RAAD VOOR DE
TRANSPORT
VEILIGHEID

Collision between two passenger trains in Dordrecht 28 November 1999

The Hague, May 2001

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SUMMARY and RECOMMENDATIONS

On 28 November 1999, two passenger trains travelling in the same direction, collided with each other, in Dordrecht. The trains in question were the Benelux train and a double-decker passenger train. During the collision, 6 passengers were injured, and the trains derailed, whereby a section of the derailed Benelux train came onto the adjacent track. Fortunately, the driver of the train approaching the site on the adjacent track noticed that the track was blocked, and was able to halt his train in time. The nature and seriousness of the collision, which could have been far more serious given the approaching train, led to the decision by the Council for Transport Safety to further investigate this accident.

The investigation by the Council showed that the double-decker had incorrectly passed a signal at red, which was operating correctly. Safety on the Dutch railway network is based on red light discipline. A red signal may not be missed by a driver, because the consequences can be catastrophic. Unfortunately, human errors still occur, and drivers do miss signals at red.
Until 1962, the only safety system on the railway network was the signal beside the track. However, the tragic accident in Harmelen in 1962[1], changed this situation.

The then Railway Accident Council advised the Minister of Transport and Public Works to equip the Dutch network with an Automatic Train Influencing system (ATB). One key consideration of the Railway Accident Council was that the intensive use of the railway network was no longer commensurate with the safety system employed. This system consisted exclusively of signals alongside the track, which had to be closely monitored by the drivers. The then Minister followed the advice. The ATB system, which (over a period of 35 years) was gradually introduced after 1962, can today be viewed as a safety net, if certain signals are missed by drivers. The designers had placed priority on avoiding train collisions at high speeds. (In this connection, it should be taken into consideration that the level of technology at the time was limited.) In the event of the passing of a signal which calls for a reduction in speed, the ATB automatically initiates rapid braking, if the driver himself does not brake.

The system is subject to at least two major limitations. On the one hand, the system accepts ‘light’ braking by a driver as a suitable reaction. The system does not check whether the braking is sufficient to bring the train to stationary in time. On the other hand, the system does not operate at speeds below 40 km per hour.

The limitations of the existing Automatic Train Influencing system are now starting to cause problems for the railways. Until 1995, on average 150 trains a year passed a red signal. Over the last few years, a considerable and unexpected rise has been noted, reaching 280 occurrences in 2000. These numbers indicate that on average, every driver misses a red signal one to two times, during his career. The passing of a red signal involves considerable risks. A modern double-decker can carry 1000 passengers at speeds of up to 140 km per hour. Above all near stations, situations arise in which trains travelling at low speed, and therefore effectively without ATB monitoring, in passing red signals can enter the route being travelled by a train at high speed.

1 Railion is the former company NS Cargo, taken over by the Deutsche Bundesbahn.

Safety on the railway is to a considerable degree dependent on the correct interaction between technical facilities (such as the ATB system) and human task implementation. There are a number of indications which suggest that this interaction is not always smooth. The question therefore unavoidably arises, whether the safety management systems of the organisations in question, and above all the coordination between them, is sufficient.

The Council for Transport Safety is investigating the causes of the unexpected considerable rise in the passing of red lights. The Council will publish the results of this investigation. The Council believes that whatever the precise causes may be, the number of times which red lights are passed must under all circumstances be drastically reduced, in the near future.

The Council for Transport Safety recommends that the management of the transport companies involved (in particular: NS Reizigers (NS Passengers), Railion[2]) formulate measures, whereby the number of occasions on which a signal at red is passed can be reduced, in the near future. The Council thereby suggests that poorly visible signals should be reported by drivers, and the results notified to Railinfrabeheer (Rail Infrastructure Management).

In 1992, the Railway Accident Council investigated a similar serious collision, in Eindhoven. The key conclusion of the Railway Accident Council at the time was that the Automatic Train Influencing system no longer complied with current requirements. The number of train kilometres in 1962 totalled more than 70 million. In 1992, this had risen to 108 million, and in 1997, had risen further to 115 million train kilometres per year. Train kilometres can be viewed as a yardstick for the average intensity of use of the network. Given the increased speeds and increased intensity of use, the risks on the railways have risen considerably.

Following the accident in Eindhoven, it was suggested by the Netherlands Railways in the hearing, that the development of an improved Dutch ATB system would be concluded, in the near future. For implementation, account not only had to be taken of an investment of some 2.5 billion guilders, but also with a period of introduction, of more than 10 years. However, new developments have taken place in this field, on a European level. At the initiative, and partly at the expense of the European Union, a new generation Automatic Train Influencing system is being developed. One important limiting condition is that rail traffic must be able to cross borders, unhindered, without switching over, as is currently the case, to the German or Belgian safety system with which a standard Dutch train is not equipped. The newer generation has practically no functional limitations. This new generation of systems is based on computer technology. The existing Dutch ATB system is based on relays (switches controlled via electrical coils). In the new system, in all reasonableness, collisions between trains are made impossible. The Minister of Transport and Public Works has stated that the Dutch network will in principle be equipped with the new European system. The Minister mentioned no specific data for this action.

The above statements indicate that the existing Automatic Train Influencing system, which in terms of functioning is effectively out of date, will still have to continue in

2 Railion is the former company NS Cargo, taken over by the Deutsche Bundesbahn.

service for a number of years. This will not apply for the high-speed lines to be built and the Betuwe Line, which from the very start will be fitted with modern systems. The Council for Transport Safety nonetheless shares the opinion of the then Railway Accident Council that the current ATB system is an out-of-date system, and no longer meets the requirements imposed upon it by current use.
Naturally, the introduction of the new Automatic Train Influencing system, according to the European standard, which in fact also offers the possibility of avoiding collisions with derailed trains on adjacent tracks, will be implemented in phases. Only once the phases are known can the urgency be determined for the other measures necessary for reducing the passing of signals at red, in the intervening period.

The Council recommends the Minister of Transport and Public Works to issue a clear statement about the phasing in which the Dutch railway network will be equipped with a modern ATB system, based on computer technology. The prevention of collisions with derailed trains on adjacent tracks should also be included in the programme of requirements.

The measures which will call for attention in the intervening period relate to the setting of part routings, the observability of signals and the design of overshoot distances.

The setting of part routings.
According to the timetable, the double-decker arrived on time (on track 5). The Benelux train arrived with a delay of 4 minutes (on track 4). According to the timetable, the Benelux train was to depart first, and the double-decker was expected – with the normal separation – to travel behind the Benelux train. In such cases, the double-decker can wait at the platform on track 5. However, in this case the traffic controller allowed the double-decker to leave the platform. The signal aspect for the driver changed to yellow, allowing the driver to leave. In principle, the aspect at the next signal is red, but may also be different (yellow or green) which allows the signal to be passed. For the double-decker, the traffic controller set a routing, whereby the next signal was at red. The double-decker therefore departed before the Benelux train, travelled at low speed – below 40 kilometres per hour – away from the platform, and missed the next signal, which was at red. The ATB system did not warn the driver of the passing of the red signal.
The traffic controller had set this part routing for the double-decker, in order to reduce the delay caused by the Benelux train. Traffic control – now a government-commissioned organisation, previously an inseparable component of Netherlands Railways – is, as may be assumed, highly willing to issue support, in limiting delays. By establishing the part routing, the primary intention was indeed as far as possible to reduce the delay. The setting of the part routing was not based on limited track capacity. Equally, the double-decker was not unnecessarily occupying the platform, thus preventing an incoming train. However, the principal question for the future is whether it is desirable to set such part routings, which are travelled at a speed of less than 40 kilometres per hour and therefore effectively without ATB monitoring. A carrier wishing to limit delays is probably running an increased risk, on these specific part routings.

The Council recommends the management of Railverkeersleiding (Rail Traffic Control) to exercise considerable caution in setting part routings travelled at speeds below 40 kilometres per hour, and thus effectively without ATB monitoring, until the moment of introduction of a new modern ATB system. If part routings are nonetheless set, the *train controller should supervise them. A reliable automatic warning signal to the train controller of the passing by a train of a signal at danger would be an essential tool.*

The design
Signals must be observable in good time. In laying the section of track in question in 1994, insufficient attention was paid to the visibility of signal 1132, which was wrongly passed. Visibility is hindered by a noise abatement screen and vegetation growing behind it.
Even after 160 years of railway business, there is no single shared opinion about the distance at which a driver should be able to see a signal. Article 53 of the Service Regulations for Main and Local Railways (Order in Council 1977) states that at a speed of 40 kilometres per hour, a braking distance of 400 metres must be available. At that distance, the signal should also be visible. This distance, which dates from the 19th century, has never been adjusted. The General Regulations, an internal set of rules, however suggest that Railinfrabeheer (Rail Infrastructure Management) considers 200 metres to be sufficient. Amongst the designers at Railinfrabeheer, the opinion is also shared that a signal should be visible 9 seconds in advance. Depending on the assumption for speed of the train, the distance of 200 metres at which the signal should be visible can in fact be adjusted downwards, according to these designers.
In Dordrecht, the distance at which signal 1132, which was passed, was visible was 120 metres. The vast majority of signals is visible at a far greater distance than 200 metres.
The Council believes that it is incorrect, with altered internal standards, to deviate from possibly out-of-date statutory requirements. Such an approach in no way helps to promote a uniform picture.

Besides visibility, a further criterion applies, which is equally important. For the driver a signal should not only be observable, but it must also be clear that the signal applies to the track on which he is travelling. In other words, on the basis of what he sees, the driver must be able to establish a link between the signal, in this case signal 1132, and the track he is travelling on. The noise abatement screen which was fitted on the inner curve, hinders any such linkage. For a long time, it is unclear which signal relates to which track. Only at the very last moment is it possible to visually establish the link between signal and track. The situation here represented a serious deviation from the obvious standard.
The Dutch railway network, depending on the possible hazard setting which could arise, offers the safety tool the overshoot distance. If a train, due to limited braking capacity, fails to come to a stop before the red signal, sometimes, as in Dordrecht at signal 1132, beyond the signal a safety margin is built in, in the form of an overshoot distance. The assumption is that the braking train, which misses the red signal, will become stationary shortly after the signal, within this overshoot distance. Another point of departure is also possible, and considerably safer. The double-decker incorrectly passes a red signal. The double-decker then occupies the block in which the collision took place. The Benelux train was able to enter that block via a green signal, whilst the same block was occupied by the double-decker. If the overshoot distance had been implemented in accordance with the principle: a single train in a single block, the passing of the red signal by the double-decker would have meant that the safety conditions for a safe routing for the Benelux train would no longer have been met. The routing for the Benelux train would then automatically have been cancelled. Because the speed of the Benelux train was in excess of 40 kilometres per hour, the ATB on this

train would have intervened, with an emergency braking, and the collision would probably not have occurred.

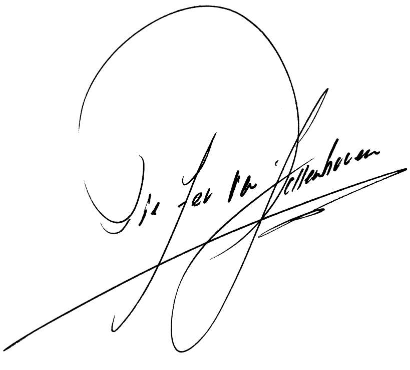
The implementation of track 36 in Dordrecht is the result of the design process employed, whereby the disciplines involved within Railinfrabeheer each follow their own design rules. As concerns the visibility of signals, even within a single discipline, there is no agreement on the points of departure to be employed. These points of departure deviate in a number of essential respects from formal, possibly out-of-date regulations, without any exemption having been requested. This approach is not in compliance with the standard sheet for safety assurance systems issued by Railned. This standard sheet calls for a critical attitude towards safety, and a continual effort to reduce safety risks.

The Council recommends the management of Railinfrabeheer to harmonise the design process for rail infrastructure with the standard sheet on safety assurance systems issued by Railned, and to harmonise the designs with the current statutory rules.

As concerns safety, the design process has not been established redundantly. There is no second opinion analysis. The design result is not independently tested. The design process is thus a primary process with no backup system.

The Council recommends the Ministry of Transport and Public Works to appoint a supervisory body for the government-commissioned organisations.

The Hague 2001
Chair of the Board
Mr Pieter van Vollenhoven



Secretary-Director
Mr. S.B. Boelens

1 INTRODUCTION

On Sunday 28 November 1999, a serious collision occurred between two passenger trains in Dordrecht. The two trains were travelling in the same direction. A double-decker passenger train, drawn by a power car, drove into a Benelux train en route for Brussels. The Benelux train was travelling at 70 kilometres per hour, at the moment of collision. The double-decker had passed a red signal. During the collision, six people were injured, and a number of carriages of the Benelux train forced off the rails. As a result, the adjacent track became blocked. The driver of the train approaching on the adjacent track saw this fact and was able to halt his train, in good time. As a result, a far more serious accident was avoided.

Until 1995, on average 150 trains passed a red signal every year. Over the last few years a considerable, unexpected rise has been noted in this number, up to 280 in 2000. Collisions between trains can only be avoided if drivers closely comply with the signals alongside the track. Safety on the railway network is based on the red light discipline of drivers. Coincidence decides what happens if a signal is not complied with. The consequences may not be serious, but they can also be extremely serious.

The absolute number of red signals passed is high. On average, in his career, a driver will pass through a red signal one to two times. One to two errors in a human life is not a large number. The small risk of errors is achieved through a number of factors: training and selection of drivers, the culture within the professional group, the culture in the company, and finally the Automatic Train Influencing system. This equipment intervenes whenever the driver fails to respond correctly to specific signals. Until the gradual introduction of the Automatic Train Influencing system was started in 1962, the safety of rail traffic was determined only by the first factors mentioned.

The risk of passing through a red signal must absolutely be kept very low, because the consequences of a collision can be so considerable. A modern double-decker can carry 1000 passengers at speeds of 140 kilometres per hour. Naturally, collisions between full passenger trains can lead to very large numbers of victims. One of the major disadvantages of the current Automatic Train Influencing system is that it does not operate below 40 kilometres per hour. The introduction of Automatic Train Influencing has considerably reduced the risk of collisions between trains both travelling at speeds exceeding 40 kilometres per hour. Accidents between two trains such as in Eindhoven and Dordrecht, whereby one is travelling faster than 40 kilometres per hour, and the other slower, however, still prove possible. The existing Automatic Train Influencing system, which was developed in the nineteen fifties, has very limited capacities. The technology available at the time meant that the safety system could only implement a limited number of functions. In the design, it was therefore opted for a system that only works above 40 kilometres per hour.

In a European framework, work is being carried out on a new-generation Automatic Train Influencing system. This new system is based on computers. The number of functions which this system can implement is not limited, technically. The new system (in the Netherlands BB21) represents the solution to the problem. Trains will then no longer be able to pass red signals. In parallel, in the Netherlands, the ATB New Generation has also been developed. The same applies for this system.
Equipping the entire network with these new systems will require considerable time

and money. The new system will cost at least 2 billion guilders. Even if all financial hindrances were removed, the installation of the system would still require a large number of years. The fitting of the current system on the railway network took decades. The new system is currently in the development phase. Acceleration of the development phase is desirable, from the point of view of safety. Because beyond the still to be built High-speed line and the Betuwe Line no specific decisions have been taken to introduce the system, the existing ATB system will unavoidably continue to be used, for a number of years to come. For this reason, the recommendations and investigations are not only limited to long-term solutions, but also deal with how a reduction in risks can be achieved, in the short term.

The number of companies and institutions involved in this accident is relatively considerable: NS Passengers, Railned, Rail Traffic Control, etc. All are former NS companies, which were made independent after 1995, with a specific objective or a specific task. The privatisation process was initiated by the European Union, and has not yet resulted in a structure recognisable by society. The point of departure for this goal of independence is to establish a separation between the infrastructure, and its use. As well as in relation to rail transport, this principle has also been applied to other sectors, due to the efforts of the European Union, for example electricity supply. The separation between the rail infrastructure and its use is contained in the new Railways Act, which has been sent to the Dutch Lower House, and will increasingly push into the background the picture in society of the Netherlands Railways as a single company.

This report is based on the facts collected in the framework of this investigation, in consultation with those directly involved. Appendix 1 contains an overview of the part reports in which these facts are contained. The investigation and the facts contained therein are aimed at preventing identical accidents taking place in the future. In this connection, the question of attributing fault plays no role.

2. THE LOCATION AND THE COMPANIES AND INSTITUTIONS INVOLVED

2.1. THE LOCATION

Figure 1. Dordrecht station and surrounding area. The arrow indicates the location of the collision.

The collision between the two trains took place at the station complex in Dordrecht. The station and its direct environment appear in figure 1. The tracks on the left lead to Rotterdam. The track on the right of the station goes to Geldermalsen. The track which bends down to the South runs to Lage-Zwaluwe, and is in a tight curve, with a speed limit of 80 kilometres per hour.

In 1994, the number of tracks between Rotterdam and Dordrecht was doubled from two to four. At Dordrecht station, the terminus for the project, the number of tracks was also expanded. In order to pass Dordrecht unhindered, a continuous track was laid on the western side, free from the platforms. Past Dordrecht station towards Lage-Zwaluwe, the track is laid on the inside of the curve. The track is intended for mixed use for through-passenger and freight trains. Via the points at which the collision took place, this track feeds back into the main track to the south. This track is also accessible from platform track 5.

2.2 NS REIZIGERS (NS PASSENGERS)

NS Passengers, one of the core companies of the NS Group, carries almost one million passengers every day. To provide this transport performance, almost 11,000 staff are involved. Approximately 3,200 of these are drivers. In 1998, the company generated turnover of 2.7 billion guilders. For the transport of passengers, approximately 2700 carriages are available, the majority (approximately 1700) making up electrical train sets, with their own traction. The remaining are drawn or pushed carriages, which are propelled by separate locomotives. The trains involved in the collision both consisted of carriages drawn by a locomotive, although the double-decker was not propelled by a normal locomotive but by a power car with passenger accommodation.

As carrier, NS Passengers is responsible for the safe transport of passengers across the railway network, at least in so far as the passengers are carried by trains of NS Passengers. Within the organisation of NS Passengers, the decision has been taken to make the line management responsible for safety. The heads of the 13 production areas of NS Passengers, the 4 network directors and the production director all have at least a personal advisor: the safety expert. This officer supports the directors and heads in their safety policy.

2.3 *RAILINFRABEHEER (Rail Infrastructure Management)*

On behalf of and at the expense of the Minister of Transport and Public Works, Railinfrabeheer is responsible for the management, improvement and expansion of the existing Dutch railway network, and the laying of new rail infrastructure. Railinfrabeheer itself is not a transport company. It is exclusively responsible for the rail infrastructure and everything which is part thereof, including rails, points, signals and the complete, extremely costly electronic operation infrastructure for signals and points, and ensuring that all these systems are maintained and comply with the functional requirements imposed by Railned. Railinfrabeheer employs more than 1100 staff. For pure maintenance of the railway network, the Minister provides an annual budget in excess of one billion guilders.

At Railinfrabeheer, too, responsibility for safety is with the line management. In addition, Railinfrabeheer has a staff department responsible for safety, managed by the safety manager. The staff department has in total eleven employees. The staff department can issue advice to other service components, on request or on its own initiative. Four of the eleven employees work in the Railinfrabeheer regions.

2.4 *RAILVERKEERSLEIDING (RAIL TRAFFIC CONTROL)*

Rail Traffic Control is a continuously operating business; 24 hours a day, 365 days a year, the in total more than 1700 employees are responsible for handling rail traffic on the Dutch network, at 17 control posts, from which the entire network is monitored. In large control rooms, the train controllers and traffic controllers work together, ensuring the timely operation of signals and points, as far as possible with a view to ensuring that trains run according to the timetable.

Rail Traffic Control is responsible for safe traffic movement by rail traffic on the Dutch railway network. With this in mind, the network is broken down into four regions. From an organisational viewpoint, the four regions are subject to the central control of Rail Traffic Control. Electronic infrastructure and other operating instruments used by Rail Traffic Control in carrying out its tasks form part of the railway network, and are thus managed and owned by Railinfrabeheer. At Rail Traffic Control, too, the line management is responsible for safety. The four regional heads and the deputy director for production all have at least a safety expert for this task, who is also the contact person for all safety matters within the organisation.

The second key task of Rail Traffic Control is disaster prevention. In railway accidents, Rail Traffic Control coordinates all activities of the rail companies involved, at the accident location.

2.5 *RAILNED, RAILWAY SAFETY department*

Railned, established in 1994, has a large number of tasks. In this framework, above all the formulation of functional specifications for rolling stock and infrastructure is essential. This means that prior to realisation, Railned indicates what safety requirements must be met by rolling stock and the infrastructure. In addition, Railned has a limited supervisory role. The department employs some 50 staff.

2.6 NEW ORGANISATION IN 1995

In relation to technology, safety has drastically increased through the introduction of the principle of redundancy: the addition of strictly speaking superfluous technical systems which in the event of a fault immediately take over the functions of a primary system. The emergency brake in a train is a special provision which is not used in normal operation. For safety, however, the emergency brake plays a key role. Train safety is considerably improved through the introduction of the emergency brake, a redundant provision. Principles of this kind apply for the organisation of business sectors. The primary responsibility for safe transport of persons and freight lies with the carriers. By implementing independent supervision within the sector, on the functioning of those carriers
– an additional system – experience has shown that generally speaking, safety in the sector increases. For projects - activities with a starting point and a finishing point - for example the construction of a track, supervision takes on a particular form. Supervision then has no permanent character, but takes on the form of an assessment of the interim and final results of the project.

In 1995, the old NS group was broken down into market-oriented companies, which are in principle not supported financially by the government, and government-commissioned organisations, which are fully financed by government. NS Passengers falls under the first category of businesses; Railinfrabeheer, Railned and Rail Traffic Control fall into the second category. These three companies work directly on behalf of the Minister of Transport and Public Works. Railned's transport safety department occupies a special position. The transport safety department formulates the frameworks and rules which the market-oriented companies must comply with, on behalf of the Minister of Transport and Public Works. Railned is also responsible for ensuring that these companies do indeed comply, in practice.

Formally, Railinfrabeheer and Rail Traffic Control are not required to conform to the frameworks and rules imposed by Railned. These three government institutions are all on a par. The two government-commissioned organisations voluntarily comply with the frameworks imposed.

In 1997, the Railned transport safety department issued the standard sheet safety assurance systems. The standard sheet calls upon the management of the various companies, to undertake a number of actions, including:

- continuous efforts to reduce risks
- to broadcast safety policy, to generate support and to ensure implementation of the policy
- to provide the necessary resources to implement policy
- to include railway safety as a performance indicator for business operation
- In addition, every year, an annual report has to be drawn up in which the management indicates what actions have been taken within the organisation in relation to safety policy, and how the management evaluates these developments.

Through the establishment of Railned's transport safety department, in the various businesses, safety policy took on a new form. Above all under the influence of the ISO 9000 series of standards, policy was intensified and formalised. In the railway world, attention has always been focused on safety; it is not by chance that rail is the safest form of transport. There was therefore already a clear focus on safety within the organisation. However, how attention for safety was translated into concrete action in the old organisation, could not be traced by the outside world. Through the new approach, attention for safety became visible and demonstrable.

As indicated, every year, the railway companies draw up a report in which the management passes judgement on the safety developments which have taken place within their own organisation, in the year just ended. When asked, the management of both Rail Traffic Control and NS Passengers expressed the opinion that in all reasonableness, with the exception of a number of points, the standard for safety assurance systems had been met. The management of Railinfrabeheer also believes that the standards are being met, but is the most reticent in that connection. The vision of Railned on compliance by Railinfrabeheer with the frameworks and standards imposed, including the standard for safety assurance systems, is not in complete agreement. Railned believes that the standards are not met.

3. THE COURSE OF EVENTS

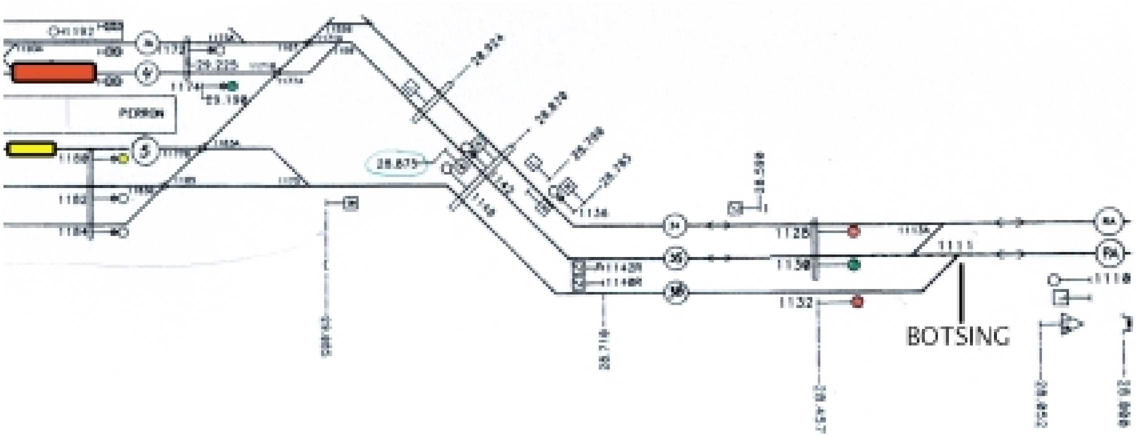


Figure 2. Diagrammatic representation of the southern section of the station complex. The station buildings are not shown. Parts of the platforms do appear on the drawing. The figures at right angles to the track indicate the kilometre measurements. The figures parallel to the track indicate the numbers of signals or points. Before track 36 was constructed, the trains travelled from track 5 via points 1177b and 1177a, over track 35.

On Sunday 28 November 1999, the double-decker was travelling according to the timetable, and arrived on time in Dordrecht, at track 5. The Benelux train arrived on track 4, at the same platform, with a delay of 4 minutes. According to the timetable, the Benelux train was due to leave first. For this train, an automatic routing (44 seconds after 12.40) was set to track PA. Signal 1174 by the platform and signal 1130 by track PA were therefore at safe. The Benelux train was due to leave at 12.39.

The double-decker, which was due to travel along track PA towards Lage-Zwaluwe, at the normal separation behind the Benelux train, would normally leave at 12.42 from track 5. If the Benelux train had left on time, a routing would have been set for the double-decker, from signal 1180 at track 5 to track PA, with signal 1132 at safe. Because the Benelux train was too late, this routing was no longer automatically set. Point 1111, which is part of this routing, was still required for the Benelux train, so no normal routing for the double-decker could be set.

To permit the double-decker to leave on time at 12.42, the train controller intervened and at 30 seconds after 12.41, set part of this routing, with a separate order. Signal 1132, the second and final signal of the routing set by the train controller, was at red. Point 1111 was still reserved for the Benelux train. Signal 1180, the first signal on the part routing for the double-decker, therefore showed yellow. The signal aspect indicated a maximum of 40 kilometres per hour, and an instruction to take account of stopping at the next signal.

The double-decker left on time, before the Benelux train. One minute later, the Benelux train left in the same direction, from track 4, on the other side of the platform. Signal 1174 showed a flashing green 6 (maximum 60 kilometres per hour) and signal 1130 was at green. Having passed the points shortly after the first signal, the sign showing the 8, at kilometre 28,875, gave the driver permission to accelerate to 80 kilometres per hour. The driver of the Benelux train increased speed. The driver of the double-decker increased speed of his train to 40 kilometres per hour, having left from track 5, and on track 36, approached signal 1132, which was at red.

The driver of the double-decker missed signal 1132, which was at red. The double-decker wrongly passed signal 1132, and occupied the section after the signal, at 57 seconds after 12.43. The Automatic Train Influencing system did not intervene, because this system does not function at speeds of 40 kilometres per hour and lower. The Benelux train, which was travelling faster and faster, at 14 seconds after 12.44 passed signal 1130, which is located next to signal 1132, and which was showing green, at a speed of 60 kilometres per hour.

Figure 3. All changes in the system: the occupation of sections, changes of signals, etc. are all automatically recorded. On this basis, it is possible to precisely determine what happened in Dordrecht. The figures indicate the train numbers. The grey rectangles have no relevance in this figure. The light-grey lines indicate the sections of set routings. The yellow lines indicate the sections occupied by a train. At the indicated moment, the double-decker passed the signal at red. The section after the signal issued a track occupied message. The Benelux train is at that moment still in front of the signal, on the routing set for it. This course of events is visible on the train controller's monitor. Train number 2238 is the train approaching on the adjacent track.

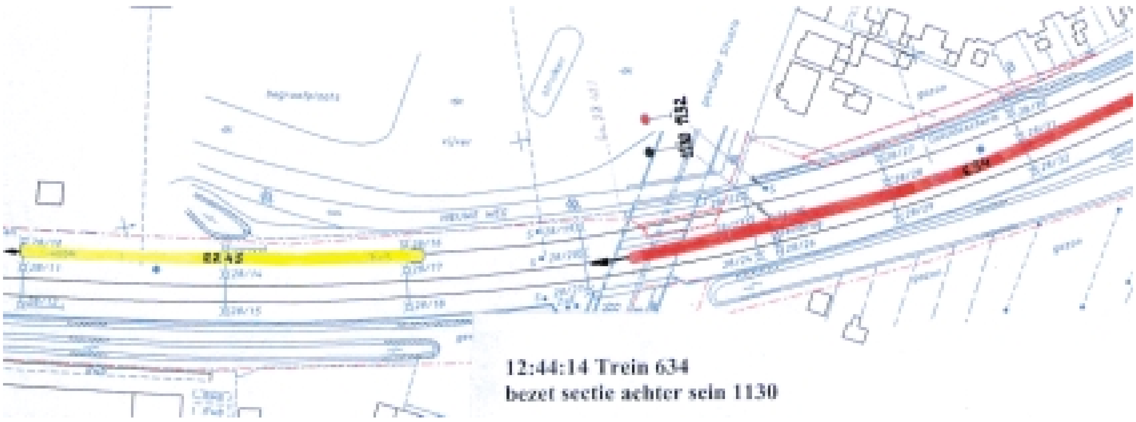


Figure 4. The Benelux train passes signal 1130, which shows green, 17 seconds after the double-decker passes the red signal 1132.

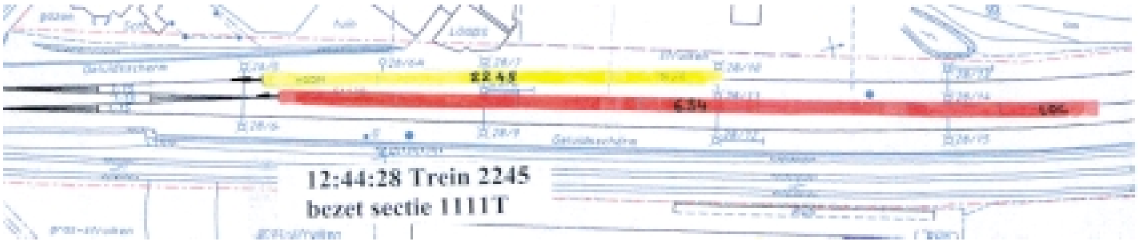


Figure 5. The Benelux train is still behind the double-decker, 21 seconds after the double-decker has passed signal 1132.

This is 17 seconds after the double-decker incorrectly passed signal 1132. The train controller is able to observe this latter fact on his monitor. The Benelux train continued along its route over switch 1111. At that moment, train speed is 70 kilometres per hour.

When the second and third carriages of the Benelux train were above the points, 31 seconds after 12.44 (34 seconds after the passing of the red signal by the double-decker), they were hit in the flank.

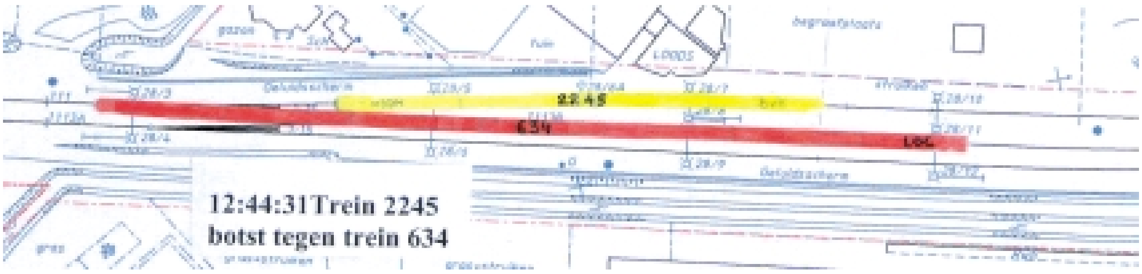


Figure 6. 34 seconds after passing the red signal, the collision takes place.

As a consequence of the collision the power car tipped outwards, against a noise abatement screen. A number of carriages of the Benelux train were derailed. They did not tip over, probably because the couplings of these carriages withstand the shock, with the rest of the train. The derailed carriages did enter the envelope of the adjacent track. The driver of the train approaching on this track, from Dordrecht Zuid saw in time that his track was blocked, and halted his train, before the derailed carriages.

During the collision, six passengers were injured, one of whom seriously. Three of them were in the power car. The other three were in the carriage behind. The 260 passengers were evacuated. Four injured passengers were taken to hospital. The severely injured passenger was hospitalised. Following treatment, the others were discharged home. The first police unit arrived at the accident, at 12.50 hours, six minutes following the collision. One minute later, the first ambulance arrived. The fire brigade was on situ at 12.53 hours, whilst the medical evacuation helicopter landed at 13.09 hours, by the Laan der Verenigde Naties crossing.

Figure 7. Overview of train positions following the collision. In the top left-hand corner, we see how the carriages of the Benelux train are blocking the adjacent track. A potentially very hazardous situation.

4. THE ANALYSIS

4.1 TECHNICAL COMPONENTS

4.1.1 The safety system

In comparison with other modes of transport, the high level of safety on the railways is effectively due to a method of monitoring trains. All railways throughout the world are subject to the same approach, which is laid down in the Netherlands in the Service Regulations for Main and Local Railways (an Order in Council accompanying the Railways Act) article 58: a train may only enter a section of track if the points are in the correct position, and it is guaranteed that this section of track is free, and that all information has been passed on to the driver, by signals. Everything is determined by the signal, and by the following of the instruction issued by that signal. The route to be followed by a train across the track – the routing – is therefore checked in advance, and approved, and also secured against other trains, by signals. The setting of these routings is a task of Rail Traffic Control, the organisation which operates the entire railway network, from a limited number of centres. The equipment used in this process prevents the setting of unsafe routings.

The section of track indicated on figure 1 is subject to Post T in Rotterdam. Post T is therefore the base for the train controller, responsible for setting routings. Train controllers must meet high standards; the medical and psychological requirements for train controllers are laid down in standard sheets. The skills requirements are also precisely described. These standards are determined by Railned. The management of Rail Traffic Control is responsible for ensuring compliance with these requirements. The train controller in question met the standards.

Over the last few years, more and more electronic aids have been provided to train controllers. Whereas only a few years ago the train controller was required to set every routing for every train by hand, train controllers can now use the Automatic Routing Setting system (abbreviated in Dutch to ARI). This system automatically carries out the setting of routings in accordance with the current timetable, on the basis of a number of criteria. If the entire train service moves according to the current timetable, thanks to the ARI, the workload on the train controller is low. If the timetable is disrupted, or in the event of deviations from the timetable, as in the past, the routings can be manually set, or the entire timetable electronically adjusted. Various options are therefore open to the train controller. The workload on the train controller in disrupted situations is generally far higher than normal.

4.1.2 Location finding of trains

Trains follow routings which are preset. No other trains are allowed to make use of these preset routings. Access to the routing is forbidden through the use of signals. However, it is required that the position of the trains on the track be known. The current location finding system for trains is based on electrical sections and represents one of the most costly elements in the railway safety system. The entire railway network is broken down into sections, in total some 40,000. A section is a piece of track in which the left-hand rail is electrically insulated from the right-hand rail. The all-steel wheel sets of a train make a short circuit between the rails, across which a voltage differential is applied. From the short circuit, it is determined that in the short-circuited section, a train is located. The position of every section is precisely known. As a result, rough train location finding is possible.

4.1.3 Automatic Train Influencing system (ATB)

Figure 8. The Automatic Train Influencing table fitted in the train cab.

Although elements of the Automatic Train Influencing system are installed in the track, the core of the system is built into the train. The existing system was developed in the nineteen fifties on the basis of relays. The state of technology at the time limited the number of safety functions the system could implement. If a driver travels faster than permitted at a specific point, after a number of seconds the system intervenes with a warning and an accelerated braking. In practical terms, this means faster than 140, 130, 80, 60 or 40 kilometres per hour. As long as the speed is 40 kilometres per hour or less, the system does not respond. On the double-decker, for which a routing had been set from signal 1180 at yellow (maximum of 40 kilometres per hour) up to the next signal 1132, showing red, the Automatic Train Influencing system offered no added value, because the train was not travelling faster than 40 kilometres per hour. If a red signal is passed without additional warnings, the train can then enter a routing where higher speeds are permitted.

Due to its special characteristics, the ATB system has effectively increased safety on the railways. Prior to the advent of the ATB, in darkness, rain and mist, safety on the track was determined exclusively by the strict discipline of the drivers. Monitoring signals alongside the track, in good time, was his responsibility and his responsibility alone. Missing a signal could have fatal consequences. Signals are practically never repeated. As a result, signals form a so-called point system. Passing a signal without observing it was a non-correctable error. A primary system without redundancy.
The added value of the ATB system above all lies in the continuous information provided about signals. The signals alongside the track only provide information to the driver at the location of the signal, in other words, at specific points. The ATB table in the driver's cab provides the driver with constant information, between two signals, about the permitted speed, with the exception of the instruction to stop. As a result, dependency on observing signals at specific points has been reduced.

Even without observing the signal alongside the track, the driver is therefore continuously aware of the maximum speed indicated by the last-passed signal. At speeds exceeding 40 kilometres per hour, i.e. in 90 to 95% of his shift, he is no longer exclusively dependent on the signal alongside the track. At speeds of less than 40 kilometres per hour, once again the former strict discipline of observing signals in good time becomes an absolute requirement.

At his control post, the train controller has no information about the Automatic Train Influencing system. In no way whatsoever is the train controller able to determine whether a train is travelling too fast or too slow. On the train controller's monitor in Rotterdam, it was immediately visible that the double-decker had incorrectly passed a red signal. The routing which had been set for a train, and was shown on the monitor, ended at red signal 1132. When the section past the red signal issued a track-occupied message, it was clear that the double-decker had passed signal 1132 at red. The occupied section was not part of the set routing, and the occupation of the track indicated that the signal at red had been passed.

4.1.4 A European initiative

At the initiative and partly at the account of the European Union, a new generation Automatic Train Influencing system is being developed. One essential precondition is that rail traffic must be able to cross borders, unhindered, without having to switch over, such as is currently the case, to the safety system operating on the other side of the border. In parallel, the ATB New Generation is being developed in the Netherlands. This, too, is computer-based. ATB New Generation, just like its predecessor, is a limited national system. The new generation of ATB systems has no functional limitations, being based on computers. The existing Dutch ATB system is based on relays (switches controlled by electrical coils). In the new system, in all reasonableness, train collisions are no longer possible. The Minister of Transport and Public Works has stated that the Dutch network should preferably be equipped with the new European system (Letter from the Minister to the Lower Chamber 1995/1996 24400 XII no. 49). The Minister has not yet set any specific date.

4.2 SIGNAL 1132

4.2.1 The risk of failure

The direct cause of the train collision in Dordrecht was the fact of the driver of the double-decker missing signal 1132. High demands are placed on drivers. Drivers are both medically and psychologically tested. The requirements which must be met are imposed by the safety department of Railned. The same applies for professional skills requirements. The driver must take an examination to determine whether he meets these requirements. The psychological and medical tests are periodically repeated. In addition, drivers are given regular retraining in relation to the characteristics and specifics of the rolling stock in use. The staff manager responsible for the driver supervises the professional skills and functioning of the driver. In the case in question, the driver met the requirements imposed.

One of the professional skills requirements relates to knowledge of the route. If a driver travels along a specific section of track, he must be conversant with the position of signals, whether they are poorly visible or not. A driver is also only allowed to drive alone along sections of track with which he is fully conversant. The driver is formally always responsible for ensuring that signals are observed in time. According to the traditional approach in the railway world, there is also effectively no problem in respect of visibility. The driver is conversant with the route, so he should always know where the signal is located, irrespective of the degree of visibility. This choice by the management of Netherlands Railways, made decades ago and still applicable, places the responsibility for an error fully with the driver, whilst no mention is ever made of minimum visibility requirements for signals.

In principle, this position should still be subscribed to, today. The discipline of the driver is still the key factor in rail safety. However, drivers are people and people make mistakes. Following the missing of signal 1132, an investigation was carried out into how many signals at red are passed in the Netherlands. This investigation demonstrated that drivers make very few mistakes indeed. Nonetheless, the total number of mistakes by all drivers together is not negligible, as demonstrated in the table below.

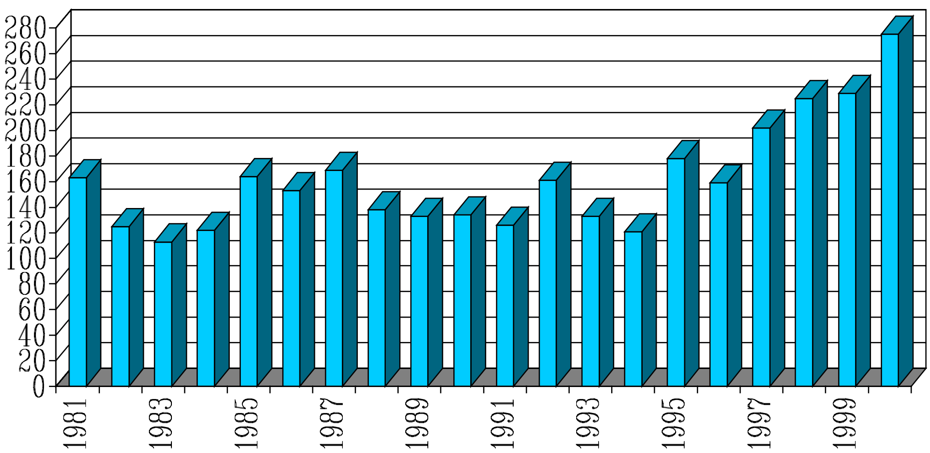


Figure 9. The total number of signals passed at red, in various years. The numbers relate to all signals at danger, and relate to both fixed and light signals. The number of fixed signals at danger equates to approximately 7% of the total.

The table shows a disturbing increase. Every passing of a signal at red is a potentially very hazardous situation. The consequences are not foreseeable. The result could be a collision, leading to an immense number of victims. The result is determined by chance. Effectively a situation not socially acceptable.

Traditionally, the number of times a signal is passed at danger is 150 a year, also in the years before 1989, not shown in the table. From 1995 onwards, a considerable rise has been observed, which for the time being has no clear explanation. In the year just ended, in fact, 280 signals at danger were passed, incorrectly. Since 1990, the number of train kilometres has only risen by 8%. The increase can therefore not be explained by an increase in train frequencies.

However, not only the frequency of signals passed at danger has increased. Other risks are also rising. Capacity and train frequency are continuously rising. Double-decker and long trains can carry a 1000 passengers. Due to these developments, the possible consequences of errors are becoming ever greater, and thus increasingly less acceptable to society. These facts are also generally recognised. It is not for nothing that new Automatic Train Influencing systems are being developed in the railway world, with support from the European Union, which should make the passing of signals at danger impossible. However, that situation is far from being reached. In the Netherlands, for the time being, the discipline of the driver remains the very last safety net. A very low risk of failure is a key factor in railway safety. As demonstrated by the graph, the risk of failure has been increasing over the last few years. This is a dangerous development, which must be reversed, in good time.

4.2.2 The design

As manager of the Dutch railway network, Railinfrabeheer has overall responsibility for the safety of the network, for train transport. In constructing the infrastructure and operating the signals, everything possible should be done to keep the risk of passing a signal at danger as small as possible. Through sound design and careful operation of signals, the number of occasions on which severe demands need to be placed on the local knowledge of the driver, should be kept to a minimum.

Figure 10. The view of signal 1132 at 200, 178, 140 and 120 metres before the signal, determined two months following the collision. In this period, the trees have few leaves. This is not the case throughout the year. During the passage by the double-decker on 28 November, the central signal for the Benelux train was at green.

At Railinfrabeheer, the design of the infrastructure takes place according to the traditional intuitive design process. The various disciplines such as rail experts, electrical engineers, etc. discuss matters with one another, in a project team. The purpose of this cooperative venture is to implement the project in such a way that the parties involved are able to operate as efficiently as possible, without hindering the others. The various parts of the project are implemented in accordance with the traditional rules of each discipline. These rules are based on years of experience accrued in-house, and are perceived by those involved as sound and safe. No independent, overall assessment of the safety aspects of the project as a whole is carried out by third parties, beyond the individual discipline.

Even after 160 years of railway operation, it has proved impossible to determine objectively at what distance prior to a signal a driver should be able to observe that signal. Article 53 of the previously mentioned Service Regulations for Main and Local Railways (RDHL) prescribes that at a speed of 40 kilometres per hour, a braking distance of 400 metres must be available. It is only possible to comply with this requirement if the signal is visible at least 400 metres in advance. This 400 metres is the maximum distance within which a train at that speed should be brought to a halt. The regulation is very old, and is based on trains with a minimal braking capacity.

Practically all trains require only a small amount of this distance. The General Regulations issued by Railinfrabeheer deviate from the RDHL regulations, and state that a signal should be visible at least 200 metres before the signal. Even these General Regulations are not automatically followed. Alternative design criteria are also employed. According to this alternative approach, a signal should be visible at a distance covered by the train in 9 seconds. The sight distance is thus made dependent on the speed in-situ. Depending on the assumption for the speed of the train, according to this approach, the distance of 200 metres at which the signal should be visible can be adjusted downwards.

On straight sections of track, the vast majority of the network, signals are generally visible at a far greater distance than 200 metres. For the specific situation in Dordrecht, where in certain circumstances trains travel without ATB protection, good observability is extremely important. For that reason, in this special situation, the statutory requirement of 400 metres would have been the preferred option. At least the 200 metre standard from the General Regulations should have been complied with.

Besides visibility, a further criterion applies, which is at least as important. For a driver, a signal should not only be observable, but also it should be clear that the signal applies to the track on which he is travelling. The driver must therefore be able to establish a link between the signal, in this case signal 1132, and the track on which he is travelling, on the basis of what he sees. The noise abatement screen installed during the construction of track 36 on the inside bend prevents such a link being established. It is unclear which signal is intended for which track. Only at the very last moment is it possible to establish the visual link between the signal and the track on which the train is travelling.

In other words, the obvious standard: a visual link between track and signal, was deviated from, to a considerable degree. The Railway Act article 36 also forbids the construction of obstacles in a zone of 20 metres, in the inside curve of railways. If safety is not adversely affected, the Minister is permitted to issue an exemption from this rule. Well back into the last century, the Minister transferred the competence to issue exemptions to the management of Netherlands Railways, and subsequently to the director of Railinfrabeheer. Noise abatement screens are installed by Railinfrabeheer. The exemptions awarded to Railinfrabeheer by itself, are no longer recorded in writing.

4.3 SIGNAL OPERATION

Figure 11. Workstation of a train controller.
The screens provide a visual overview.

Rail Traffic Control is responsible for operating the signals. It is beyond doubt that within the framework laid down by the management of Rail Traffic Control, the signals may be operated, as was carried out on 28 November. The framework speaks for itself. The control system may not make any mistakes. In other words: signals cannot be operated in such a way that they result in routings which cross one another, and are thus in conflict with one another.

The management of Rail Traffic Control considers this sufficiently secure, and allows the train controllers to use these technical systems fully, with practically no limitations. If so required, in other words, any technically possible routing may be set.

Furthermore, the management believes that the train controllers should not take over any of the tasks of the driver. Drivers should observe and comply with the signals outside, and should not count on any further additional warnings from the train controller. On the basis of the current rules, the handling of the Benelux train and the double-decker by the train controller was in full compliance.

The current approach by Rail Traffic Control is characterised by the accurate implementation of the specified tasks, and the limitation of delays. However, it should also be considered possible for Rail Traffic Control to play an active role in respect of safety. In this connection, greater account than is currently the case could be taken of part routings, difficult elements in the infrastructure and the specific characteristics of Automatic Train Influencing.

If the trains travel according to the timetable, the routings are automatically set by the ARI (Automatic Routing Setting system). In the event of a delay, all trains travelling shortly thereafter are also delayed. The train controller can prevent this by fully or partially decommissioning the ARI, and manually intervening in the process of setting routings. Routings set by ARI are based on the timetable, and thus relate to complete routings. In Dordrecht, a part routing was manually set for the double-decker, in order to reduce the accumulated delay. If, contrary to the normal timetable pattern which is completed without the intervention of the train controller, part of a routing is set which consists of only a yellow and a red signal, and which in addition is poorly visible, it should be possible for the train controller to monitor the progress of this train movement. In this case, on his screen, he would have seen that the double-decker had passed the signal.

The collision did not take place until 34 seconds after the signal at red had been passed. The Benelux train would have required 20 seconds to stop, and the double-decker 10 seconds. The train controller could have pushed the alarm button on the Telerail. Through this action, all drivers are instructed, via an acoustic alarm in the cab, to lower the speed of their train and to travel by sight (stop for any hazard). Immediately thereafter, he could have recalled signal 1130. If he had done this within 15 seconds, it would have been highly likely that the Benelux train would still have been halted in time, either by the driver or by an ATB intervention.

The train controller is only able to observe the incorrect passing of a signal by constantly monitoring the screen. This is not part of his task. In the past, the passing of a signal at red during a specified period was automatically notified to the train controller, by an extension of the safety system. On the basis of a large number of false alarms, this component was subsequently removed from the system.

However, this is not the only form of improved monitoring by the train controller. On the basis of his choices in respect of the set routings, the double-decker left the platform in Dordrecht at 12.42, and the Benelux train left one minute later, from the same platform.

Both trains had to travel to Lage-Zwaluwe. Together, all this means that the double-decker would be travelling on track PA (see figure 2) behind the Benelux train, with a separation of approximately one minute. By allowing the double-decker to depart before the Benelux train, in this situation, the traffic controller merely created greater confusion. Holding the double-decker at the platform, and allowing it to leave shortly after the Benelux train would also have been possible, and would have had the same effect. The driver would then have been able to see that he was expected to feed in behind the Benelux train.

4.4 OVERSHOOT DISTANCES

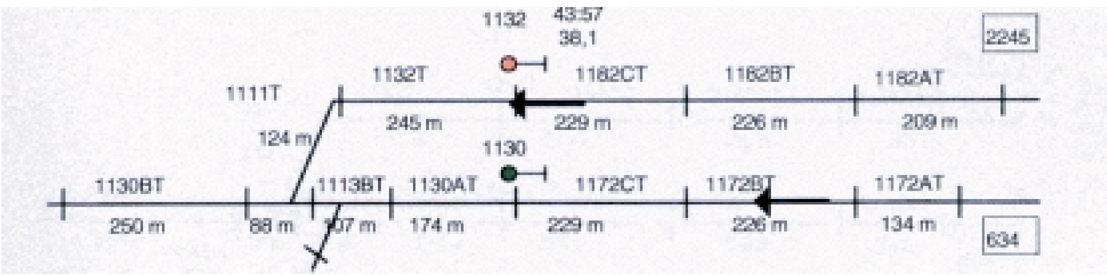


Figure 12. The track at signals 1130 and 1132 broken down into track sections. The arrows indicate the positions of the trains at the moment the double-decker wrongly passed signal 1132 (see also figure 3).

The diagram above shows the layout of the track at signal 1132, which was at red, and 1130, which was at green. Behind both signals are the so-called overshoot distances. The purpose of overshoot distances is to increase safety. They have no other function. The overshoot distance is a margin for trains which due to starting a braking action too late are no longer able to halt to stationary, before signal 1132 or 1130. The overshoot distance by signal 1132 is a section with a length of 245 metres, and at signal 1130, a section of track with a length of 174 metres. In the Netherlands, at least if there are no stations or other hindrances, overshoot distances are still applied at moving bridges and other particular hazard points.

When the double-decker passed signal 1132 at danger, the signal aspect in signal 1130 for the Benelux train did not change from green to red. This is remarkable. The section of track past signals 1130 and 1132 until the next signal, not appearing on figure 12, makes up a single block. A common principle in railway safety is: one train in one block. Signals which grant access to a block switch to red at the moment that the block in question is occupied, for whatever reason. When the yellow double-decker incorrectly passed signal 1132, signal 1130 should in fact have immediately switched to red. This did not happen in Dordrecht. The overshoot distance, a safety provision applied immediately after signal 1132, delayed the switching of signal 1132 to red, by at least 22 seconds.

In complex blocks, such as that in Dordrecht, Railinfrabeheer, the railway network manager, does not apply the principle: one train in one block. Instead, Railinfrabeheer operates a far more limited principle. To display a signal at safe (for example 1130), only those sections of track are checked for being free and unhindered which are located directly in the routing to be followed. In this case, only those sections were checked which were actually to be travelled by the Benelux train. The overshoot distance behind signal 1132, in which the double-decker was incorrectly located, is in fact a section of track not to be travelled by the Benelux train. In other words, this section was not checked as free and unhindered. If such a check had been carried out, the accident would very probably not have occurred.

On the Benelux train, travelling at 60 kilometres per hour, the Automatic Train Influencing system would have responded immediately to the block-occupied message. At that speed, the braking distance is approximately 140 metres. If the driver had not responded to the change in the ATB cab signal, after 4 seconds, the ATB system would have intervened with a full braking. (The driver is also able to respond earlier by applying full braking, but could also respond by applying limited braking, to prevent the ATB intervention. Because in this case the driver does not have access to some information relating to the cause of the ATB intervention, limited braking by the driver in order to prevent the ATB intervention is not an obvious option). The Benelux train was travelling at 17 metres per second. In theory, 208 metres would then be required to come to stationary. At that moment, the Benelux train was in section 1172BT. The minimum braking distance available was 229 metres, sufficient to still have reached stationary, before signal 1130.

The point of departure of Railinfrabeheer was formulated a long time ago, well before the introduction of Automatic Train Influencing. As a consequence, the railway infrastructure can be used very efficiently, at low cost. One disadvantageous effect is that overshoot distances delay the switching of signals to danger, in the event of unintended train movements.

5. CONCLUSIONS and RECOMMENDATIONS

To a considerable degree, safety depends on the correct interaction between the technical provisions and human task implementation. Whether this interaction takes the optimum form is always a continuous source of concern, and must therefore be continuously, systematically and fully monitored. For this purpose, a safety management philosophy is required, which consists of an effective safety management system, supported by a culture of safety.

This investigation gives rise to doubt about the relative priority given to safety in the organisation at Railinfrabeheer, NS Passengers, Railned and Rail Traffic Control, and about the quality of decision making in respect of safety. The question also emerges as to whether the safety management systems of these organisations, and above all the coordination between them, are sufficient. Indications which point towards this question are:

- the absence of initiatives for arriving at replacement of the out-of-date Automatic Train Influencing system
- the implementation of designs whereby the components are insufficiently harmonised
- the wanting application and enforcement of legislation and regulation and internal standards
- the policy in respect of setting part routings to limit delays, without managing any increased risks
- the decision to remove the automatic alarm when a signal at danger is passed
- the late response to the considerable growth in the number of occasions on which a signal at danger is passed.

As a consequence, step by step, the dependency on human task implementation has increased. The incontrovertible statistic about human failure then means that incidents and accidents are increasing in frequency, rather than being reduced. The remedy should first be sought in a more systematic application of safety management, supported by a culture of safety. These two features determine the framework and the limiting conditions within which drivers and other staff carry out their work. Together, these two could represent an important stimulus for best working practice.

RED LIGHT DISCIPLINE
The direct cause of the train collision in Dordrecht was the missing of signal 1132 by the driver of the double-decker. The limitations of the current Automatic Train Influencing system mean that precise compliance with all signals is a basic precondition for maintaining an acceptable level of safety on the railways. Driver discipline is a key factor in this equation. Nonetheless it is known that we cannot blindly trust driver discipline. Until 1995, the number of occasions on which a signal at danger was passed was 150 per year. Broadly speaking, this meant that every driver made a mistake one to two times in his working life. Since 1995, this number has risen however, to a total of 280 occasions in the year 2000. As a consequence, risks on the network have increased considerably. This represents a serious reduction of the level of safety on the railways.

The Council for Transport Safety recommends the management of the transport companies involved (in particular: NS Reizigers (NS Passengers), Railion[3]) to formulate measures whereby the number of occasions on which a signal at red is passed can be reduced, in the near future. The Council thereby suggests that poorly visible signals should be reported by drivers and the results notified to Railinfrabeheer (Rail Infrastructure Management).

AUTOMATIC TRAIN INFLUENCING

Following the accident in Harmelen in 1962, the Railway Accident Council advised the Minister of Transport and Public Works to fit the Dutch railway network with Automatic Train Influencing. One key consideration on the part of the Council was the finding that the intensive use of the railway network was no longer commensurate with the safety system which consisted exclusively of signals alongside the track. In 1962, driver discipline represented the foundation of the system, which contained no redundancy, whereby in the event of any failure, there was no backup system to prevent a train collision.

The Minister followed this recommendation and the railway network was equipped with an Automatic Train Influencing system of American origin. In 1962, the system was not fully perfected. In the period, computers were not used to control the systems, but instead relays (switches controlled by electrical coils), which due to their size offered only limited capabilities. For this reason, the number of tasks or functions which the ATB system can implement is limited. The designers of the system opted for prevention of train collisions at high speed. The system therefore does not operate at speeds below 40 kilometres per hour. For the same reason, the system also does not respond to signals at danger. The ‘influencing’ method is also limited. If a driver responds to a signal issuing an instruction to reduce speed, by braking lightly, the ATB system is satisfied. The ATB does not check whether the braking is sufficient to bring the train to stationary, within the braking distance available.

The collision in Dordrecht occurred whilst both trains were equipped with a correctly-functioning ATB system. Due to the limitations of the system, the collision was not avoided. Situations such as those in Dordrecht, whereby nothing more than a red signal and the correct response to that signal by the driver is meant to prevent a collision between trains, occur commonly. In principle, at any major station with side tracks. In 1992, the Railway Accident Council investigated a serious collision at the Eindhoven complex. One of the conclusions of the Council was that the Automatic Train Influencing system was no longer sufficient to requirements.

In 1962, the year in which the Railway Accident Council advised the Minister to equip the network with ATB, the number of train kilometres travelled on the Dutch railway network was more than 70 million. In 1992, the year of the collision in Eindhoven, the number of train kilometres (a yardstick for the average intensity on the network) was 108 million. In 1999, this had risen to 115 million. However, not only intensity of use has increased.
Due to the introduction of double-deckers, the number of passengers per train has also risen. The risks on the rail have been massively increased, by that fact alone.
Despite the Automatic Train Influencing system, at many locations on the railway net-

3 Railion is the former NS Cargo, as taken over by the Deutsche Bundesbahn.

work, safety is determined by the discipline of the driver. From this fact, as was the case in 1992 following the accident in Eindhoven, the conclusion must be drawn that the current Automatic Train Influencing system is no longer sufficient to the requirements imposed by railway use today.

These requirements mean that there must always be a safety net, in the event of a driver error. The current ATB system does not meet this requirement. On a European scale, a new Automatic Train Influencing system is being developed, which does meet modern requirements. The Minister, who since the reorganisation in 1995 is directly responsible for the Dutch railway network, has announced that in principle the Dutch railway network will be equipped with this system. The risk of trains colliding with derailed trains on adjacent tracks can also be prevented with this system. When the railway network will be equipped with the system, the Minister has not announced.

The Council recommends the Minister of Transport and Public Works to issue a clear statement about the phasing in which the Dutch railway network will be equipped with a modern, computer technology-based ATB system. The prevention of collisions with derailed trains on adjacent tracks should also be included in the programme of requirements.

SETTING PART ROUTINGS

For the double-decker, the train controller had set a routing which consisted of a yellow signal followed by a signal at danger, which was poorly visible. This routing met the currently applicable safety rules issued by the management of Rail Traffic Control. Nonetheless, this is a part routing which is recognised as being problematic. The train controller could have seen that the double-decker had missed signal 1132. The train controller had access to a number of possibilities according to which he could have attempted to prevent the collision. The precondition is that the train controller constantly monitors the screen, in order to follow the process. However, the management of Rail Traffic Control does not consider this a task of the train controller. It is the task of Rail Traffic Control to set routings, but not to subsequently monitor them. For this reason, none of the possibilities available could be used. The Council believes that the policy of the management of Rail Traffic Control, to make do with the unlimited acceptance of all technically possible routings without any follow-up action, is evidence of a too limited understanding of the tasks of the train controller.

The Council recommends the management of Rail Traffic Control to exercise considerable caution in setting part routings travelled at speeds below 40 kilometres per hour, and thus effectively without ATB monitoring, until the moment of introduction of a new modern ATB system. If part routings are nonetheless set, the train controller should supervise them. A reliable automatic warning signal to the train controller of the passing by a train of a signal at danger would be an essential tool.

THE DESIGN

Track 36 at Dordrecht, constructed by Railinfrabeheer, demonstrates a number of shortcomings. Signals should be visible in time. In addition, it should be clear that the signals are intended for the track along which the train is travelling. Track 36 does not meet these requirements.

In constructing track 36 in 1994, insufficient attention was paid to the visibility of signal 1132. Visibility is hindered by the construction of a noise abatement screen installed at the time of construction of track 36, and the vegetation which has grown behind that screen. The Council considers the visibility of signal 1132 insufficient.

Despite the passing of signal 1132 at danger, the signal aspect at signal 1130 did not switch from green to red. Behind these signals are overshoot distances. These are built-in safety margins for trains which have braked slightly too late. For the construction of these overshoot distances, design rules were applied which date from the nineteen fifties. At that time, continuous train detection was not fitted everywhere, and ATB (Automatic Train Influencing) also did not exist. The train collision in Dordrecht would not have occurred if the overshoot distance had been different. The Council places question marks by the design rules employed by Railinfrabeheer.

The implementation of track 36 in Dordrecht is the result of following the design process, whereby the disciplines involved within Railinfrabeheer each apply their own design rules. As concerns visibility of signals, even within a single discipline, there is no agreement about the points of departure to be employed. These deviate essentially from the formal, perhaps out-of-date regulations, without any exemption having been requested. This approach is contrary to the standard sheet on safety assurance systems issued by Railned. This standard sheet calls for a critical attitude in terms of safety, and continuous efforts to reduce safety risks.

The Council recommends the management of Railinfrabeheer to harmonise the design process for rail infrastructure with the standard sheet on safety assurance systems issued by Railned, and to harmonise the designs with the current statutory rules.

A design is developed solely by a specific discipline, the primary system. The design process is not established redundantly, in terms of safety. The second opinion approach does not exist. The result is not independently assessed, due to the absence of a supervisory body.

The Council recommends the Minister of Transport and Public Works to appoint a supervisory body for the government-commissioned organisations.

OVERVIEW OF PART INVESTIGATIONS

This final report is based on the following part reports, prepared under the auspices of the Council for Transport Safety. These part reports, in particular, provide explicit descriptions of the various facts (operational, technical, organisational). The part reports are available on request.

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 9 June 2000, Fact-finding
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 9 June 2000, Control process
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 19 July 2000, Frameworks and rules
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 19 July 2000, Nature of injuries and material damage
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 19 July 2000, Environmental risks
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 19 July 2000, Conditions of parties involved[4]
  By the Council for Transport Safety / Railned

- Investigation Two passenger trains collide in Dordrecht on 28 November 1999
  Part report dated 18 July 2000, Countering the consequences
  By the Council for Transport Safety / Railned / Ministry of Home Affairs
  and Kingdom Relations, Inspectorate for Fire Prevention and Contingency Planning

- Signals 1180 and 1132 in Dordrecht / An ergonomic evaluation
  Railned 15 June 2000
  Carried out on behalf of the Council for Transport Safety

4 Due to its particular character, this part report will only be issued to persons or organisations for whom this information is specially relevant.