for shared issues as referred to above. However, the Board also observes that the SPAD steering group is a temporary project organisation for the detailing and implementation of the SPAD reduction plan. Subsection 6.1 has already explained that the SPAD reduction plan encompasses only some of the available issues. Moreover, subsequent to the implementation of the measures specified in the SPAD reduction plan control of the SPAD issue can be maintained only in the presence of an adequate consultative and decision-making structure within the railway sector. The Board is aware that a Railway Centre of Expertise is being set up within the railway sector. However, it is not clear whether this body will include a standing consultative and decision-making structure for the control of the SPAD issue.

Minister of Transport, Public Works and Water Management
The Board is of the opinion that the Minister should, as an element of the Minister's responsibility for the system, intervene when the railway companies fail to fulfil their duty of care for railway safety to an adequate extent. As explained earlier, the essence of the policy for the control of the SPAD issue adopted since 2004 is that the railway companies are required to achieve the targets set in the SPAD reduction plan, namely the 50% reduction of the number of SPADs and the 75% reduction of the SPAD risk as compared to 2003. The Board is of the opinion that the achievement of these reduction targets will not automatically imply 'adequate control' as required by the Railways Act since this safety level is not defined in terms of a specific number of SPADs or accidents caused by SPADs but rather in terms of the implementation of all control measures that are reasonably possible (ALARP). Subsection 6.1 stated that the current reduction targets are based on an overall estimate of the effect that can be achieved by the implementation of the original package of measures. For this reason the Board is of the opinion that the Minister is unjustifiably satisfied with the achievement of a safety level for the control of the SPAD that has not been demonstrated to be ALARP.

Inspectorate for Transport, Public Works and Water Management (IVW)
The Dutch Safety Board has investigated[122] how the IVW, in its role of supervisor, has approached the incorporation of the control of the SPAD issue in the railway companies' safety management (systems). It has transpired that the SMSs have been assessed at system level, whereby it has neither been verified that an inventory has been made of all the relevant risks nor that those risks are controlled.[123]

The Board has also observed that the IVW attends the meetings of the SPAD steering group in the formal role of observer but also plays an active role in the SPAD steering group that extends beyond the role of 'observer'. For example, the IVW has played a prominent role in the development of the method used for the selection of the signals posing the greatest risk within the context of the rollout of the ATB-VV. The Board understands that this situation has arisen as a result of the IVW's specific expertise on SPADs. The Board finds this remarkable, since this results in the IVW's involvement in the selection of the measures to be implemented for the control of the SPAD issue, a situation which can be detrimental to the IVW's role as an independent supervisor. Moreover, in the Board's opinion the railway companies should possess the necessary in-house expertise on the SPAD issue.

6.2.3 Sub-conclusions:

The Dutch Safety Board has reached the following conclusions on the manner in which the parties involved fulfil their responsibilities for the control of the SPAD issue:

- The railway companies do not utilise all the available measures for the control of the SPAD issue and the measures they do implement are not based on an ALARP assessment. The control of the SPAD issue is insufficiently integrated in their safety management (systems).

- The Minister does not fullfil the responsibility for the system in an adequate manner. The Minister has adopted the targets specified in the SPAD reduction plan and has not required the railway companies to carry out an ALARP assessment.

- The Inspectorate for Transport, Public Works and Water Management (IVW) carries out assessments of the railway companies' safety management (systems) that unjustifiably devote no attention to the absence of inventories of all the relevant risks and the control of the identified risks. The IVW's active role in the SPAD steering group can complicate the Inspectorate's role as an independent supervisor.

122 This investigation was in part carried out within the scope of the Dutch Safety Board's investigation of the derailment of a goods train at Amsterdam-Muiderpoort on 22 November 2008.
123 See also the findings in the Board's report of the investigation of the derailment at Amsterdam-Muiderpoort published in March 2010.

7 CONCLUSIONS

This investigation focused on the question as to how the relevant parties control the risk of a collision caused by a SPAD and the measures that can be implemented to improve the control of the SPAD issue.

This question is broken down into the following five questions to be answered by the investigation:
1. What caused the SPAD accompanying the accident at Barendrecht?
2. To what extent were the available control measures for the prevention of the accident and/or limitation of the consequences deployed at Barendrecht?
3. If any control measures were not deployed at Barendrecht then was this unique to this case or was this structural?
4. How was the current approach to the SPAD issue developed and on which considerations is the approach based?
5. To what extent have the parties involved fulfilled their responsibility for the control of the SPAD issue?

The Board has reached the following conclusions on the basis of the results from its investigation:

Conclusion 1.a) The train collision occurred because the mixed goods train passed a signal set at danger without authorisation. It is plausible that this occurred because the driver of the mixed goods train became unwell. The investigation has revealed that the mixed goods train passed a signal that was later observed to be set at danger. The Dutch Safety Board has noted a number of indications that this occurred because the driver of the mixed goods train was unwell. Firstly, during its journey the mixed goods train had been stopped twice by an intervention of the dead man's system. Secondly, the driver initiated a braking action only two to three seconds before the collision whilst there were earlier indications of the threat of an accident (such as passing a signal set at danger and passing over a set of open points). In conclusion, the autopsy revealed that the train driver suffered from an hereditary heart disorder that can result in cardiac arrhythmia, dizziness and/or fainting. Complaints of this nature arising during the journey could have given cause to the two interventions of the dead man's system, the train passing a signal set at danger and the driver's failure to realise that the train had passed a set of open points.

Conclusion 1.b) The options available to reduce the risk that train drivers become unwell during the journey or continue the journey while they are unwell have not been utilised to an adequate extent. Although it is not possible to entirely preclude the risk of train drivers becoming unwell during their work, options are available for the reduction of this risk. These options were not utilised to an adequate extent in the collision at Barendrecht:
- A symptom indicative of this disorder was observed during the train driver's last medical examination but did not give cause to further medical examination.
- The power to make a decision on the train driver's continuation of the journey following an intervention by the dead man's system currently rests with the driver. As a result, the driver could continue the journey without an intervention or consultation. The mixed goods train was brought to a standstill twice by an intervention of the dead man's system during the relevant journey but the driver was able to continue his journey without giving notification of the intervention by the dead man's system.

Conclusion 2.a) The schedules were designed in a manner such that the mixed goods train and the container train would need to travel over the same section of track at the same time. As a result, the signal for the mixed goods train was set at danger. The schedulers and rail traffic managers did not identify and, consequently, did not correct the conflict. It was possible to design the schedules for Barendrecht in a manner that avoided conflicts or to subsequently modify the schedules to ensure that the trains would not be confronted with signals set at danger. This did not occur. This was in part due to the absence of 'instructions for use' for the deployment of the tracks at Barendrecht for the schedulers and rail traffic managers, the inability of the scheduling system to identify conflicts, and the schedulers and rail traffic managers' complete reliance on signals set at danger as an adequate means of correcting conflicts. The available options for preventing one of the trains at Barendrecht from being confronted with a signal set at danger were not utilised.

Conclusion 2.b) Various options available for the control of the SPAD issue were not utilised in the case of the Barendrecht collision or were utilised to an inadequate extent. The following options were not utilised in the accident or utilised to only an adequate extent:

- Warning and intervention: the locomotive was not equipped with an effective system to warn the driver that the train was approaching a signal set at danger or to intervene in the event that the driver failed to respond.
- ATP: the train and signal were equipped solely with ATB-EG. Since the train was travelling slower than 40 km/hour the system did not intervene with the initiation of an automatic braking action.
- Opposite signal: the SPAD did not result in the opposite signal immediately being set at danger (either automatically or by an intervention by the rail traffic manager), as a result of which the driver of the container train applied the brakes 15 seconds later than could have been the case.
- Intervention by the rail traffic manager: the rail traffic manager did not send an emergency call as a consequence of the SPAD, as a result of which the driver of the container train was not immediately aware that the mixed goods train had passed a signal set at danger.

Conclusion 3. The collision at Barendrecht occurred in circumstances that are also encountered at other locations in the Dutch railway network. Options available to control of the SPAD issue are not utilised or are utilised to an inadequate extent.

- There are no instructions stipulating that schedules shall be prepared in a manner that in practice avoids trains being confronted with signals set at danger whenever possible. The scheduling system does not provide for the identification of conflicts and no final reviews of scheduling conflicts are carried out.
- In practice, there is insufficient feedback from the rail traffic managers who perform the schedules to the schedulers who prepare the schedules, as a result of which scheduling conflicts can remain unresolved.
- The performance of inadequate medical examinations, the absence of notification functionality for the dead man's systems and the absence of an effective warning system are also problems encountered elsewhere in the Netherlands.
- About 65% of all operated signals and the large majority of the automatic signals are equipped solely with ATB-EG automatic train protection.
- The protection system is designed in a manner that does not ensure that a SPAD results in the opposite signals automatically being set at danger.
- Monitoring the train movements for SPADs is not part of the rail traffic managers' duties and they do not have the technical support required to do so.

Conclusion 4. The approach to the SPAD issue in the past decades has not resulted in the adequate control of safety risks with suitable measures. Until 2004, the approach to the SPAD issue was limited to the introduction of ATB-EG on the main railway lines and ATB-NG on the regional railway lines. Since then the policy has been comprised of the implementation of the SPAD reduction plan (with equipping some of the operated signals with ATB-VV as the most important measure) in the short term and the introduction of ERTMS in the long term. Dealing with the SPAD issue has been delayed by the unjustifiable expectation that ERTMS, regarded as solution for the SPAD issue, would be introduced on the entire railway network within the near future. As a result, the general introduction of ATB-NG has not taken place and other control measures have been addressed too late and to only a limited extent. The SPAD reduction is not based on a thorough analysis of the SPAD issue. No assessment has been carried out on the basis of the ALARP principle to determine whether the available control measures should or should not be implemented.

Conclusion 5.a) The railway companies do not fulfil their responsibility to control the SPAD issue to an adequate extent. Pursuant to the Railways Act, the railway companies are expected to implement all possible measures to control the SPAD issue unless they can demonstrate that the costs of a measure are unreasonable and/or that a measure will have other detrimental consequences. However, in practice it has transpired that the railway companies do not implement all possible measures to control the SPAD issue and that decisions on the possible implementation of measures are not based on an ALARP assessment. The control of the SPAD issue is inadequately integrated in the railway companies' safety management (systems). The Board observes that the legislation and regulations are satisfactory, but that the railway companies do not fulfil their (statutory) responsibilities in an adequate manner.

Conclusion 5.b) The Minister does not fulfil the Minister's responsibility to control the SPAD issue to an adequate extent. The Minister's responsibilities are laid down in the Railways Act. The Minister is required to supervise the railway companies' fulfilment of their ALARP obligation. The Inspectorate for Transport, Public Works and Water Management carries out this duty on the Minister's behalf. However, the Minister (and the Inspectorate) fail to impose adequate compulsion on the companies to fulfil this obligation. This is illustrated by the fact that the Minister has adopted the reduction targets specified in the SPAD reduction plan and has not also required the railway companies to fulfil their ALARP obligation. Consequently, the Board observes that the legislation and regulations are satisfactory, but that the Minister does not fulfil the Minister's (statutory) responsibilities in an adequate manner.

8 RECOMMENDATIONS

To the railway companies

The essence of, the Railways Act is that the infrastructure manager and carriers bear the full responsibility for safety, each for their part. They must cooperate as necessary. They must then make use of all the measures available to control risks unless specific measures have demonstrably unreasonable consequences (the ALARP principle).

1. Undertake joint adequate actions for the suitable control of the SPAD issue in both the short and long term. Begin by identifying all potential measures focused on the reduction of the number of signals set at danger, the prevention of SPADs and the prevention of collisions due to SPADs. Then implement these measures unless specific measures have demonstrably unreasonable consequences.

Explanatory note: In the Board's view the appropriate manner to adopt this recommendation is to draw up a specific plan of action for the implementation of all these measures. It is desirable that one party should take the lead in preparing this plan: in the Board's view this should be ProRail, since this party fulfils the role of node for all information about the safety of the railways. When specific measures are demonstrably infeasible for the railway companies then the Board expects the railway companies to enter into consultations with the Minister of Infrastructure and the Environment to examine the opportunities available to resolve these problems.

2. Develop a (technical or organisational) system within the near future which assigns the power to make a decision on the train driver's continuation of the journey following an intervention by the dead man's system to a functionary other than the driver.

To the Minister of Infrastructure and the Environment

Pursuant to the Railways Act, the Minister bears the responsibility for the system, a responsibility which includes the exercise of the supervision and enforcement required to ensure that the parties actually fulfil the responsibilities assigned to them. The railway companies have not succeeded in reducing the SPAD issue to ALARP level since the Railways Acts came into force and the Minister has not required them to do so. Consequently, the essence of the Railways Act has not been implemented in practice to date. The Dutch Safety Board is of the opinion that this implementation is essential.

3. Make sure, as the party bearing the responsibility for the system, that the railway companies assume their responsibility for the adequate control of the SPAD issue in the short and long term.

Explanatory note: the Board expects that in adopting this recommendation the Minister plays the coordinating role explicitly assigned to the Minister in the Railways Act and increases the stringency of the supervision of the railway companies to provide for the joint approach as referred to in the Railways Act.

4. Within the next twelve months, specify which blocks of tracks, yards and rolling stock shall be equipped with ERTMS together with the associated timeframes, and specify which measures shall be implemented on blocks of track and yards that will not be equipped with ERTMS. Make sure that all parties involved invest in the necessary interim measures to be implemented before the actual introduction of ERTMS.

Administrative bodies to which a recommendation is addressed are requested to make known their position regarding this recommendation to the relevant minister within six months after publication of this report. Non-administrative bodies or persons to whom a recommendation is addressed are requested to make known their position regarding the follow-up of this recommendation to the relevant minister within one year. Copies of these responses should simultaneously be issued to the Chair of the Dutch Safety Board and the Minister of Public Safety and Justice.

On the expiry of the response period the Dutch Safety Board will publish the responses to the report on the Board's website, www.onderzoeksraad.nl. When no responses are received the Board also gives notification of the fact on the aforementioned website.

ANNEX 1: JUSTIFICATION OF INVESTIGATION

Investigation by the Dutch Safety Board
The Dutch Safety Board carries out independent investigations into the (presumed) causes of incidents. The Board's investigation is not intended solely to identify the causes of incidents but also, and above all, to reveal the underlying causes and any shortcomings at system level. When the Board's investigations reveal structural safety shortcomings then the Dutch Safety Board can draw up recommendations for the rectification of these shortcomings. The objective of this investigation is in line with the above: the Dutch Safety Board has conducted an investigation into the collision at Barendrecht to identify lessons to be learned for the prevention of accidents of this nature or the restriction of their consequences.

Reason for the investigation
The Dutch Safety Board has a statutory obligation to conduct investigations into serious railway accidents. In addition, the Dutch Safety Board is of the opinion that this investigation was necessary in view of the potential severity of train collisions in general, the extent of the damage and the disruption of rail traffic caused by this collision as well as the possibility that the same problem had been an issue in earlier collisions.

Investigation questions
The first question to be answered prior to an investigation of any structural causes was: 'What actually occurred prior to the collision of the two goods trains at Barendrecht?'

Since it transpired that the collision was caused by a SPAD (a train passing a signal set at danger) the Dutch Safety Board's investigation focused on the question as to how the relevant parties control the risk of a collision caused by a SPAD and the measures that can be implemented to improve the control of the SPAD issue.

This question is broken down into the following five questions to be answered by the investigation:
1. What caused the SPAD accompanying the accident at Barendrecht?
2. To what extent were the available control measures for the prevention of the accident and/or limitation of the consequences deployed at Barendrecht?
3. If any control measures were not deployed at Barendrecht then was this unique to this case or was this structural?
4. How was the current approach to the SPAD issue developed and on which considerations is the approach based?
5. To what extent have the parties involved fulfilled their responsibility for the control of the SPAD issue?

Other investigations
The carriers (DB Schenker and ERS Railways), ProRail and Keyrail, the Railway Police and the Inspectorate for Transport, Public Works and Water Management's Rail Supervision Division, carried out investigations at the scene of the accident. The Dutch Safety Board has made use of their findings.

The Safety Board requested DeltaRail to carry out a further investigation, under the Safety Board's supervision, of the facts and technical cause of the collision at Barendrecht. Lloyd's Register Rail Europe BV also provided support for this investigation.

Investigation method
The investigation encompassed: an on-site investigation, a study of the relevant documents and interviews. The interviews were held with officers of the various parties involved, in this instance DB Schenker, ERS Railways, NS Reizigers, ProRail, Keyrail, the Inspectorate for Transport, Public Works and Water Management and the Ministry of Transport, Public Works and Water Management. The objective of these interviews was to gain an insight into the cause of the collision and into the manner in which the various parties fulfil their responsibility for the control of the SPAD issue.

Tripod analysis

This investigation included an analysis carried out using Tripod Beta (hereinafter referred to as 'Tripod'). Tripod offers a framework for the systematic collection of the findings on the cause of incidents. The Tripod model assumes that barriers will normally prevent incidents. Accidents can occur when barriers are not in place or do not perform correctly. Tripod assumes that barriers fail because of active failures. The model assists investigations in the identification of failures of this nature.

The Tripod analysis was based on a causal model of collisions related to SPADs. This model was prepared using general knowledge about railway operations and data from earlier investigations carried out by the Dutch Safety Board. The model reveals that a collision related to a SPAD occurs in a three-phase process and that risk control measures can be implemented in each of those phases (see Section 5).

Figure 11 shows the causal model and the barriers of relevance to this investigation.[124]

124 Information about the notation used in Tripod Beta diagrams is enclosed in the Tripod Beta User Guide: http://www.tripodfoundation.com/documenten/Tripod%20Beta_User%20guide_02a.pdf. Tripod diagrams drawn up by the Dutch Safety Board can exhibit minor variances from the conventions prescribed for the Tripod model. These variances result from Tripod Beta's pronounced operational focus, which is not fully compatible with the Dutch Safety Board's approach.

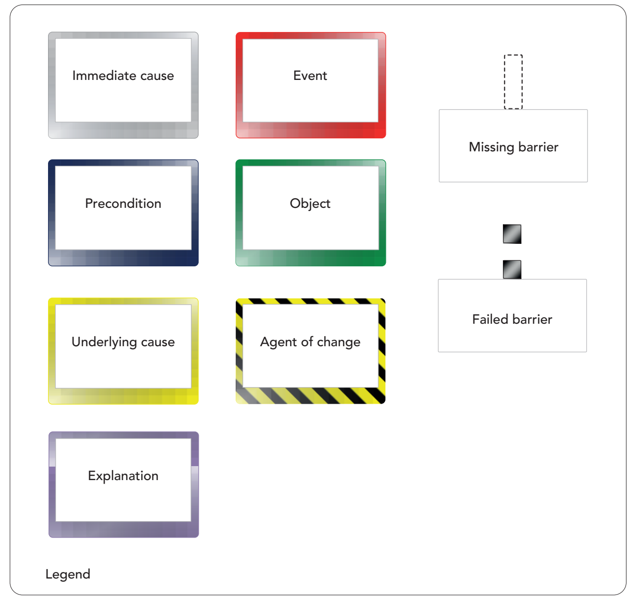

Figure 11: Causal model of collisions related to SPADs

These were then investigated further using the Tripod method. This investigation revealed a number of preconditions[125] and underlying causes[126] that gave cause to the active failures that occurred. These are shown in Figure 12.

125 The Tripod model understands 'preconditions' as: the underlying facts and circumstances of an active failure.

126 The Tripod model understands 'underlying causes' as: structural safety shortcomings that create the preconditions attached to active failure.

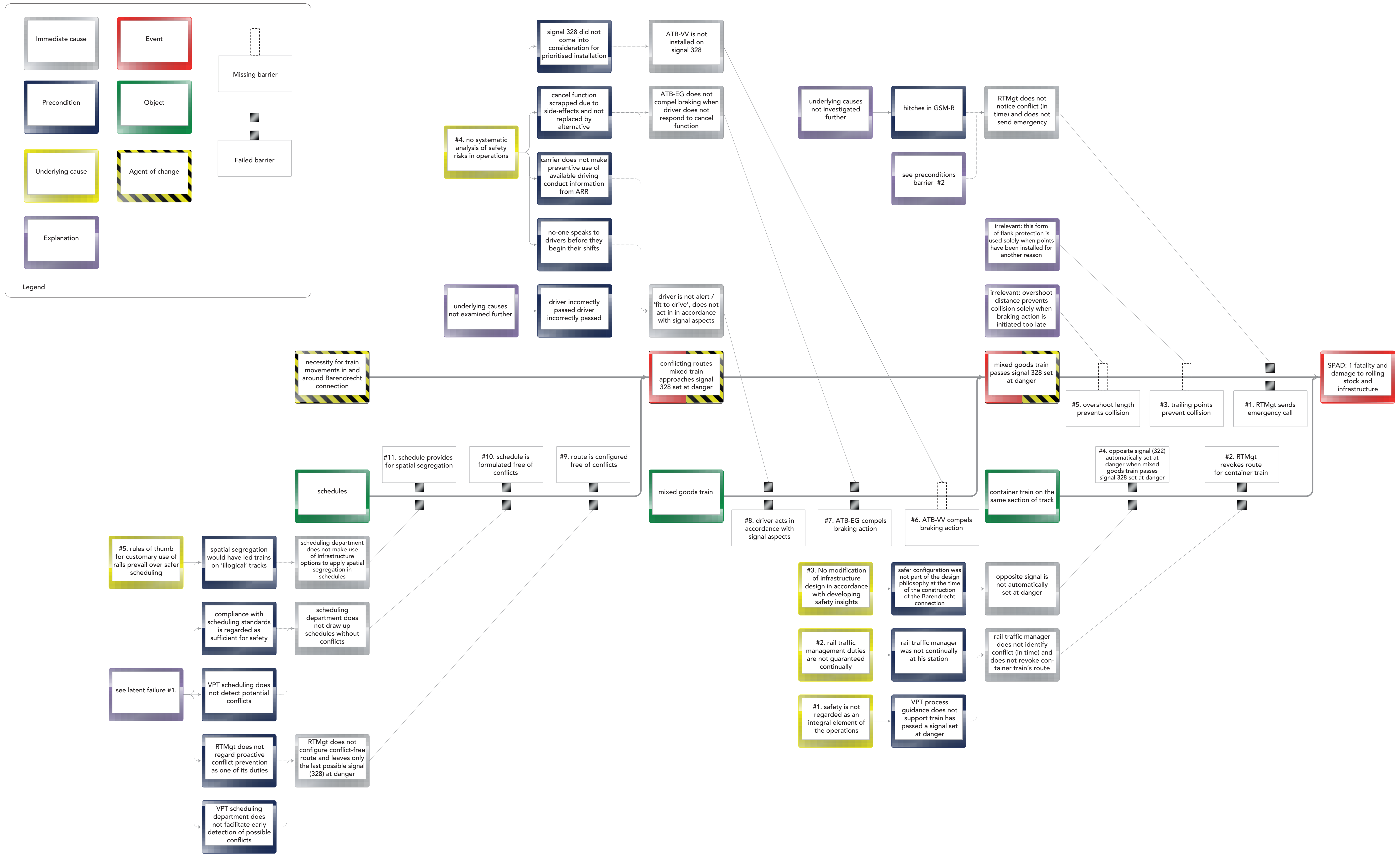

Figure 12: Causal model of collisions related to SPADs (including preconditions and latent failures [underlying causes])

The Dutch Safety Board has not carried out investigations of specific control measures that were found to have performed correctly in the Barendrecht accident (such as the signals and the train's braking effect) to determine whether their correct performance is general in the Netherlands. Nor, for the purposes of clarity, have these measures been included in the Tripod analysis.

Project team

Investigation Manager:
J.J.G. Bovens

Core team:

T.T. van Prooijen	Project Manager
R.J.H. Damstra	Investigator
A. Sloetjes	Investigator
J. van den Top	Investigator
M. van het Loo	Substantive process support department
N. Smit	Investigation consultant

Support:

E.J. Willeboordse	Investigation consultant
I.C. Elias	Substantive process support department
A. Legierse	Factual investigation support
M. Hiensch	Factual investigation support
A.W. Noppe	Legal Advisor

Advisory committee
The project team was supported by an advisory committee comprised of two members of the Board and five external experts. The members of this committee were as follows:

J.P. Visser	Member of the Board (Chair of the advisory committee)
Annie Brouwer-Korf	Member of the Board
F.G. Bauduin	
W.A.G. Döbken	
I.A. Hansen	
P.M. Ranke	
P.J.A. Smets	

ANNEX 2: RESPONSES AFTER INSPECTION

A comments version of this report was submitted to the parties involved, in accordance with the Rijkswet Onderzoeksraad voor Veiligheid ('Kingdom Act on the Dutch Safety Board'). These parties were requested to check the report for errors and points that were not clear. The comments version of this report was submitted to the following parties:

- The widow of the train driver killed in the accident
- DB Schenker (the carrier operating the goods train)
- ERS Railways (the carrier operating the goods train)
- NS HiSpeed (the carrier operating the international passenger train)
- NS Reizigers (the carrier operating the passenger train)
- Keyrail (the manager of the goods railway line railway infrastructure)
- ProRail (the infrastructure manager)
- Maetis (the medical examination organisation)
- The Inspectorate for Transport, Public Works and Water Management (supervision/enforcement of railway safety)
- The Minister of Transport, Public Works and Water Management (the system responsibility for railway safety)

The comments received after the inspections were processed as follows:

- The Board has adopted supplementations, corrections at detail level and editorial comments. The report has been amended accordingly and comments of the aforementioned forms are not listed individually.
- The Board has responded to substantive comments. In some instances this has resulted in an amendment of the report but has not resulted in an amendment in others. These responses are listed in a table published on the Dutch Safety Board's website: **www.onderzoeksraad.nl**. Each comment is accompanied by an indication of the subsection to which the comment relates, the party that submitted the comment and whether the comment has or has not been adopted. The comments that have been adopted are supplemented with an explanation of the manner in which they were incorporated in the report: the comments that are not adopted are supplemented with the Board's reason for its decision not to adopt the comment.

ANNEX 3: EXPLANATION OF TECHNICAL TERMS AND PROCESSES

The following subsections contain a brief explanation of frequently-used railway terms and their mutual relationships.

The track is released only when safety is assured
Pursuant to one of the main principles of the control of railway traffic the infrastructure for each train movement needs to be released explicitly for that train. Each train schedule assigns the train what is referred to as a *train path* which specifies the tracks the train will use during its journey and the times at which it will use those tracks. The train path can be regarded as an agreement between the network manager and the carrier on the train's timing. All train paths jointly constitute the *schedules*, which serve as an operational plan: the *rail traffic manager* (who works at the *rail traffic management centre*, part of the network manager's organisation) amends this plan as required and releases the infrastructure required for a train movement in time, provided that this can be released in a safe manner. The released infrastructure is referred to as a *route* and constitutes the operationalisation of the train path.

The *protection* 'locks' (formerly physically, nowadays electronically) the entire route. Sets of points, for example, are locked and the sections of track that have already been released cannot be assigned to another route. Once the train has passed the sections of track are freed ready for assignment to another route. The task of the *detection* system is to determine which sections of track are free.

The train's speed must be compatible with the limitations imposed by the released track
The route can be subject to a variety of limitations, such as speed restrictions at sets of points or in curves, at the end of the route (for example, when the continuation of the route is not yet available due to other train traffic or a malfunction of a set of points on the route). These limitations must be displayed to the driver, usually in the form of symbols displayed by *signals* along the track or in the train's cabin. These can be in the form of light signals, signs, aural signals or gestures. The standardised meanings of all symbols are listed in Annex 4 to the Regeling Spoorverkeer ('Railway traffic Regulations').

The *train driver* must control the train in a manner such that the train's movement remains within the limitations imposed by the released route. To this end the driver must be able to observe the signals in time, interpret the symbols and take suitable action, such as the initiation of a braking action. Since train's have a long braking distance the driver must receive warning of an approaching limitation in good time, i.e. at a distance sufficient for the braking distance required to reduce the train's speed to the requisite speed. The train's *brake system* is controlled by an air line to which all the wagons in the train are connected.

The train's *dead man's system* is designed to stop a train in the event that the driver is no longer in a position to do so. The driver's ability to stop the train is demonstrated by the requirement that the driver presses a button at least once a minute; if the driver fails to do so then the dead man's system immediately brings the train to a standstill. The train's compliance with the limitations imposed by the route is monitored by *automatic train protection (ATP)*. If necessary, the ATP system intervenes and warns the driver and/or initiates a braking action. This is possible only when the train protection system is configured for the limitations imposed by the relevant route.

Safety engineering design principle: in the event of a malfunction the system goes to a safe condition
One of the safety engineering design principles specifies that the system reverts to the safest condition whenever possible. An explicit command is required to switch to every condition that is less safe. This is referred to as the *fail-safe* principle. For example, signals are normally set at danger: they can allow trains to pass only when a number of safety conditions are met. Similarly, the detection system also reports sections of railway as occupied unless the converse has been demonstrated. In addition, the brakes on trains are applied when there is no power: the train can be moved only when there is sufficient air pressure to release the brakes. As a result, malfunctions

(such as a power failure or air leak) usually result in the system reverting to the safe condition. However, it is not feasible to design a fail-safe solution for every conceivable form of failure.

ANNEX 4: EXPLANATION OF THE FINDINGS FROM THE TECHNICAL INSPECTION

The Dutch Safety Board has carried out an investigation of the causes of the train collision at Barendrecht. The causes that played a role in the accident are discussed in the main text of this report. This Annex reviews a number of other potential causes that were ruled out by the investigation.

Signal aspects: An analysis of the log file of the protection system (VPI) revealed that signal 328 had not been operated and, consequently, was set to display 'danger'. This signal was inspected at 03:00 on the night of the accident and was seen to be set at danger at that time. The signal preceding this signal (P-852), which should have warned the driver that he was approaching a signal set at danger by displaying a yellow 'caution' signal, was also inspected that night and was seen to be set at caution. Consequently, the Dutch Safety Board concludes that the driver was displayed the correct signal aspects.

A reconstruction journey and an analysis of the automatic trip registration (see below) revealed that prior to signal P-852 set at caution the driver was displayed a 'green-flashing 6' signal by signal 114. However, since the train had previously switched from track 67c to track 68b its speed was already 40 km/hour. Consequently, the train had been travelling at a speed of approximately 40 km/hour for a longer period of time, but had not continually been governed by a 'caution' signal aspect.

Visibility of the signals: The visibility of the signals was examined during a reconstruction journey in the night of 2/3 October 2009. This revealed that signal P-852 was visible at a distance of 750 metres and signal 328 at a distance of 500 metres. These signals were, in view of the speed of the mixed goods train, visible at 47 and 72 seconds respectively before the train passed them. Consequently, there was sufficient reaction time and braking distance to bring the train to a standstill ahead of the signal set at danger.

Automatic train protection system (ATB-EG): The mixed goods train's ATP was switched on. An analysis of the relevant locomotive's automatic trip registration revealed that the ATP code that was received was in agreement with the route's signal aspect. On approaching the signal set at danger the ATP, in accordance with the system's design, monitored a speed ceiling of 40 km/hour. The container train's ATP system was functioning correctly. The driver received an ATP message[127] once the mixed goods train entered the points section of the route configured for the container train. The Dutch Safety Board concludes that ATB-EG functioned in accordance with the design. However, the technical design of ATB-EG is such that the system does not provide any information about the location of a signal set at danger.[128] For this reason the system limits the speed of a train approaching a signal set at danger to 40 km/hour, but cannot intervene when the train passes a signal set at danger.

Revocation of a signal shortly before a train passes: According to the log file of the protection system (VPI), signal 328 had last been set at an aspect other than danger from 17:01 to 17:03. The locomotive's automatic trip registration did not register any change in the monitored speed indicative of the revocation of the signal. The Dutch Safety Board concluded that the signal was not revoked shortly before the train passed the signal.

The train's braking power: An on-site inspection revealed that the rear end valve of the mixed goods train's second container wagon was in the closed position and was damaged. If this valve was also closed during the train's journey then this would have limited the train's braking power, since the brakes of the wagons after the closed valve would not have been applied when the train braked. The maximum theoretical braking deceleration would then have needed to be supplied

127 More information is available in the explanation of the automatic trip registration at the end of this Annex.
128 ATB-VV, installed on an increasing number of signals, does include this information lacking with ATB-EG.

by the two locomotives and the first two wagons (with a combined weight of 202 tonnes whilst the total weight of the train was 1088 tonnes). The braking deceleration would not then have exceeded approximately 0.2 m/s². An inspection revealed that the braking deceleration earlier during the journey had been sufficient (0.74 and 0.82 m/s² respectively during two emergency braking actions), normal levels for a goods train. The Dutch Safety Board concludes that the train's braking deceleration was normal.[129]

Power failure: Consideration was originally given to a power failure that could have made a contribution to the collision. A distinction needs to be made between the power supplies for the protection equipment and the power supply for the trains' traction units via the overhead wires. In the event of a disruption of the power supply to the protection equipment the signals are extinguished, the system switches to the safe mode in which all blocks of track send an 'occupied' message and the ATP signals for the trains in the relevant area fall away. However, symptoms of this nature were not registered at the location of the accident, although this did occur at the Rotterdam Zuid, Rotterdam Stadion, Rotterdam Lombardijen and IJsselmonde stations at the time of the collision since one of the derailed wagons separated a power cable. It can be concluded that the failure of the power supplies to the protection equipment was caused by the collision.

The overhead wire was damaged in the collision and the substation supplying power to the overhead wire automatically disconnected the power supply. The substation will then have regularly endeavoured to reconnect the power supply to the overhead wire, which can also have resulted in the indication of a malfunction. The damage to the overhead wire was also caused by the collision. The rail traffic managers' impression that a power failure had occurred prior to the collision can be explained by the collision causing the power failure. The power failure was visible on the rail traffic managers' monitors immediately, whilst they received information about the collision only a few minutes later.

Electromagnetic interference: On the commissioning of the HSL-Zuid high-speed railway line malfunctions occurred at a variety of locations along the parallel conventional tracks: when high-speed trains were in the vicinity then trains travelling on the conventional tracks were brought to a standstill by interventions of the automatic train protection system. This was caused by malfunctions of the two parallel tracks caused by electromagnetic interference. Since the route of the HSL-Zuid high-speed railway line passes under the location of the collision the Dutch Safety Board investigated whether electromagnetic interference could have played a role in the circumstances resulting in the collision at Barendrecht.

Electromagnetic interference refers to electromagnetic radiation that disrupts the performance of equipment. Moving electrical charges create (electro)magnetic fields which on fluctuating in turn create an electrical field that can generate a potential difference across a conductor lying in the magnetic field: this phenomenon is referred to as 'induction'. An induction voltage can disrupt the performance of equipment.

In the aforementioned example the high currents passing through the overhead wires of the HSL-Zuid high-speed railway line generated an induction voltage in the tracks of the parallel conventional railway lines. The ATP equipment regarded this voltage as an invalid ATP code, as a result of which the ATP switched to the safe mode and brought the trains to a standstill. The Dutch Safety Board's investigation revealed that this specific situation did not play a role in the collision at Barendrecht.

Interference could also have caused a disruption of the train detection system, as a result of which a route could have been unjustifiably released. Other similar causes can also be excluded from playing a contribution to the collision. The Dutch Safety Board bases this conclusion on the following reasons:

129 If the train's limited braking deceleration had made a contribution to the collision then the registration system would have included a record that the brakes had been applied but that the train nevertheless failed to slow to a sufficient degree. Since the driver applied the brakes only 2 seconds before the collision this is not the case.

- Firstly, there are no fluctuating electrical fields on this section of the HSL-Zuid high-speed railway line and, consequently, there are no interference problems caused by the high-speed railway line. Currents of this nature can be generated by the use of alternating currents or the frequent switching in and off of direct currents. Neither were present at Barendrecht:
  - alternating currents were not present: the overhead wire at the location carried the 1500V direct current customary in the Netherlands (the 25 kV alternating current section of the HSL-Zuid high-speed railway line began several kilometres to the south of the location).
  - The frequent switching in and out of a direct current can occur when, for example, the traction system of a train makes use of energy-consumption controllers (what are referred to as ‘choppers’). However, no train passed immediately before the collision. The last train before the collision left the section of the HSL-Zuid high-speed railway line at 22:19, 13 minutes before the collision.
- Secondly, the various log files (of the automatic trip registration and the protection system (VPI) that configure and monitor the routes) did not include any records indicative of an undesirable performance of the system.

The Dutch Safety Board concludes that electromagnetic interference did not play a role in the circumstances leading to the train collision at Barendrecht.

Automatic trip registration: The following subsection reviews the information obtained from the automatic trip registration systems of the mixed goods train and container train.

Mixed goods train. The automatic trip registration (ARR) of the mixed goods train (locomotive number 6514) was read out in Rotterdam on 29 September 2009 in the presence of the Dutch Safety Board, Inspectorate for Transport, Public Works and Water Management, ProRail and DeltaRail. The trip registration file, in the form of a text file in a table, was made available to DeltaRail for further analysis.

It should be noted that the time records in the ARR are not in agreement with the time according to the train number tracking system (TNTS), which uses the actual time. The time difference between the TNTS and ARR was determined on the basis of the time at which the two systems indicated that the collision had occurred. The time of the collision indicated by the ARR is based on the last logged time, namely: 21:30:02. The time of the collision as indicated by the TNTS was determined as 22:32:35. Apart from the fact that the ARR was set to winter time, the ARR’s time lagged that of the TNTS by 2 minutes and 33 seconds. To avoid confusion the following ARR charts have been corrected to TNTS time.

Figure 13 shows the speed of the mixed goods train in the last minutes before the accident. The driver reduced the speed to just under 40 km/hour at about 22:27 since the train needed to pass over the set of points in the IJsselmonde yard in the switch position. The train’s speed subsequently remained approximately constant. The ATP code changed from yellow to yellow 6 at about 22:29:40 and the driver slightly increased the train’s speed. The ATP code changed back from yellow 6 to yellow at about 22:31:00, when the train passed signal P-852 set at caution. The driver kept the speed constant at about 39 km/hour. The driver operated the train’s brake handle shortly before the collision, and the locomotive’s brakes were also applied.

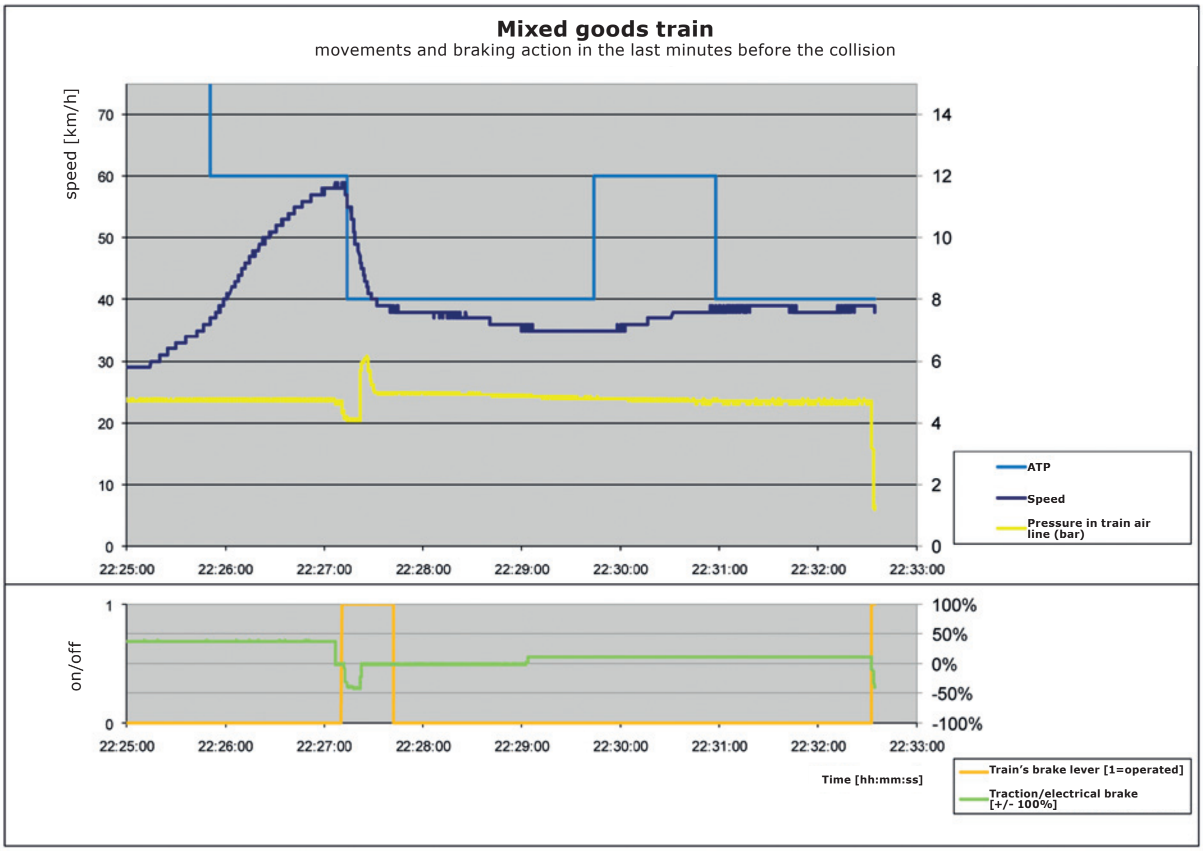

Figure 13: The mixed goods train's movements and braking actions in the minutes before the collision

The mixed goods train was travelling between Nunspeet and Harderwijk at about 19:50 at a speed of approximately 80 km/hour when the braking system's air pressure fell away: the train's brakes were applied and the locomotive's electrodynamic brakes were fully applied (see Figure 14). This braking action was not initiated by the driver: he operated the brake lever more than 10 seconds later. The train continued to brake until it came to a standstill.

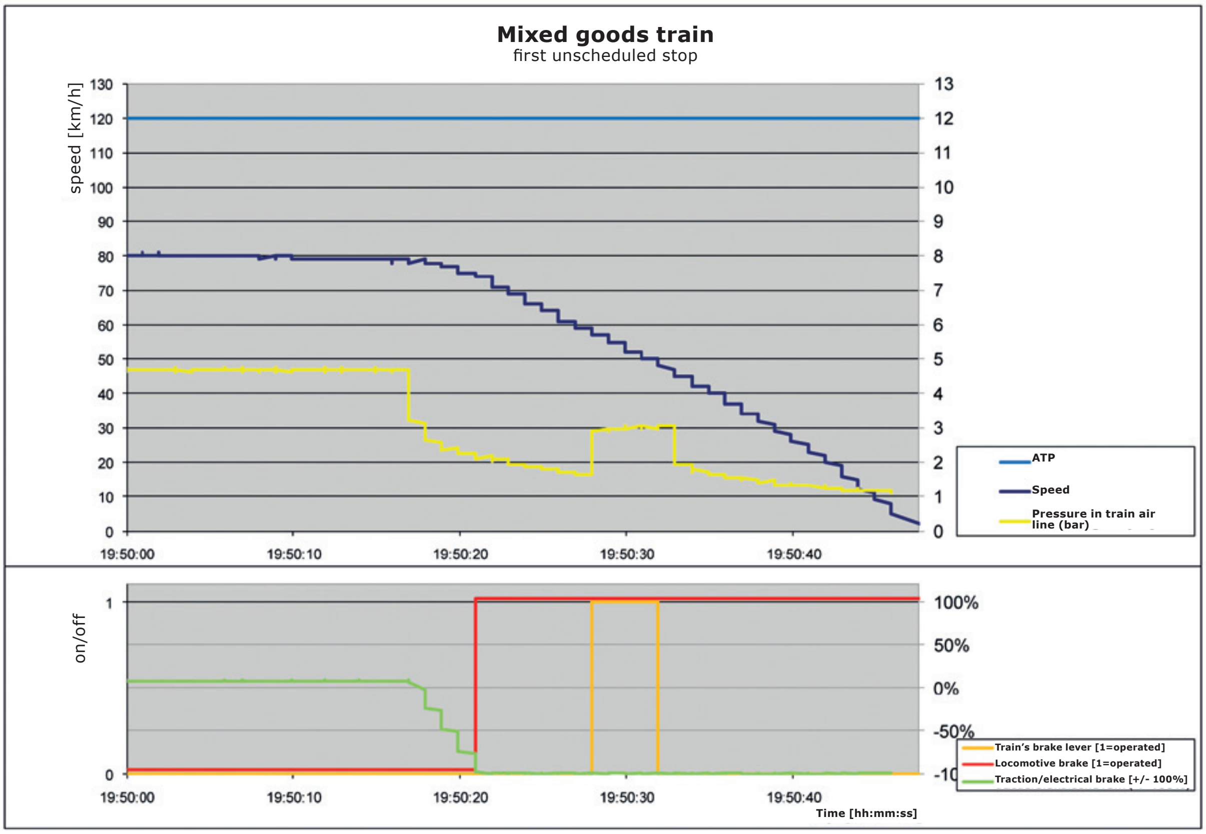

Figure 14: The mixed goods train's movements and braking actions at about 19:50

A similar braking action occurred at about 21:05 (Figure 15).

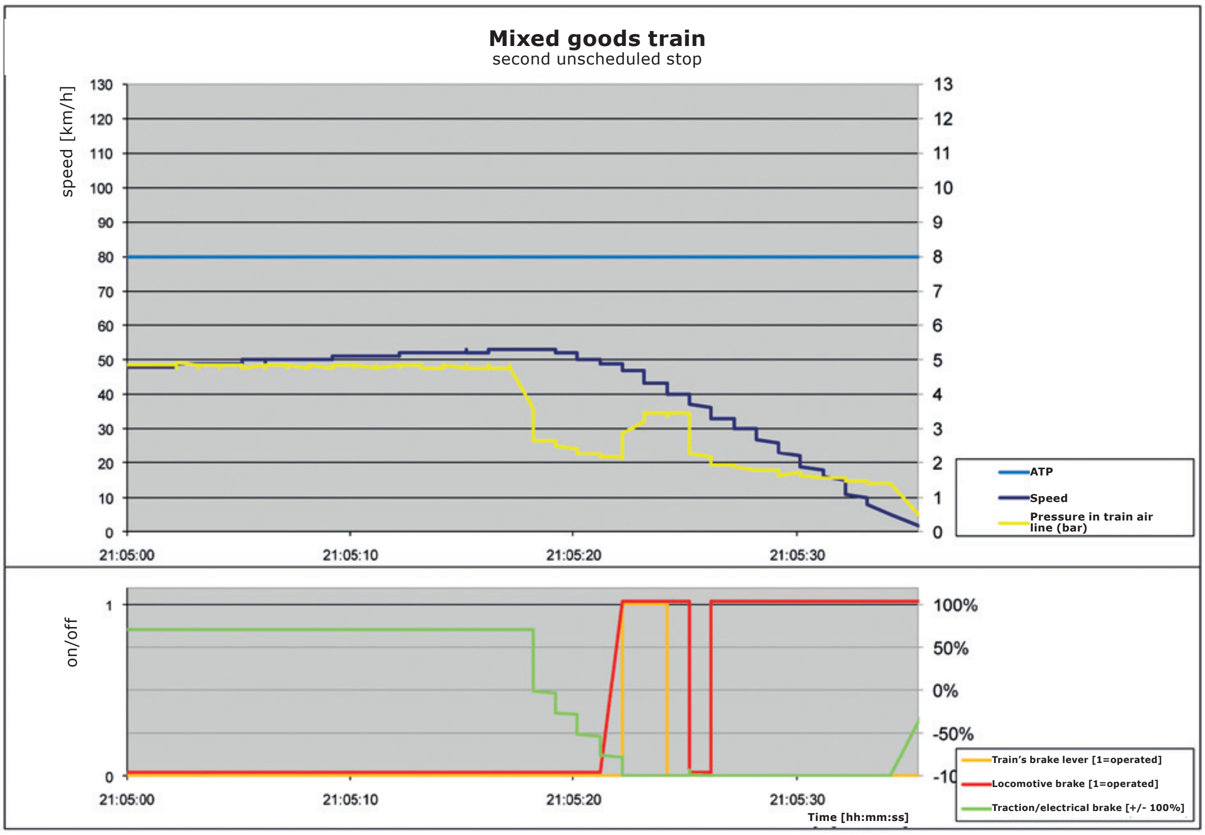

Figure 15: The mixed goods train's movements and braking actions at about 21:05

The maximum speed was not transgressed and there was no ATP code malfunction in either of these instances. Since no message was sent about a malfunction the most probable cause of these braking actions was an intervention by the dead man's system. The automatic trip registration does not include records of an intervention by the dead man's system as such. Any such intervention can be derived solely from the other data.

Container train. The automatic trip registration (ARR) of the container train (locomotive number 6616) was read out in Rotterdam on 29 September 2009 in the presence of the Dutch Safety Board, Inspectorate for Transport, Public Works and Water Management, ProRail and DeltaRail. The trip registration file, in the form of a text file in a table, was made available to DeltaRail for further analysis.

It should be noted that the time records in the ARR are not in agreement with the time according to the train number tracking system (TNTS), which uses the actual time. The time difference between the TNTS and ARR was determined on the basis of the time at which the two systems indicated that the collision had occurred. The time of the collision indicated by the ARR is based on the last logged time, namely: 21.30:46. The time of the collision as indicated by the TNTS was determined as 22:32:35. Apart from the fact that the ARR was set to winter time, the ARR's time lagged that of the TNTS by 1 minutes and 49 seconds. To avoid confusion the following ARR charts have been corrected to TNTS time.

Figure 16 shows the speed of the container train in the last minutes before the accident. After its departure from Kijfhoek the train accelerated until it reached a speed of between 70 and 80 km/hour about one minute before the collision. At 22:32:28 the ATB indicated that the container train's route was no longer free. The driver initiated an emergency braking action one second later. It is not possible to determine from the data whether this emergency braking action was in response to the ATP message or was due to the driver seeing the train approaching him on the same track. The emergency braking action resulted in the rapid decrease of the train's speed from 73 km/hour to 68 km/hour.

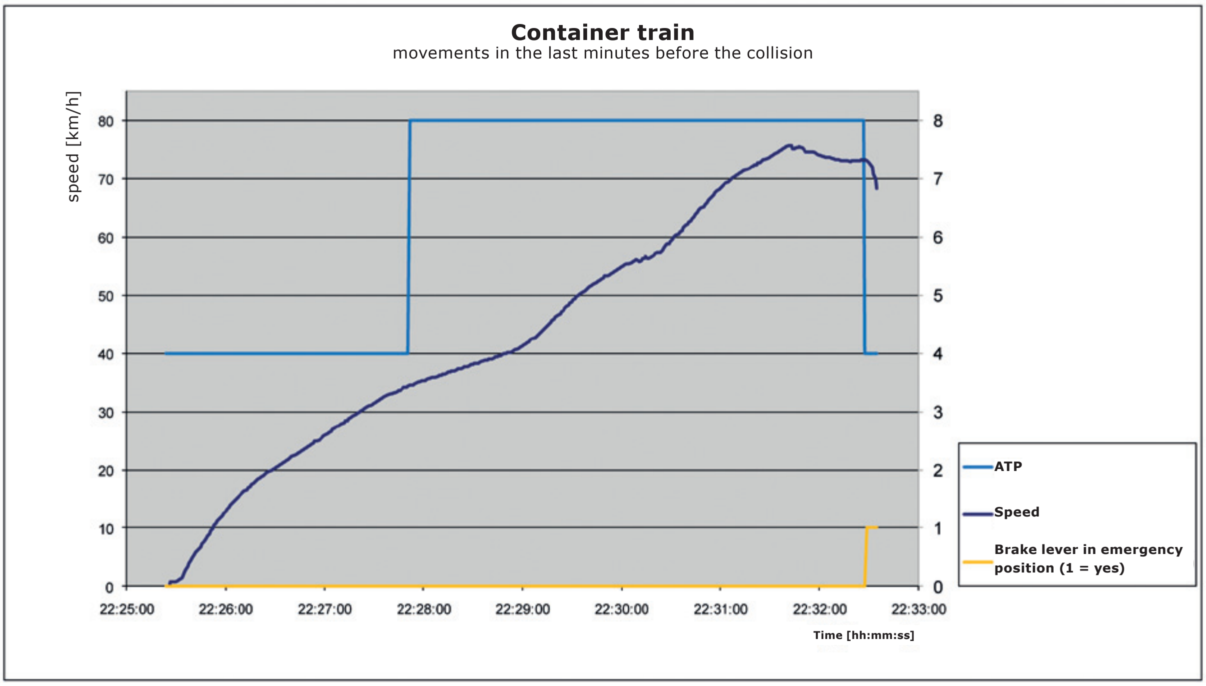

Figure 16: The container train's movements and braking actions in the minutes before the collision

ANNEX 5: RELEVANT RECOMMENDATIONS FROM THE DUTCH SAFETY BOARD AND ITS LEGAL PREDECESSORS

This investigation revealed a number of issues requiring attention that have been known for a longer period of time: the Dutch Safety Board had already requested attention for these issues in earlier investigations. The relevant recommendations from these investigations are listed below, together with a summary of the response from the party to whom the recommendation was addressed and information on the adoption of the recommendation as revealed during the course of the current investigation ('lesson(s) from Barendrecht').

Eindhoven, 31 October 1992.
Collision between express train and slow train, Railway Accident Board report, July 1993

Recommendation 1: (addressed to the Minister of Transport, Public Works and Water Management): The second generation of ATP should be introduced throughout the entire railway network as quickly as possible. This should be based on the most rapid scenario (completion in 2005).	
Response(s)	According to NS Dutch Railways the financing of ATB-NG (cost of between NLG 1.5 and 2 thousand million) is not feasible until 2005. The Minister will make a decision only after a study of the feasibility of the ERTMS to be developed at a European level.
Lesson(s) from Barendrecht	ATB-NG has not been introduced.
Recommendation 2a: (addressed to NS Dutch Railways): During the period in which the risk of collisions between trains travelling at high and low speeds at crossings and connections (as was the case at Eindhoven) is not covered by the introduction of this ATP second generation other measures should be implemented to reduce this risk, whereby as a first option particular and serious consideration should be given to the reduction of train speeds at crossings and connections.	
Response(s)	The implementation of this measure will make it impossible to carry out the train timetables.
Lesson(s) from Barendrecht	As has been shown by Section 5, other measures for the reduction of the risk of SPADs are still available.

Dordrecht, 28 November 1999
Collision between two passenger trains, Transport Safety Board report, 25 June 2001

Recommendation 2: The Board recommends that the Minister of Transport, Public Works and Water Management should make an explicit statement on the phasing of the implementation of a modern ATP system based on modern computer technology in the Dutch railway network. In addition, the prevention of collisions with derailed trains from the opposite direction should be incorporated in the schedule of requirements.	
Response(s)	A short-term policy has been drawn up for the introduction of an ATP system throughout the country. The entire Netherlands shall be equipped with ATB-EG or ATB-NG by 2005. The Minister's long-term policy is specified in the Railway Safety Framework Document: 'The replacement of ATB by new systems such as ERTMS, ATB-NG or other systems is not based on the resolution of safety bottlenecks but solely on the limitations below 40 km/hour should an improvement in safety be feasible. New systems shall be based on capacity management, interoperability, the controllability of the train services and information about the performance of the services. (...)' In view of the cost of the replacement (several million euros for the introduction throughout the Netherlands) and the low benefits to safety other arguments for arguments such as quality improvement, capacity management and interoperability shall need to be decisive. The mandatory installation of ERTMS shall be an issue solely for large-scale railway modernisation programmes or construction projects. Consequently, although the spirit of the recommendation has been adopted it is not possible to issue a specific schedule within the period of time you stipulate.
Lesson(s) from Barendrecht	• ATB (EG or NG) has been introduced on a national scale. However, this has not completely resolved the problem of passing signals at danger. • A specific schedule for the introduction of ERTMS has not been issued. • No specific information has been given other than the specific safety arguments for the introduction of ERTMS as deemed to be necessary by the Ministry. The estimates are largely based on overall figures, not on specific solutions for specific bottlenecks.
Recommendation 3: The Board recommends that the rail traffic management's Management Board exercises great restraint in the configuration of routes with sections of track that need to be used at speeds lower than 40 kilometres per hour and, consequently, without protection by ATP, until the time that a new and modern ATP system has been introduced on those sections of track. The rail traffic manager should supervise the use of any such sections of track that are nevertheless configured in routes. It will then be essential that the rail traffic controllers are equipped with systems capable of generating a reliable automatic message for the rail traffic manager to inform them that a train has passed a signal set at danger.	
Response(s)	Work on the 'train has passed a signal set at danger' functionality is in progress.
Lesson(s) from Barendrecht	No great reticence is exercised in configuring routes with signals set at danger and there is no system for the generation of a message in the event that a train passes a signal set at danger.

Apeldoorn, 30 April 2003
Goods train derailment near Apeldoorn, 30 April 2003, Dutch Safety Board, 8 March 2005

<table>
<tr><td colspan="2">Recommendation 1: Railion Nederland N.V. is recommended to improve its safety management system such that the risks of travelling with goods trains are sufficiently recognised and reduced as far as reasonably possible. Under all circumstances, the Board considers at least the following: (a) providing a facility which monitors the maximum train speed when the driver fails in this task, as long as a future safety system (such as for example ATB New Generation) does not provide this facility; and (b) supervising the driving behaviour of drivers in practice (including control of maximum speed) for example through the preventive reading out of the journey registration system in locomotives, and by frequently supervising and assessing drivers, given the possibility of human failure as a result for example of microsleep.</td></tr>
<tr><td>Response(s)</td><td>Railion notes that the report devotes insufficient attention to: the poor quality of the infrastructure, the playing down of Railion's RI&Es that have received formal approval, NSR's scheduling of the routes and their configuration by rail traffic management. Railion also states that safety management must be based on the pl an-do-check-act cycle of improvement, as is the case at Railion as demonstrated by the company's certification from the Inspectorate for Transport, Public Works and Water Management, ISO-9001 and approval by working conditions bodies.
Re. 1a, Railion states that the implementation of a technical facility to monitor train speeds is not feasible from a commercial perspective, as a result of which Railion will not adopt this recommendation.
Re. 1b, Railion states that trip registrations are read out on a random basis, the employees have been notified of an explicit sanctions policy, management has intensified its supervision, a vigilance test for drivers has been introduced and the ATB++ functionality shall be implemented.</td></tr>
<tr><td>Lesson(s) from Barendrecht</td><td>The analyses of trip registrations should be expanded to encompass interventions by the dead man's system.</td></tr>
<tr><td colspan="2">Recommendation 4: The Inspectorate for Transport and Water Management is recommended to increase the supervision of goods transport. Under all circumstances, the Board considers at least the following: (a) in issuing a safety certificate, to ensure the completeness and accuracy of the risk assessment and evaluation of the primary process (the driving of goods trains by drivers) including the accompanying action plan; and (b) drawing up a structural inspection programme in respect of maximum speeds of goods trains of all operators.</td></tr>
<tr><td>Response(s)</td><td>The essence of the Inspectorate for Transport and Water Management's response is as follows: The railway company bears the primary responsibility for the completeness and correctness of the risk inventory and evaluation. (...) The Inspectorate assesses whether an inventory and evaluation have been made of the most important safety-critical activities in the railway company's risk inventory and evaluation and whether suitable measures have been implemented.</td></tr>
<tr><td>Lesson(s) from Barendrecht</td><td>Irrespective of whether 'The Inspectorate assesses whether an inventory and evaluation have been made of the most important safety-critical activities in the railway company's risk inventory and evaluation and whether suitable measures have been implemented', the Supervisory Board observes that additional suitable measures could have been implemented.</td></tr>
</table>

Amsterdam, 21 May 2004
Passing a red sign at Amsterdam Central Station, Dutch Safety Board, 5 July 2005

Recommendation 1: The Minister of Transport, Public Works and Water Management, ProRail, the operators and the Inspectorate for Transport and Water Management are recommended to supervise implementation of the SPAD reduction plan, of the SPAD working group, by critically monitoring and evaluating the progress and results, and working on a renewed European ATB system for the long term, whereby the speed of trains is continuously and automatically controlled.	
Response(s)	• Minister of Transport, Public Works and Water Management: The Ministry of Transport, Public Works and Water Management monitors the work of both the steering group and working group critically, whereby the Ministry urges transparency and clarity: in informing the States-General at regular intervals the parties involved are compelled to formulate clear targets, draw up schedules, provide an insight into the specified measures and implement those measures. It can be observed that work in the preparations for the implementation of measures at 1000 locations is in progress. Work is being carried out on a new European protection system (ETCS) at European level. Members of staff from both the Ministry of Transport, Public Works and Water Management and ProRail take part in the relevant working groups. The Ministry of Transport, Public Works and Water Management's role in the realisation of ETCS in the Netherlands is explained further in the response to recommendation 2. • ProRail: ProRail takes part in both the SPAD working group and SPAD steering group. Work is currently in progress on the detailing and implementation of the improvement measures laid down in the adopted plan of approach. In addition, ProRail wishes to draw attention to the fact that ERTMS/ETCS has been installed in three major construction projects (the HSL-Zuid high-speed railway line, Betuweroute goods railway line and the new four-track Amsterdam-Utrecht railway link). • Railion: Railion was actively involved in the formulation of the SPAD reduction plan: the company's management cycle provides assurances for the monitoring of the progress in implementation. Railion also states that the company is currently at work on the conversion of locomotives to ETCS ready for their future deployment on the Betuweroute goods railway line. • NS Reizigers (NSR): NSR is a standing member of the SPAD steering group and is closely involved in all four projects falling within the scope of the SPAD reduction plan. For example, within the scope of what is referred to as the 'train driver programme' NSR has implemented measures such as the development and introduction of the vigilance test, the formulation and distribution of the 'Grip op alertheid' ('Grip on alertness') programme and the development and introduction of guidelines for the structural and uniform settlement of SPADs. In addition, NSR organised a train drivers' conference at the 2006: work is currently in progress on the three most promising suggestions for improvement (including a digital discussion platform) proposed during the conference. NSR has also taken active part in the yard analyses and configuration instructions by submitting users' experiences and recommendations. With respect to the second section of the recommendation NSR has stated that the company actively monitors national and international developments in ERTMS, has anticipated these in the various working groups and has participated in the formulation of the ETCS implementation plan.
Lesson(s) from Barendrecht	• The Ministry of Transport, Public Works and Water Management monitors the work of the SPAD steering group. However, the implementation of the SPAD reduction plan is taking longer than had been foreseen and the plan's targets have not been achieved to date.

<table>
<tr><td></td><td>• ProRail takes part in the SPAD steering group, but the plan’s targets have not been achieved to date. Although, as ProRail states, specific plans have been adopted for the introduction of ERTMS within the context of the aforementioned construction projects this is not the case for the entire railway network.
• Railion (now DB Schenker) takes part in the SPAD steering group, but the plan’s targets have not been achieved to date. Railion states that it will install ERTMS/ETCS in the rolling stock to be deployed on the Betuweroute goods railway. However, the plans for the existing network are not clear.
• NS Reizigers takes part in the SPAD steering group, but the plan’s targets have not been achieved to date. NS Reizigers’ efforts with respect to the introduction of ERTMS have not yet resulted in a specific introduction plan.</td></tr>
<tr><td colspan="2">Recommendation 2: The Minister of Transport, Public Works and Water Management is recommended, to that end, to draw up a concrete plan in which a timetable is included, which lays down the implementation of the continuous automatic speed control.</td></tr>
<tr><td>Response(s)</td><td>The policy line for the introduction of the new protection systems is specified in the ‘Veiligheid op de rails’ (‘Safety on the rails’) framework document (08-11-2004). This can be summarised as follows:
• The risk points in the infrastructure shall be modified with respect to the established shortcomings of the current system (ATB-EG).
• The current system (ATB-EG) will not be replaced by ATB-NG. The new railway lines (such as the HSL-Zuid high-speed and Betuweroute goods railway lines) shall be equipped with ERTMS. The Amsterdam-Utrecht railway line shall be equipped with ERTMS alongside the current systems.
• The migration from the current systems to ERTMS solely on the basis of safety considerations would not appear to be efficient at present. For this reason the migration from the current systems to ETCS shall primarily be based on reasons of capacity management, interoperability, the controllability of and provision of information about train services, the replacement of existing systems, speeds in excess of 160 km/hour and the introduction of European state-of-the-art systems. In addition, the migration will depend on the availability of authorised equipment and the availability of the necessary funds. The European Commission will probably adopt what is referred to as the ‘Technical Specification for Interoperability (TSI) for ‘control-command and signalling’ (which encompasses ETCS) at the end of 2005. Within this context the member states (including the Netherlands) will be under the obligation to draw up an implementation plan for ETCS (probably at the end of 2006). In so doing, the recommendation will be adopted.</td></tr>
<tr><td>Lesson(s) from Barendrecht</td><td>The risk points of the infrastructure have indeed been and are being modified by means of the installation of ATB-VV. Although specific plans have been adopted for the introduction of ERTMS within the context of the aforementioned construction projects, this is not the case for the entire railway network. No specific information has been given other than the specific safety arguments for the introduction of ERTMS that were deemed to be necessary by the Ministry. The estimates are largely based on overall figures, not on specific solutions for specific bottlenecks.</td></tr>
</table>

Recommendation 3: ProRail and the operators are recommended to take up and put into practice their own responsibility for safety by demonstrating that they operate as safety as possible (ALARP) within the possible safety limitations of the railway system (ATB, visibility of signals, rail characteristics, etc.). However, they should nonetheless work progressively and creatively on solving these problems. In this respect, they should not in advance exclude drastic measures (e.g. reducing train frequencies), and communicating clearly on these matters with the Ministry of Transport, Public Works and Water Management, as the body responsible for the system.	
Response(s)	• ProRail: The Inspectorate for Transport, Public Works and Water Management completed the assessment of the safety management systems (SMSs) of ProRail’s Infra-management, Infra-projects and Railway development business units in mid-2006. The Inspectorate for Transport, Public Works and Water Management came to the conclusion that the SMSs of the relevant business units comply with the requirements laid down in the Railway Safety Directive 2004/49/EC and are operational. The SMSs of ProRail’s other business units shall be completed at the end of 2006 and the SMSs of the entire company shall then be reviewed. ProRail has also stated that the company has drawn up a safety agenda with four spearheads. In addition, ProRail has stated that the company is actively involved in the detailing of the SPAD steering group’s plan of approach. Some of the planned measures have been implemented, whereby ProRail was involved in the yard analysis and the subsequent decision-making on the modifications, the selection of the ATB++ system and the resolution of high-risk signals. The other measures are currently being implemented, whereby ProRail is involved in the improvement of the visibility of specific high-risk signals, the development and implementation of the ATB++ equipment and the development of a software package for the simulation and evaluation of SPADs. ProRail is also taking part in the detailing of the recommendations listed in the Inspectorate for Transport, Public Works and Water Management’s report on the analysis of SPADs in the period from 2001 to 2005: ProRail’s contribution is largely comprised of an examination of the potential consequences the possible termination of the configuration of sub-routes could have for the capacity of the network. • Railion: Railion’s safety policy is based on the ALARP principle. The company’s coherent system for supervision, audits and the provision of information has ensured that the policy is implemented in practice. Railion has also stated that the company assumes that the recommendation for any necessary reduction of train frequencies relates to the Inspectorate for Transport, Public Works and Water Management, the body that in extreme situations can instruct ProRail to declare a block of track ‘overloaded’ for safety reasons. Railion also expressed the hope/expectation that in 2007 the Inspectorate for Transport, Public Works and Water Management will follow up the observations in the organisation’s SPAD analysis in the period from 2001 to 2005 that was published at the end of 2006. Within this context Railion refers, in particular, to the possible correlation between the relatively high number of SPADs by goods train and the possibility that goods trains are relatively frequently confronted with dwarf signals (set at danger). • NSR: The Inspectorate for Transport, Public Works and Water Management assessed NSR’s SMS in 2006. Following this assessment NSR’s safety certificate was renewed for the maximum period of three years. NSR wishes to draw attention to the fact that this implies that NSR has implemented safe procedures and works in a safe manner, and continually endeavours to make improvements. NSR also wishes to point out that a variety of measures have been and are being implemented within the context of the SPAD reduction plan, measures which relate to technical issues, the management of the transport process and improvements in human conduct: the company cannot preclude the implementation of drastic measures in the future.

<table>
<tr><td>Lesson(s) from Barendrecht</td><td>

- ProRail: All the reasonable measures that are available have not been utilised. ProRail takes part in the SPAD steering group, but the plan's targets have not been achieved to date.
- Railion: Railion's response states that Railion's safety policy is based on the ALARP principle. However, the investigation has revealed that DB Schenker (formerly Railion) does not control the SPAD issue in accordance with the ALARP principle since not all the reasonable measures that are available have been utilised.
- NSR takes part in the SPAD steering group, but the plan's targets have not been achieved to date. The Dutch Safety Board has not investigated the extent to which NSR's proportional share of the targets have been achieved.

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Recommendation 4: The Minister of Transport, Public Works and Water Management is recommended to improve the effectiveness of guidance and inspection of ProRail and the operators, under all circumstances by:

- formulating clear, company-specific safety targets (for example concrete reduction in number of SPADs), which are 'compulsory' for the parties involved.
- explicitly basing the concessions, safety certificates and supervision on the assessment of the quality of application in daily practice of the safety management system of the parties involved.
- undertaking an evaluation of the degree to which the safety certificate has contributed to the quality of the safety management and safety culture of the operators.

</td></tr>
<tr><td>Response(s)</td><td>

- The Minister's duty is to impose safety targets on the sector on the basis of targets such as the maximum risks confronting passengers and employees The railway companies are required to implement the necessary measures, whereby the implementation of these measures must be assured by their safety management systems (SMSs). The obligation to implement an SMS was imposed on the railway infrastructure manager (ProRail) only once the Railways Act came into force (at the beginning of 2005). ProRail has since submitted its first SMS for assessment. This SMS will be assessed in the second half of 2005. When this is complete the part of the recommendation under 1) will have been adopted.
- The part of the recommendation under 2) has already been adopted in the sense that the Inspectorate for Transport, Public Works and Water Management assesses the railway companies' safety assurance systems once every three years. This assessment also reviews whether the system has been implemented within the company and is effective. These assessments also extend to on-site inspections, accident investigations, trend analyses and information from third parties on their experiences.
- The Inspectorate for Transport, Public Works and Water Management will evaluate the feasibility of improvements in the assessment of safety certificates, whereby the Inspectorate will link up with the working groups of the European Railway Agency (ERA) that are engaged in the harmonisation of the assessment system on the basis of international experience with safety certificates.
- Pursuant to the transport concession granted to the company NS Dutch Railways is under the obligation to ensure, within certain limits, that the trains travel on time. The 'punctuality' performance indicator used for this purpose must include at least train arrival times: NS Dutch Railways is not under the obligation to control train departure times.

Although the recommendation is not addressed to ProRail, the company has nevertheless responded to the recommendation. In essence, the company's response states that ProRail is consulting with the carriers on the manner in which the punctuality of departures can be measured.

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Lesson(s) from Barendrecht	• The Minister and the railways sector have worked on the formulation of specific targets which have not been achieved and are not based on the ALARP principles. • The Inspectorate for Transport, Public Works and Water Management's approach to the SPAD issue is based on the substance of its inspections/audits carried out within the context of the concessions and the safety certificates rather than explicitly on the quality of the implementation of the SMS in everyday practice.

ANNEX 6: THE SPAD PROBLEM IN THE NETHERLANDS

This Annex reviews the policy the Netherlands has conducted in the past decades for the control of the SPAD issue.

Development and introduction of ATB-EG
During the period from 1960 to 1995 NS Dutch Railways was a state-controlled company in which all the operations were aggregated under the responsibility of the managing director. The operational process, the train movements, was assigned to the operations department, the rolling stock to the rolling stock and workshops department and the infrastructure to the infrastructure department.

During the first half of the twentieth century little work was carried out on the introduction of an ATP system on the Netherlands' railway network of the time. However, various other countries had begun work on the introduction of a system of this nature and Germany, Switzerland, the UK, France and the USA, in particular, all installed different ATP systems in their networks. NS Dutch Railways did carry out exploratory studies in the nineteen-fifties, primarily focused on the feasibility of using the US system (manufactured by GRS) in the Netherlands and in part based on the wish to display signal aspects in the train drivers' cabins.

An extremely serious head-on collision between two passenger trains occurred in Harmelen in 1962, which caused 93 fatalities and dozens of seriously injured. The direct cause of the accident was one of the train driver's failure to see a signal set at caution, probably due to the fog. The driver began to brake only once the train reached the signal set at danger where the train should have stopped. As a result, the train was travelling at high speed (more than 100 km/hour) when it entered a block of track released for a passenger train which was approaching from the opposite direction.

The extremely serious train accident at Harmelen was investigated by the Railway Accident Board. The investigation focused on the feasibility of preventing collisions of this nature. The Railway Accident Board's most important recommendation was that work should begin on the introduction of an ATP system before 1 January 1964. The Railway Accident Board also issued a number of points for attention relating to the advantages and disadvantages of the ATP systems available at the time, but did not express a preference.

NS Dutch Railways' Management Board was an advocate of the US GRS system and stated that it expected that the entire network would be equipped with a system of this nature by 1975. The Ministry of Transport, Public Works and Water Management was of the opinion that this expectation was not realistic. The Ministry was of the opinion, justifiably in retrospect, that the modification and introduction of the US system would take at least 25 years. This was in part the reason why the Ministry advocated a German system which it expected could be introduced more rapidly. The Ministry ultimately reached a decision on this issue in 1963, when it decided that NS Dutch Railways would be instructed to develop and install an ATP system based on the US GRS system. The target was formulated as follows: Ensure that all sections of track with a permitted speed in excess of 100 km/hour and the trains that use those tracks are equipped with ATP before 1972 (i.e. within the next 10 years).

The system was originally referred to as ATP, subsequently changed to ATB-EG when work began on a revised version of the system in the nineteen-eighties. The construction and implementation took much more time than scheduled on the basis of the commitment made by NS Dutch Railways. The 1963 target was achieved only in around 1995 (i.e. after 30 years rather than the original 10 years). This delay was due, in addition to issues such as technical setbacks and a lack of schooled staff, to the following two factors:

- It was originally decided to install the equipment solely in the then relatively new rolling stock rather than in all rolling stock. As a result, in view of the extended service life of some types

of rolling stock (about 40 years), all types of trains were equipped with ATB-EG only during the course of the nineteen-nineties;[130]
- It was decided that the infrastructure would be equipped with ATP when sections of track underwent major overhauls or reconstruction work. In a number instances this also involved the replacement of traditional protection systems by relay protection systems. Since this cycle also has a duration of 40 years the last sections of track were equipped with ATB-EG only in the first half of the nineteen-nineties.

Within this context it is important to note that the system selected at the time (ATB-EG) has the two following functional limitations:
- The system is not aware of the position of a signal set at danger and limits solely the speed at which the train approaches the signal to 40 km/hour;
- The braking force[131] is not monitored.

It is important to note that the installation of ATB-EG on the infrastructure did not extend to the 40 km/hour zones of the yards, a carefully-considered decision at the time of the selection of the system in 1963, since the risk of SPADs involving trains travelling slower that 40 km/hour was regarded as low with the then operations and a complicated ATP system at that time would have imposed too many limitations on the many shunting movements carried out in the yards in those years.

Development and (limited) introduction of ATB-NG and ERTMS/ETCS
NS Dutch Railways began work on the development of a second generation ATP in the mid-nineteen-eighties, a decision made for a number of reasons, namely:
- The wish for higher train speeds and the improved control of train movements;
- The existing system (ATB-EG) was at threat of becoming technically obsolescent and was due for replacement;
- The earlier standpoint that the ATP system did not need to operate at speeds of below 40 km/hour was revised following a number of accidents. For these reasons there was a need to eliminate the functional limitations of ATB-EG (no functionality below 40 km/hours and no braking force monitoring);
- There was a wish to introduce lighter rolling stock (light rail transit). Another ATP system would be required for the regional railway lines where the light rail services would operate in view of the different wheel-rail contact with trains of this type.

The development, testing and approval of this system, called ATB-NG, took about ten years. The system was released for use in 1997. The original intention was to install ATB-NG on the branch lines, which had not been equipped with ATB-EG, and as the replacement for the ATB-EG installed on the main railway lines. However, this latter did not ultimately take place due to a number of developments that can be summarised as follows:
- The government was working on the Fourth Policy Document on Spatial Planning in the second half of the nineteen-eighties, and within this context NS Dutch Railways published its 'Rail 21' document in 1988. This proposed that the railway capacity be doubled and the train services revised to make them more compatible with the public's need for public transport. The Ministry of Transport, Public Works and Water Management adopted NS Dutch Railways plan in full. The House of Representatives of the States-General approved the plan at the end of the nineteen-eighties and the necessary financing (approximately 250 million euros) was made available (as part of the 'Key National Spatial Planning Decision - PKB Part E'). These documents did not refer explicitly to the selection of the ATP system, although NS Dutch Railways assumed that ATB-NG (then in the development phase) would become the new standard;
- The European Union issued a Directive in 1991 which stipulated that all member states were to introduce a segregation between the management of the railway infrastructure and the operation of the train services on that infrastructure and, in addition, the state-controlled railway companies that had operated the services until then were to be privatised. This was based on the reasoning that these measures would, in analogy with road traffic and inland

130 With the exception of a number of trains used to carry out work on the railways and historic rolling stock.
131 The degree to which the driver applies the brakes. ATB-EG is 'satisfied' when the brakes are applied, irrespective of whether the braking action will be sufficient to bring the train to a standstill in time.

navigation, promote competition and, as a result, increase efficiency. Within this context it was decided that the various national ATP systems would be replaced by one new system to be developed at a European level, what was referred to as the 'ERTMS/ETCS' system;
- A collision between two passenger trains occurred at the Eindhoven yard in 1992, which caused 48 injuries and would, in slightly different circumstances, certainly have caused a number of fatalities. The Railway Accident Board investigated this accident and concluded that the accident could have been avoided if an ATP system had been installed which did not suffer from ATB-EG's functional limitations. During the Railway Accident Board's hearings NS Dutch Railways' Management Board stated that the development work on ATB-NG was almost complete and that the Board intended to equip the entire main railway network with the system. According to this schedule the work would be completed in the period between 2017 and 2027, whilst completion in 2005 was considered feasible if the work was carried out at an accelerated pace. The most important recommendation in the Railway Accident Board's report, published in 1993, was that the entire railway network should be equipped with second generation ATP as soon as possible. Within this context the Railway Accident Board, in line with the statement made by NS Dutch Railways' Management Board, envisaged completion in 2005;
- In the summer of 1993, NS Dutch Railways began work on what was referred to as the 'Diana project' with the objective of determining the strategy for the required expansion and modernisation of the ATP system (with a timeframe extending to 2010). In the autumn of 1993, NS Dutch Railways' Management Board decided to temporise the planned national introduction of ATB-NG, in part in view of the pending European standardisation (ERTMS/ETCS). This decision encompassed the following three elements:
  - The blocks of track that were not equipped with ATP at the time (the branch lines) would be equipped with ATB-NG and the trains using those tracks would also be equipped with ATB-NG;
  - The new railway lines to be constructed (the HSL-Zuid high-speed and Betuweroute goods railway lines) would be equipped with ATB-NG or ERTMS/ETCS, whereby NS Dutch Railways assumed at the time that ATB-NG would be compatible with ERTMS/ETCS, an assumption that later proved to be incorrect;
  - An ATP system would now be installed in the yards. On the replacement or renovation of blocks of track and trains equipped with ATB-EG then the tracks and trains would be re-equipped with ATB-EG.
- In the autumn of 1993, the Minister of Transport, Public Works and Water Management decided to explore the developments in ERTMS/ETCS before adopting a definitive standpoint on the Railway Accident Board's recommendations and NS Dutch Railway's (revised) plans;
- In the spring of 1996, the Minister of Transport, Public Works and Water Management stated in a written answer to questions from the House of Representatives of the States-General that ATB-EG would not be replaced by the ATB-NG system that was now available, but would be replaced in the longer term by ERTMS/ETCS that was then in the development phase. The Minister also stated that ATB-NG would be installed solely on branch lines that had not previously been equipped with ATB-EG.

The branch lines and the associated trains were equipped with ATB-NG in the period between 1996 and 2005. In addition, the Gouda – Alphen aan den Rijn track was equipped with ATB-NG in preparation for a trial with light-rail trains and components from the ATB-NG were used on the ATB-EG Den Haag Mariahoeve – Hoofddorp track so that trains could travel at speeds of 160 km/hour (ATB-M+).

In this same period two newly-constructed railway lines, the Betuweroute goods and HSL-Zuid high-speed railway lines, were the first Dutch railway lines to be equipped with the new ERTMS system. The commissioning of the two systems was preceded by a very lengthy and extensive test and approval programme.

Increase in SPADs and the 'SPAD working group'
In the second half of the nineteen-nineties the number of SPADs increased from approximately 150 to approximately 250 per annum. In addition, accidents related to SPADs continued to occur (2-4 per annum). For this reason, in the period between 2001 and 2003 the sector began consultations and studies in preparation for the implementation of supplementary measures. These preparations were coordinated by the SPAD reduction working group, a consultative body in which

representatives from NS Dutch Railways and ProRail took part. The activities of this working group were continued by the 'SPAD steering group'.

SPAD reduction plan

A head-on collision occurred on the Amsterdam Central Station yard on 21 May 2004 which caused 19 injuries. The accident resulted in a great deal of commotion in the media and the political arena. In the months after the accident the aforementioned 'SPAD working group' carried out an inventory of potential measures for the control of the SPAD issue. This inventory served as the basis for what is referred to as the 'SPAD reduction plan', comprised of four categories of measures relating to:

1. The train driver's vigilance (the train driver programme);
2. The visibility/recognisability of signals in the yards (yard analysis);
3. A number of rail traffic management issues (configuration instructions for approximately 25 signals involving a repeated SPAD);
4. The development of a new ATP system (the later ATB-VV) for approximately 1,000 signals in yards.

It was estimated that the SPAD reduction plan would result in a 50% reduction of the number of SPADs and a 75% reduction of the associated risk. The Minister of Transport, Public Works and Water Management adopted the SPAD reduction plan, including the targets and a budget of approximately 45 million euros, at the end of 2004. At the same time the 'SPAD working group' was upgraded on the formal institution of the 'SPAD steering group', which was assigned the task of implementing the reduction plan within a period of five years (achievement of the reduction targets in 2009).

The SPAD steering group is a collaborative arrangement in which representatives from ProRail, all railway companies and railway contractors take part. The meetings are also attended by representatives from the Ministry of Transport, Public Works and Water Management and the Inspectorate for Public Works and Water Management (as observers). The steering group is supported by a programme bureau which is comprised of a programme manager and three programme assistants, all employed by ProRail. The steering group is the decision-making body: the programme bureau provides support and coordinates the work, whilst the studies/activities are carried out by the organisations participating in the steering group or are outsourced to third parties.

Three of the four measures (the train driver programme, analysis of the yards and configuration instructions) were implemented in the period from 2005 to 2007 inclusive. The implementation of the fourth measure (the development and introduction of ATB-VV for approximately 1,000 signals in yards) would take more time. The Ministry of Transport, Public Works and Water Management was of the opinion that ATB-VV could be introduced in the rolling stock more rapidly than ERTMS. This was one of the reasons for the selection of ATB-VV. Pursuant to the original schedule the installation of ATB-VV would be completed at the end of 2008. However, this deadline was not met.

During the course of the project studies carried out by the Inspectorate for Transport, Public Works and Water Management revealed that the effect of the measures to be implemented would probably be less than had originally been expected. As a result, the 'SPAD steering group' expanded the package of measures to include the following actions:

1. The number of signals equipped with ATB-VV was increased from 1,000 to about 1,260;
2. A further investigation of signals involving a repeated SPAD would be carried out;
3. A further investigation of SPADs by departing trains would be carried out;
4. A further investigation of SPADs by rolling stock would be carried out (rolling stock in which the handbrake had not been applied);
5. A further investigation of the relatively large number of SPADs by shunting trains would be carried out;
6. A further investigation of the relatively large number of SPADs by goods trains would be carried out.

Supplementary measures following the accident at Barendrecht

Following the accident at Barendrecht the Minister of Transport, Public Works and Water Management requested an independent study to determine the total number of extra signals and the specific signals that would need to be equipped with ATB-VV to achieve the reduction targets for the SPAD issue. The remit for the study also extended to a comparative study of the SPAD control measures implemented by the countries surrounding the Netherlands and a review of potential alternatives for the cancel function that had been decommissioned in the nineteen-nineties.[132] The study was carried out by Oranjewoud/Save and the report was published in May 2010.

The remit for the study encompassed the following three elements:
- the performance of an international benchmark study of measures for the control of the SPAD issue;
- a study of the number and selection of the signals to be equipped with ATB-VV required for the achievement of the reduction targets; and
- A study of measures to increase train-driver alertness in 40 km/hour zones (as an alternative for the decommissioned cancel function).

The study yielded the following findings:
- Benchmark study of reduction measures
  - The number of SPADs per train or passenger kilometre is higher in the Netherlands than in the UK and Germany.
  - The number of accidents/fatalities per train kilometre is lower in the Netherlands than in Germany but higher than in the UK.
  - All signals in the UK are equipped with (the UK version of) ATB-VV.
  - Alongside the Netherlands, solely the UK has formulated a specific policy (with targets) for the control of the SPAD issue.
- Number of/selection of signals to be equipped with ATB-VV
  - It was expected that equipping the 1,264 signals currently selected would not achieve the plan's targets (50% reduction of the number of SPADs and the 75% reduction of the SPAD risk). It was estimated, on the basis of a 'substantiated estimate', that an additional approximately 640 signals would need to be equipped with ATB-VV to achieve the plan's target for the reduction of the number of SPADs and that an additional approximately 1,040 signals would need to be equipped with ATB-VV to achieve the plan's target for the reduction of the risk.
  - Oranjewoud/Save recommended that the selection of these additional signals should in any case include the approximately 350 signals along the most important routes for the transport of hazardous materials (the basic hazardous materials railway network). In addition, the report recommended waiting for the developments in the SPAD issue in 2010 and then using this information to determine the total number of extra signals and the specific signals that would need to be equipped with ATB-VV to achieve the reduction targets.
- Alternatives for the cancel function
  - Oranjewoud/Save expected little effect from the possible reintroduction of the original cancel function.
  - However, Oranjewoud/Save did expect a material effect from the introduction of a special attention signal in the cabin in 40 km/hour zones (i.e. in yards) and from warnings in specific situations (such as a specific warning signal in the cabin when the train approaches a signal set at danger).

The Minister of Transport, Public Works and Water Management has stated that the results from the Oranjewoud/Save study have given cause to his decision to implement the following measures:
- The railway sector will be requested to study the feasibility of introducing longer overshoot distances for new signals.
- An additional 350 signals will be equipped with ATB-VV within the context of the basic hazardous materials railway network;
- The effectiveness of ATB-VV will be evaluated in 2011 and the results from this evaluation will be used to determine the number of additional signals and which additional signals shall also be equipped with ATB-VV;

132 When trains are travelling in a 40 km/hour zone with the brakes released the drivers must indicate their alertness to the ATP system by pressing a button once every 20 seconds to override (cancel) a buzzer. The cancel function was removed from virtually all rolling stock at the end of the nineteen-nineties.

- The railway sector will be requested to study the feasibility of increasing the effectiveness of ATB-VV by the modification of what is referred to as the 'braking criterion'.[133]
- The railway companies will be requested to give the Minister of Transport, Public Works and Water Management information about the feasibility of implementing alternatives for the cancel function.

133 The design of ATB-VV assumes that the speed of a train approaching a signal set at danger will not be (very much) more than 40 km/hour: ATB-VV does not guarantee that trains travelling at higher speeds will be brought to a standstill before the signal set at danger. 'Modification of the braking criterion' refers to the configuration of ATB-EG such that an automatic braking action is also initiated in the event that the driver applies only a low braking force after passing a signal set at caution. This modification increases the probability that the train's speed when it approaches the signal set at danger will not be (very much) higher than 40 km/hour and that the ATB-VV system will be able to bring the train to a standstill before the signal set at danger.

ANNEX 7: DEVELOPMENT OF ERTMS

Introduction
ERTMS[134] is a train protection system developed at a European level[135] that uses a cabin display to provide the driver detailed information about the configured route. As a result, ERTMS obviates the need for signals along the track. In addition, ERTMS is an automatic train protection system that monitors the driver's compliance with the signalled commands. The system makes use of full braking curve monitoring[136] that is configured for the specific train's braking power. As a result, ERTMS does not suffer from the design limitations of the existing signalling and ATP systems.

ERTMS is a protection system based on software and, in analogy with computer programs, is regularly updated with new versions that expand the functionality. Consequently, ERTMS is never 'finished'. New versions are formally adopted by the European Railway Agency (ERA). The current version is 2.3.0d; new functions have since been adopted for inclusion in a new version, 3.0.0, that will be tested from the end of 2012. The industry will then be able to develop systems that comply with the new specifications.

The introduction of ERTMS is mandatory for new railway lines and must be introduced on a number of existing railway lines in the trans-European corridors of importance to freight transport by 2015 to 2020. All European member states also submitted an ERTMS Implementation Plan to the European Commission in 2007.

Introduction of ERTMS in the Netherlands
Following a study of the introduction of ERTMS in the Netherlands the Dutch Safety Board has concluded that although ERTMS is indeed in a technical condition that will enable the system to make a contribution to the resolution of the SPAD issue, it is still insufficiently clear how and when the system can be introduced in the Netherlands. In view of the current policy the system cannot be expected to achieve a large-scale reduction SPAD issue in the years until 2025. The Dutch Safety Board bases this conclusion on the following observations.

It is not clear how ERTMS will make a contribution to the improvement of the performance of the railway system, whilst this knowledge is necessary. During the period between 1999 and 2006 the Ministry of Transport, Public Works and Water Management has, in the First Railway Safety Framework Document and its response to the various reports of investigations carried out by the (legal predecessors of) the Dutch Safety Board, repeatedly stated that the replacement of ATB-EG by other systems shall not be based solely on improvements in railway safety but shall also be based on capacity management, interoperability, the controllability of the train services and information about the performance of the services. For this reason the implementation studies should be based on an analysis of the improvements that are feasible with ERTMS and which cannot be achieved with the existing systems. In view of the high cost of the system the benefits shall need to be sought in areas other solely than improvements in safety. A study that began in 1998[137] designed to map the improvements of this nature in the performance of the existing network was terminated in 2002 on the request of the Ministry of Transport, Public Works and Water Management for the benefit of the introduction of ERTMS on the Betuweroute goods railway line and the reconstructed Amsterdam - Utrecht railway line. In January 2010, ProRail completed a study that identified (some of) the capacity gains of this nature.

134 ERTMS is the abbreviation of 'European Rail Traffic Management System'.
135 The development began in two parallel projects carried out by the EU and the European national railway companies. These two projects were subsequently merged and expanded to include the signalling industry.
136 Braking curve monitoring refers to the continual monitoring of a moving train's ability to reduce speed in time for a signal set at danger or other speed restriction.
137 This refers to project BB21; the element of the project that was terminated related to the development of ERTMS for the existing railway network.

Three other implementation studies have been carried out in the intervening period:[138]

- A study carried out by ProRail in 2003;
- An ERTMS implementation plan drawn up by ProRail and NS Dutch Railways in 2006, to comply with the requirement that all members states were to submit this plan to the European Commission in 2007;
- A social cost-benefit analysis carried out by Decisio in 2009 on the request of the Minister of Transport, Public Works and Water Management.

However, these studies focused on the replacement period for existing systems and the question as to whether the implementation of ERTMS should begin with the infrastructure or with the rolling stock, and devoted less attention to the saving potential offered by ERTMS in comparison with the existing technologies. Although it has been known since 1999 that performance improvements are of essential importance to the introduction of ERTMS, the question as to how the system can make a contribution to these performance improvements has been addressed to only a limited extent and at an abstract level. All three studies concluded that the costs incurred by and benefits offered by ERTMS are still uncertain.

It is not yet clear how ERTMS needs to be financed. The amount of the costs and benefits are not only qualified as uncertain by these studies: this is also apparent from correspondence[139] between the railway companies and the Ministry of Transport, Public Works and Water Management and the interviews which the Board has conducted with the parties involved have revealed that the costs and benefits are not distributed evenly between the parties. Savings for one party are, for example, feasible when another party makes investments. The carriers and ProRail have reached agreement on a joint implementation plan that cannot be financed by these parties. They urge the Ministry to provide for the rapid initiation of the work in the introduction of the system, whereby the Ministry will need to bear (a large) part (of) the costs. The Ministry is prepared to do so only in the event of an evident social interest.

To break this impasse the railway companies submitted a proposal to the Minister in April 2010 relating to the appointment of a director for the introduction of ERTMS and the formation of a joint ERTMS Centre of Expertise.

It is not yet clear precisely where ERTMS will be introduced. The aforementioned implementation studies refer solely to the main railway network and not to the regional railway lines. It is also unclear whether ERTMS can be implemented rapidly on existing yards, whilst these are the very sections of the railway network where the risk of SPADs is greatest. The railway lines that have been or are currently being equipped with ERTMS all terminate just outside the major nodes (the HSL-Zuid high-speed railway line, the Betuweroute goods railway line, the Havenspoorlijn goods railway line, the Amsterdam – Utrecht railway line and the Hanzelijn railway line). Although the installation of the system is technically feasible at the nodes, this often requires the replacement of the stations' protection systems. This replacement is expensive. When the Havenspoorlijn goods railway line was equipped with ERTMS this did not extend to the yards, a decision made to reduce the complexity of the system. As a result, although the railway line has been equipped with ERTMS the yards suffer from the same 'gap' previously left on the installation of ATB-EG.

Nor is it clear when ERTMS will actually be introduced: the Ministry of Transport, Public Works and Water Management maintains uncertain course in this respect, whereby the Ministry argues that it is not desirable to equip all signals with ATB-VV since ERTMS will be installed within the next

138 ProRail, Beleidstransitie treinbeveiliging en –beheersing ('Train protection and control policy transition'), March 2003; ProRail, NS and BRG, Implementatiestrategie ERTMS. ('ERTMS implementation strategy') Onderbouwing van de strategische keuzes met businesscase ('Substantiation of the strategic choices with a business case'), 24 August 2006; Decisio and SYSTRA S.A., Social Cost Benefit Analysis of implementation strategies for ERTMS in the Netherlands, 8 January 2010.

139 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 21 September 2007; Letter from NS Dutch Railways, ProRail and BRG to the Minister of Transport, Public Works and Water Management, 19 June 2008; Letter from NS Dutch Railways, ProRail and BRG to the Minister of Transport, Public Works and Water Management, 9 April 2010.

approximately eight to ten years[140] but also adopts a 'wait-and-see' position with respect to ERTMS since the Ministry presumes that the Netherlands is in the vanguard with the introduction of ERTMS and that moving too far in advance could give rise to excessive risks.[141] The Ministry is of the opinion that the current version of the ERTMS specifications (2.3.0d) are not sufficiently future-proof for introduction on the Dutch railway network. The Minister intends to wait until equipment with the functionality of version 3.0.0 becomes available, which is expected to be released in 2015.[142] In view of the adopted strategy to begin with the rolling stock and then proceed to the modernisation of the infrastructure it will not be possible to begin work on the infrastructure before 2018.[143] Experience acquired in the past[144] indicates that a rollout to large parts of the network requires a period of several decades and that the speed of the implementation is structurally underestimated. For this reason, in view of the current policy it is not realistic to expect that large parts of the railway network will be equipped with ERTMS before 2025.

Introduction of ERTMS outside the Netherlands

The Dutch Safety Board also carried out a brief study of the introduction of ERTMS outside the Netherlands on the basis of the implementation plans each member state submitted to the European Commission in 2007, and supplemented with some more recent information.

This revealed that many other countries have drawn up plans for the implementation of ERTMS that are more specific than those of the Netherlands. The Dutch Safety Board found the following issues striking:

- It is possible to prepare a specific plan for the implementation, whereby members states can adopt a dynamic approach or a more gradual approach. Some countries have decided to convert their entire network, such as Denmark (completion in 2021) and Luxembourg (completion in 2011). Austria, Italy and Switzerland have far-reaching and specific implementation plans for at least the most important sections of their networks. A number of large countries (Germany, France and the UK) have made a carefully-considered choice for slower implementation and solely the mandatory goods traffic corridors will be equipped with ERTMS within the short term. Germany and the UK combine the installation of ERTMS with the natural replacement of the existing protection systems.
- The commercial services of a number of countries use ERTMS: the commercial services in Spain, Switzerland and Luxembourg do so on a fairly large scale and are satisfied with the system's performance. A number of countries outside Europe use the system (such as China and India).
- Germany, Denmark, Switzerland and Italy are of the opinion that ERTMS version 3.0.0 is required for the suitable application of the system in their railway networks, although these countries are of the opinion that it is both feasible and necessary to begin work on the preparations now.

The Dutch Safety Board observes that the Netherlands is not in the vanguard with the introduction of ERTMS and that even if version 3.0.0 is deemed to be necessary it is still feasible to prepare a specific plan for the implementation of the system. The Dutch Safety Board concludes that ERTMS can offer an appropriate technical means of controlling SPADs, but that in the current approach the system will not be able to make a material contribution to the control of the SPAD issue before 2025.

140 Minutes of a General Meeting, Parliamentary Document number 29893-94.
141 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 21 September 2007, Ministry of Transport, Public Works and Water Management/DGP-2007/6541/Parliamentary Document number 29893-54.
142 Letter from the Minister of Transport, Public Works and Water Management to the House of Representatives of the States-General, 12 December 2008. The new functionality relates primarily to modifications of the ERTMS train equipment, such as the more accurate determination of the braking distance.
143 The modifications to version 3.0.0 relate to modifications in the equipment for the rolling stock, not the equipment for the infrastructure. Rolling stock equipped with version 3.0.0 is compatible with the infrastructure equipped with version 2.3.0d (Annex to Parliamentary Document number 29893-73, July 2008). Consequently, in principle the infrastructure could already be equipped with ERTMS version 2.3.0.
144 See Annex 6.

The following experiences with ERTMS outside the Netherlands are known:
- In Spain, approximately 10,00 km of high-speed railway lines is equipped with Level 1 and Level 2.[145] A number of suppliers were selected: the equipment from the various suppliers is suitably compatible. The users are satisfied with the system;
- In Switzerland, a number of new railway lines and 600 vehicles have been equipped with ERTMS Level 2. The experiences are favourable;
- In Austria, 800 km of track has been put out to tender for the installation of Level 1 (with some sections equipped with Level 2);
- ERTMS is also supplied to a number of countries outside Europe. The majority of these investments have been made in China, where about 1,000 km of track has been equipped with ETCS. Since harmonisation with neighbouring European countries is not then an issue it can be assumed that these countries have selected ETCS because it is the most suitable system for their applications;
- Germany, Denmark, Switzerland and Italy are of the opinion that ERTMS version 3.0.0 is required for the suitable application of the system in their railway networks, but that it is nevertheless necessary to begin work on the preparations.

In contrast to the Netherlands, a number of countries are apparently in a position to finance ERTMS or, when financing is not expedient in the short term, make a carefully-considered decision to implement the system at a slower pace:
- Rapid introduction:
  - In 1999, Luxembourg decided to equip the entire network with ERTMS Level 1: the work will be completed in 2011. 70% of the network is now equipped with the system and the users are satisfied with its performance;
  - In 2009, Denmark decided to equip the entire network with ETCS Level 2; the work will be completed in 2021.
- Gradual transition:
  - Belgium, Switzerland and Italy have decided on a gradual transition to ERTMS whereby in the first instance ERTMS components will be used to take over or supplement the functionality of the existing protection systems. This will avoid the destruction of capital;
  - Switzerland, Belgium and Germany plan to introduce ECTS Level 1 LS as an interim measure. This relates to ETCS Level 1 without cabin signalling, whereby the existing signals along the track are retained for the time being. Switzerland plans to complete the introduction in 2017.
- Slow introduction: (Germany, the UK and France have planned the introduction of ERTMS solely along the mandatory international corridors for the time being).
  - The reason for France’s decision is unknown. The majority of the equipment will be Level 1;
  - The UK has opted for Level 2 and plans to introduce the new system when the old system is to be replaced;
  - Germany has also opted for Level 2 in view of the capacity benefits. Level 1 LS can be installed as an interim measure. Where possible technical preparations will be made pending the arrival of ERTMS. Germany supports the development, but states that in view of the limited financing options and the size of the railway network the country is compelled to introduce ERTMS at a slow pace.

Other than Luxembourg no countries would appear to have introduced ERTMS in large existing stations.

145 The ETCS levels refer to the manner in which information about the block protection system’s configured route is transmitted to the train. Level 1 transmits this information using beacons in the track and Level 2 transmits this information by telephone over the GSM-R network.

ANNEX 8: TRAIN COLLISIONS RELATED TO SPADS

no.	year	date	location	accident			victims			rolling stock
				collision	derailment	other	slightly injured	severely injured	fatalities	
	2000	none								
1	2001	21-5-2001	Zwolle	x			7	1	-	p train* / g train**
2		8-6-2001	Amsterdam CS	x			-	-	-	g train / g train
3		13-6-2001	Utrecht CS	x			5	-	-	p train / p train
4		12-9-2001	Deventer		x		-	-	-	p train
5		27-11-2001	Amsterdam CS	x			-	-	-	p train / g train
6	2002	3-1-2002	Groningen	x			1	-	-	p train / p train
7		18-4-2002	Roermond		x		-	-	-	g train
8		26-6-2002	Amersfoort	x			1	-	-	p train / p train
9		16-9-2002	Rotterdam	x			-	-	-	p train / p train
10		10-10-2002	Utrecht	x			-	-	-	p train / g train
11	2003	20-3-2003	Roermond	x			30	17	1	p train / g train
12		17-6-2003	Utrecht	x			1	-	-	p train / shunting unit
13	2004	2-4-2004	Amersfoort	x			-	-	-	p train / shunting unit
14		21-5-2004	Amsterdam CS	x			13	6	-	p train / shunting unit
15		30-9-2004	Roosendaal	x			45	1	-	p train / locomotive
16	2005	11-2-2005	Rotterdam	x			-	-	-	p train / p train
17		25-11-2005	Lunetten	x			-	-	-	g train / g train

* passenger train
** goods train

no.	year	date	location	accident			victims			rolling stock
				collision	derailment	other	slightly injured	severely injured	fatalities	
18	2006	3-2-2006	Utrecht	x			-	-	-	carriage / p train
19		19-5-2006	Waalhaven	x			-	-	-	g train / g train
20		15-9-2006	Amersfoort	x			16	1	-	p train / locomotive
21		20-11-2006	Rotterdam CS	x			-	-	-	shunting unit / g train
22		21-11-2006	Arnhem	x			58	3	-	p train / g train
23		21-12-2006	Maasvlakte	x			-	-	-	shunting unit / g train
24	2007	12-3-2007	Amsterdam-Muiderpoort	x			1	-	-	p train / p train
25		16-6-2007	Weesp	x			-	-	-	p train / p train
26		19-9-2007	Zutphen	x			-	-	-	g train / p train
27	2008	9-4-2008	Ede-Wageningen	x			-	-	-	p train / p train
28		11-10-2008	Gouda	x			-	-	-	p train / p train
29		2-11-2008	Amersfoort	x			-	-	-	g train / p train
30		6-12-2008	Waalhaven	x			-	-	-	g train / g train
31	2009	29-5-2009	Zwolle	x			2	-	-	p train / g train
32		24-9-2009	Barendrecht	x			-	1	1	g train / g train

The Dutch Safety Board
telephone +31(0)70 333 70 00 • **e-mail** info@safetyboard.nl • **website** www.safetyboard.nl
visiting address Anna van Saksenlaan 50 • 2593 HT The Hague
postal address PO Box 95404 • 2509 CK The Hague • The Netherlands