Goods train derailment near Apeldoorn on 30 April 2003

The Hague, February 2005

The Safety Investigation Board

The Dutch Safety Investigation Board is an independent administrative body and individual legal entity instituted in Dutch law and tasked with investigating and determining the causes or probable causes of individual incidents or categories of incidents in all sectors. The sole objective of such investigations is to prevent future accidents or incidents, and if considered meaningful on the basis of the results, to duly issue recommendations. The organisation consists of a Board with five permanent members and ten permanent committees. For specific investigations, special Supervisory Committees are appointed. The Board is supported by an office consisting of researchers, secretary-rapporteurs and other support staff.

The Safety Investigation Board is the legal successor to the Council for Transport Safety. The present investigation was carried out by the Council for Transport Safety but is being published under the auspices of the Investigation Board. The appendix contains a statement of accountability for the investigation.

Visitors' address:	Anna van Saksenlaan 50 2593 HT The Hague	Correspondence address	P.O. Box 95404 2509 CK The Hague
Telephone:	+31 (0)70 333 7000	Fax:	+31 (0)70 333 7077
Internet:	http:/ www.safetyboard.nl		

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CONSIDERATIONS

On 30 April 2003, a goods train loaded with steel coils derailed close to Apeldoorn, leading to considerable havoc. The investigation by the Council for Transport Safety has demonstrated that the derailment was caused because the goods train passed through a set of points at a speed of 70 kilometres per hour, whilst a maximum speed of 40 kilometres per hour was permitted. This excessive speed was due to a lack of alertness on the part of the driver, caused by sleepiness. There is even a possibility of 'microsleep', a brief period of sleep (up to 30 seconds) followed by a period of 'sleep-induced sluggishness' during which it is possible to react, but less rapidly and less accurately. Another factor which probably contributed to the derailment was the insufficient securing of the steel coils as a result of which they were able to shift.

The report before you clearly shows that this derailment cannot be considered as a one-off accident, but that it was due to structural safety shortcomings. The most important safety shortcoming relates to insufficient control of the speed of goods trains. A second safety shortcoming relates to the loading process.

Control of speed
The most important safety shortcoming exposed by the derailment near Apeldoorn is that the speed of goods trains is insufficiently controlled. The crucial safety task, namely the control of speed, is almost entirely left to human intervention. If a driver fails, for whatever reason, there are no technical provisions to step in. Certainly at night, drivers (as is the case with all people) can fail due to sleepiness, because working at those moments conflicts fundamentally with the natural biorhythm. In addition, at night, circumstances are more monotonous which promotes the occurrence of (micro) sleep.

Control of speed consists of two aspects: monitoring maximum speed and slowing the train in time. For both aspects, the current system for Automatic Train Control (ATB) [1] has proved insufficient as a catch net in the event of driver failure, as was the case in Apeldoorn as a result of reduced alertness. Firstly, the ATB system is set merely to monitor the locally-applicable track section speed, and not the maximum speed set for a specific train. This is primarily a problem for goods traffic, because goods trains generally have a maximum speed of 100 kilometres per hour or lower, because of their weight and braking force, whilst many track section speeds have been set at 130 or 140. The ATB then does not respond to a violation of the maximum train speed, but only if the locally-applicable maximum track section speed is exceeded. Secondly, the ATB system is unable to check whether the initiated braking is sufficient to reduce the speed to the level indicated by the signal (in this case) 40 kilometres per hour (the so-called 'braking curve monitoring'). If these monitoring possibilities had been included in the design of the ATB system, the speed violation in Apeldoorn would have been detected at an earlier stage, and the derailment could have been prevented.

The outlined risks of (uncontrolled) speed violations and reduced alertness on the part of the driver are inherent in the transport of goods by rail. The transport process for goods by rail in fact primarily takes place at night (with the accompanying risks of reduced alertness and sleep) and the limitations of the ATB system, as described, are above all relevant for goods trains, because the maximum train speed (which is often lower than the track-related maximum speed) is not technically limited. Any operator should be thoroughly aware of the resultant risks, and should take adequate control measures. Against this background, the Board is surprised by the fact that both risks have been insufficiently recognised by Railion, and that this operator has not thoroughly charted out

[1] ATB First Generation; the ATB system such as that employed at Apeldoorn, and at this moment employed for the vast majority of the Dutch railway network. The Board is undertaking a separate investigation into safety shortcomings of this ATB system, as a result of the collision in Amsterdam in May 2004.

the scale of the problem, despite the fact that both speed and sleep in night hours are well-known phenomena, for which there is greater attention within other transport sectors such as road traffic (speed) and air transport (sleep). The speed of trucks, for example, is technically limited by a built-in speed limiter. Railion makes no use of such simple means of monitoring the maximum train speed. Furthermore, Railion fails to make use of the journey registration system already present in its locomotives, for monitoring compliance with maximum train speeds and the driving behaviour of the train drivers. Certainly given the fact that the same problems of sleep and speed violations have emerged in previous incidents and accidents, the Board has concluded that within Railion, these safety aspects have received insufficient attention.

The outlined shortcomings in respect of speed control of goods trains are one hundred percent the individual responsibility of the operator. In addition, the government also has a responsibility for ensuring that operators comply with laws and regulations as laid down, and impose relevant requirements on the manner in which operators take up their own responsibility. The responsibility for supervision and enforcement has been granted to the Transport and Water Management Inspectorate (IVW). Any such inspectorate may be expected to specifically focus on the major risks, which without any doubt include speed violations by goods trains. We have noted that in inspections by the IVW, this aspect was not dealt with. In addition, in issuing its safety certificate (which effectively contains the approval for the operator's safety management system), the IVW failed to note that the relevant risks in relation to speed control and travelling during night-time hours were insufficiently considered in the risk assessment and evaluation of the operator.

Loading process
In the judgement of the Board, the safety of the load reveals a second shortcoming. The steel coils on the train in question were not correctly secured. The traces on the first derailed wagon indicate that the coils shifted due to the occurrence of lateral forces and that this shift in all probability contributed to the derailment.

A simulation investigation has demonstrated that for the transport of oiled steel (for example the coils transported in this case), the coefficient of friction between load and wagon reaches such a critically low value, that the shifting of the load is a clear possibility. This critical parameter relating to the safe transport of goods was not adequately considered, in the system. Neither the forwarder (Corus) nor the operator (Railion) gave any indication that prior to the accident they were aware of this critical parameter. The safety system for loading (both regulations and the design of the wagon and the loading instructions) would appear to be based on the transport of non-oiled steel, which ignores the fact that oiled products are also transported.

Finally
As concerns the infrastructure, the Board was unable to determine whether there were indeed any deviations, because essential information concerning the condition of the infrastructure shortly prior to the derailment could not be provided by the infrastructure manager. The Board considers this fact undesirable, also because the absence of information hinders the investigation into underlying causes.

The Board believes that the above described safety shortcomings relating to the management of speed and the loading practices are unacceptable; certainly if we consider that a derailment could also occur with the transport of hazardous substances, or that a derailment could result in a collision with a train travelling in the opposite direction. There is a realistic risk that in such cases, the result would not be restricted to merely material damage. Against this background, the Board has issued recommendations for raising the safety of goods transport by rail to a higher plane.

Recommendations:

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;*
   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.*

2. Railion Nederland N.V. is recommended to better identify the risks of loading processes.
   In that respect, account must for example be taken of the coefficient of friction of oiled steel on steel, and the related risk of the shifting of the steel coils. The result of this inventory and evaluation must be laid down in unequivocal and effective loading instructions.

3. Corus Strip Products IJmuiden is recommended to better identify the risks of the loading process (in particular of oiled coils) on goods wagons. It is also recommended that the loading process be organised such that compliance with the loading instructions agreed with the operator (for example in respect of securing the load) is guaranteed.

4. The Transport and Water Management Inspectorate is recommended to increase the supervision of goods transport.
   Under all circumstances, the Board would recommend 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*
   b) *drawing up a structural inspection programme in respect of maximum speeds of goods trains of all operators.*

1 INTRODUCTION

1.1 The accident

In the night of Tuesday to Wednesday 30 April 2003, at around 0.42 hours, a goods train derailed, when passing through the Apeldoorn complex. The goods train, operated by Railion Nederland N.V., consisted of an electrical locomotive and 21 goods wagons loaded with steel coils. The train was en route from Beverwijk Hoogovens Centraal to the border near Oldenzaal, with as its eventual destination Salzgitter in Germany. The derailment caused tremendous havoc, and considerable material damage. Parts of the derailed goods wagons and load ended up on the adjacent public highway.

Following the derailment, the Council for Transport Safety carried out an initial investigation into the immediate and possible underlying causes of the accident. This initial investigation indicated a number of different shortcomings. The suspicion that these were structural shortcomings, and the fact that every week in total some 1400 goods trains travel along the Dutch railway network, caused the Council to decide to initiate a further-reaching investigation into the accident.

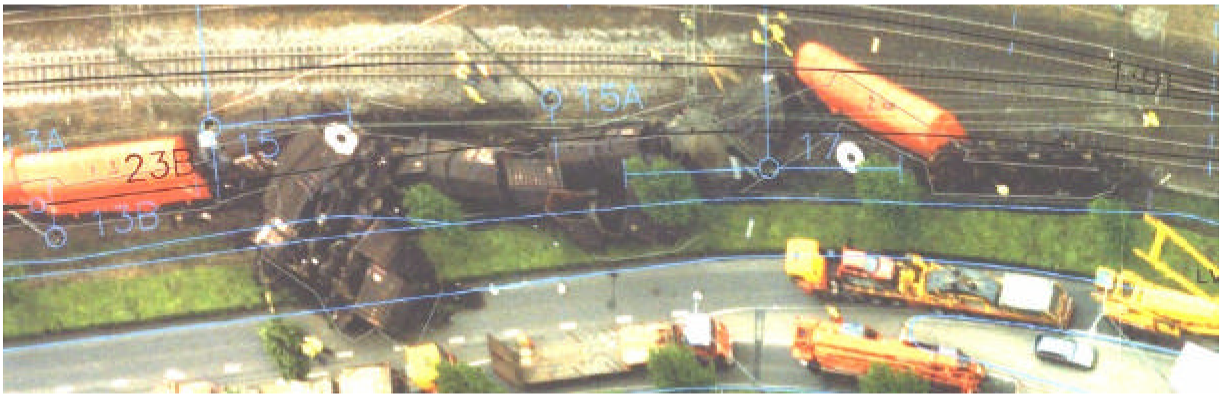

Figure 1: Aerial photo from the National Police Agency (KLPD) of the havoc following the derailment

1.2 Task of the Safety Investigation Board

The statutory task of both the Council for Transport Safety (up to 1 February 2005) and of the Safety Investigation Board (from 1 February 2005) is

- to investigate the (suspected) causes of accidents and
- to formulate recommendations aimed at preventing future accidents or incidents.

The Council for Transport Safety, like the Safety Investigation Board, is an independent organisation. Neither Council nor Board carries out investigations into questions of guilt; this is specifically a task for police and the judicial authorities.

(Underlying) causes of an accident or incident always occupy a central position.
In that connection, attention is primarily focused on the (manageable) circumstances and background within which it was possible for the accident to take place.

1.3 The investigation

The investigation consisted of a number of phases. The first phase focused on determining the immediate cause of the derailment. For this purpose, use was made of a simulation study based on evidence collected at the accident site. From this study, it was determined that the speed of the train, probably in combination with the shifting of the load, played a decisive role in the derailment.

The second phase of the investigation concentrated on the question what actions by the parties involved may have caused the identified deviations in respect of the loading and driving of the train. The infrastructure and route control were also discussed at this point. From these investigations, it emerged that the speed of the train had risen too high, partly as a consequence of the reduced alertness of the driver, due to sleep. As concerns the physical state of the infrastructure shortly before the accident, no details were available. It can however be stated that even without deviations in the infrastructure, the derailment can be explained in accordance with the identified traces.

In the final phase of the investigation, the frameworks and rules applicable for the situation in question at the time of the accident were investigated. On this basis, the Council judged the extent to which the risks exposed by the accident were sufficiently recognised by the parties involved, and whether sufficient measures had been taken.

The reference framework on the basis of which the Board issues any such judgement consists firstly of the applicable legislation. In this legislation it is for example specified that the operator is required to inventorise, analyse and monitor safety-critical activities in its business process. The safety objectives drawn up on this basis must then be implemented in that business practice.
Secondly, the reference framework consists of the general conviction of the Board that safety must at all times be managed, guaranteed and continuously improved. To achieve this goal, within every single process, under all circumstances, the following safety steps must be taken:

a) inventory and evaluation of risks
b) on this basis, the drawing up of a plan and identification of preventive and repressive measures
c) organisation and coordination of the implementation of safety plans and measures
d) monitoring safety, and investigating and analysing incidents, near accidents and accidents
e) implementing periodic observations, inspections, audits and (risk) analyses with a view to identifying points for improvement and actively focusing on those points
f) implementing a periodic evaluation and as necessary adjusting safety policy

In these respects, both government and commercial operators have their own responsibilities. Commercial companies are responsible for managing, ensuring and continuously improving their own processes. It is the responsibility of government to ensure that operators comply with all law and regulations as laid down, and to impose requirements on the way in which operators implement their own responsibility.

1.4 Organisations involved

A number of private and public organisations were involved in the Apeldoorn derailment. Below, each of these organisations is introduced.

1.4.1 Railion

Railion Nederland N.V. is the largest rail transport company for goods in the Netherlands and is part of Railion Deutschland AG (27,000 employees) which in turn is part of the Stinnes group. Stinnes is a joint venture established by the Deutsche Bundesbahn with the objective of undertaking international activities. Railion Nederland, in its current form, in principle emerged from the goods wing of the Netherlands Railways. In the Netherlands, Railion employs 1200 people. Railion operates its own locomotives, goods wagons and employs approximately 370 drivers. Every week, some 1400 goods trains travel through the Netherlands amounting to 72,000 trains every year. Of these 1400 goods trains per week, approximately one quarter contain hazardous substances; the remaining three quarters carry other goods such as containers and steel. Railion operates several trains every week, loaded with steel coils. In the Netherlands, for the most part, goods trains travel in evening and night-time hours.

1.4.2 Corus

Corus Staal BV, based in IJmuiden, is the largest operating company in the Netherlands of Corus Group Plc. Corus Group Plc is a multinational steel manufacturer established in 1999 following a merger between the British-based British Steel Plc (currently Corus UK Ltd) and the Dutch-based Koninklijke Hoogovens N.V. (today Corus Nederland BV). In 2003, annual production totalled 19 million tonnes of steel, of which 6.5 million tonnes were produced in IJmuiden. The major customers are the construction industry (30%), the automotive industry (16%) and the packaging industry (15%). Total turnover in 2003 amounted to 8 billion GBP (approx. 11.5 billion Euro). The total number of employees worldwide, at year end 2004, was 49,400, of whom approximately half are employed in the United Kingdom of Great Britain, and almost one quarter (12,000) in the Netherlands.
Corus Staal BV operates three Business Units, namely Corus Strip Products IJmuiden, Corus Packaging Plus and Corus Colors. The derailed train was loaded at Corus Strip Products IJmuiden.

1.4.3 Prorail

Prorail is the government-appointed manager of the Dutch railway network. Prorail is an independent company, financed almost entirely by the government. Prorail emerged following a merger between the former government-commissioned organisations Railverkeersleiding (Rail Traffic Control), Railinfrabeheer (Rail Infrastructure Management) and Railned. At present, ProRail employs some 2900 staff, and consists of three main components. Railinfrabeheer is responsible for the management, maintenance and laying of the railway infrastructure. Railned and Rail Traffic Control are active in capacity management. In the event of disasters and incidents, Prorail is also responsible for sounding the alarm and information provision, and for tackling the consequences, in as much as relevant to railway aspects.

1.4.4 Ministry of Transport, Public Works and Water Management

The policy in respect of the transport of goods by rail has been allocated within the Ministry of Transport, Public Works and Water Management to two Directorates General:

- Directorate General for Goods Transport (DGG), Transport Safety Directorate, Cargo and Risk Policy department.
- Directorate General for Passenger Transport (DGP), Rail Directorate.

The Rail Directorate of DGP is responsible for policy preparation in relation to rail safety. This Directorate is also responsible for drawing up policy documents in respect of railway safety.
The Transport Safety Directorate of DGG makes specific contributions to that process, in respect of the transport of goods in general, and the transport of hazardous substances in particular.

Supervision and administrative enforcement within the railway sector are the task of the Transport and Water Management Inspectorate, Rail Division. The Transport and Water Management Inspectorate (IVW) is part of the Ministry of Transport, Public Works and Water Management. Since 1 July 2001, IVW has been monitoring and promoting the safety of transport by road, ship, in the air and from 1 January 2003, also by rail. The organisation is also responsible for supervising 'water management aspects'. In this process, the Inspectorate makes a contribution to the safety, quality of life and accessibility of the Netherlands, with the fewest possible accidents, incidents and environmental pollution.
The Transport and Water Management Inspectorate is directly responsible to the Secretary General for the Ministry of Transport, Public Works and Water Management, and as such occupies the same position within the Ministry as the policy Directorate General (such as DGG and DGP).

2 THE COURSE OF EVENTS

2.1 Departure

On 28 and 29 April 2003, wagons were loaded at Corus in IJmuiden with steel coils and transported to the stabling sidings of the Beverwijk Hoogovens Centraal complex. On 29 April, at the start of the evening, a train was assembled at Beverwijk Hoogovens Centraal, consisting of 21 wagons loaded with coils.
At around 20:00 hours, the train was inspected and approved by the duty Railion wagon inspector, after which, at 21:30 hours, an electrical locomotive (E-loc 1613) was coupled to the train. Following a successful brake test, the train, no. 47555 departed at 21.33 hours (more than 10 minutes later than planned) heading for Amsterdam – Amersfoort. The total weight of the train was 1758 tonnes. The goods train was scheduled with a timetable speed of 80 kilometres per hour. The maximum speed of the train, based on the available braking percentage, was set at 95 kilometres per hour.

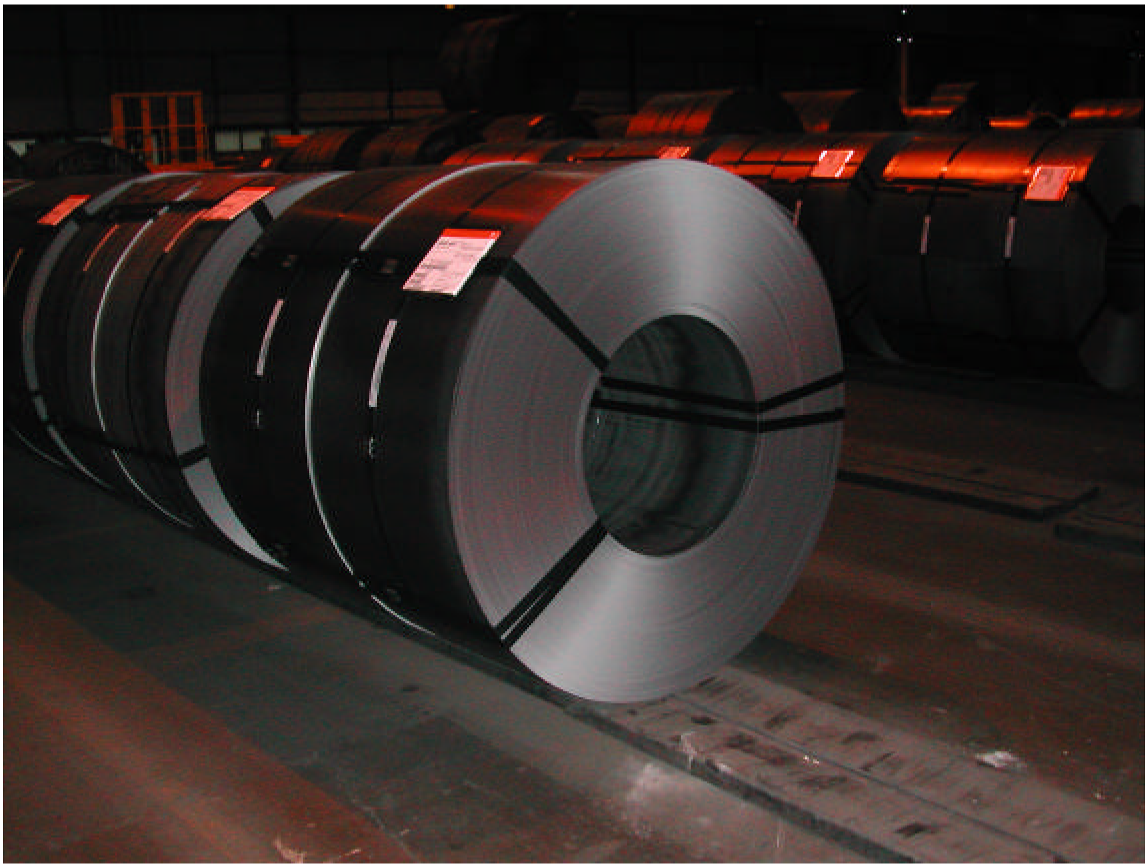

Figure 2 Steel coils; weight between 11 and 27 tonnes; cross-section between 1.5 and 2 metres.

2.2 The Amersfoort – Apeldoorn route

At around midnight, the train passed through Amersfoort. By this stage, the delay had been reduced to approximately 5 minutes. At Stroe, approximately halfway along the 44 kilometre route between Amersfoort and Apeldoorn, in accordance with the timetable, the train was placed on a siding. When the route was once again released, the driver raised the speed to approximately 95 kilometres per hour.

From approximately 10 kilometres before Apeldoorn, the track is on a downward gradient, on average approximately 3 metres per kilometre. The driver failed to notice that the speed of the train had gradually risen to approximately 118 kilometres per hour.

Approximately 1250 metres before a set of points for a right-hand turnout (points 23a), the train passed a signal (signal 12) showing 'yellow 4', which means that by the next signal, the driver must have reduced the speed to a maximum of 40 kilometres per hour. The driver failed to respond directly to this signal, but only several seconds later, when having passed the signal, the ATB code change signal sounded, in the cab. The driver responded with light braking, thus complying with the ATB braking criterion (as a result of which the ATB system did not intervene). However, this braking was insufficient to be travelling at 40 kilometres per hour, by the next signal. When the driver saw a signal at red (which was intended for the adjacent track) and noted the excessive speed, he initiated urgent braking. However, it was too late to sufficiently reduce the speed. At signal 28 (showing 'green flashing'; maximum speed 40 kilometres per hour), the train was still travelling at approximately 80 kilometres per hour.

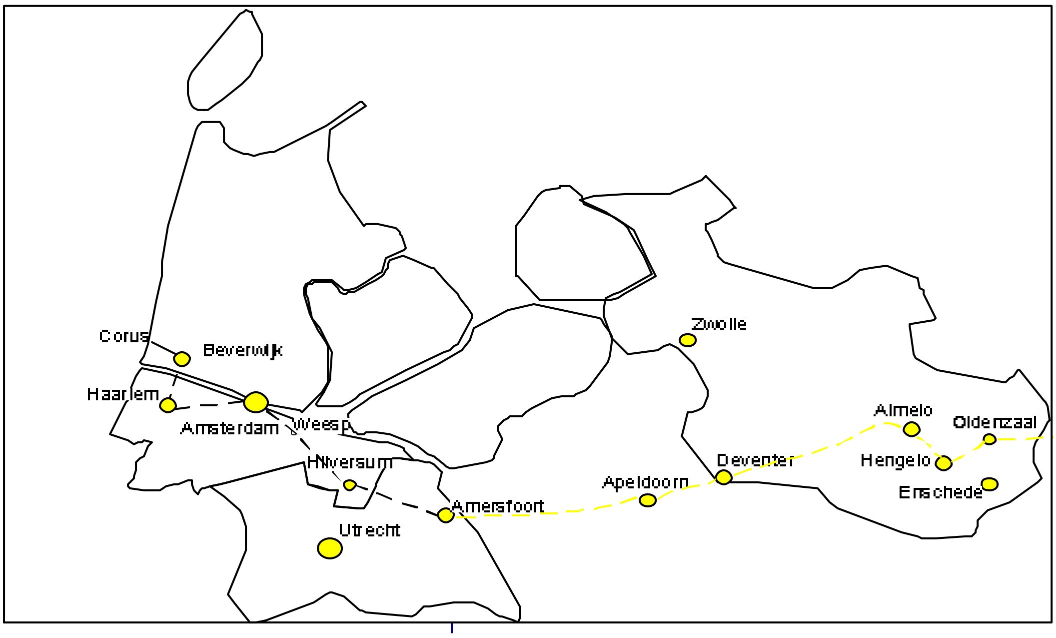

Figure 3 Route of the train through the Netherlands

2.3 The derailment and the consequences

Points 23a are located approximately hundred metres after signal 28. The maximum speed at these points is 40 kilometres per hour, when switched to right-hand turnout and 60 kilometres per hour when switched to left-hand turnout. The route for this train had been set via the right-hand turnout setting of the points, to track 105, therefore with a maximum speed of 40 kilometres per hour. On reaching the points, the train was still travelling at 70 kilometres per hour.

At around 0:42 hours, the train derailed. Due to the forces occurring in the train upon entering the points, the right-hand wheels of the first wagon broke free of the rails, after which point the front bogie[2] started running on the right-hand side, next to the track.

[2] A bogie is a movable component of a rail vehicle (generally) with two axles on which the top section is mounted by means of a pivot. (Normally) there are two sets of bogies on every vehicle; there are also rail vehicles with two fixed axles.

This bogie continued running alongside the track for approximately 100 metres, until the train entered a left-hand bend, at points 23b. At this time, the first wagon tilted to the right. Following the derailment of the first wagon, a further 9 wagons derailed. The back 11 wagons did not derail.

As a result of the tilting and derailment of the wagon behind the locomotive, the rear axle of the locomotive was also derailed to the left-hand side. The locomotive came to a stop at a level crossing. The driver had immediately recognised that the train had derailed, and notified the traffic controller. The traffic controller initiated all the measures necessary in this situation.

The consequences of the derailment were considerable. The infrastructure, the track between points 23a and 23b and the section of track towards the level crossing were severely damaged over a distance of several hundred metres, and had to be replaced. The damage to the goods stock was very considerable: ten wagons and the locomotive derailed. Due to the derailment, the wheels of the wagons buried themselves in the track. As a result, and because of the toppling of the first wagon, the front section of the train came to a halt very rapidly. Due to the massive deceleration, the next six wagons toppled over across and alongside the track. In respect of the direction of travel of the train, the wagons derailed to the right, next to the track, whereby coils of steel also fell from the train, and parts of the goods wagons (the steel hoods) ended up crossing the verge and finishing up on the adjacent public highway. Of the ten derailed wagons, seven were irreparably damaged. The locomotive suffered minor damage.

Figure 4 An impression of the havoc following the derailment

3 ANALYSIS

3.1 Immediate cause of the derailment

The first question that arose following the derailment of the goods train near Apeldoorn on 30 April 2003 was precisely how the derailment took place. The answer to this question is contained in this paragraph. The next question as to why it happened as it happened (the question about the underlying causes) is then answered in the subsequent paragraphs. All the details in this chapter relate to the situation before 30 April 2003, unless otherwise indicated.

3.1.1 Reconstruction of the derailment

From Beverwijk to Amersfoort, the train journey took place without incident. After Amersfoort, by which stage it was already around midnight, the train headed towards Apeldoorn. Following a brief stop at Stroe, the driver raised the speed of the train to approximately 95 kilometres per hour; the specified maximum speed for this train. When the train had reached this speed, at some point, the driver lost concentration as a consequence of sleep, probably microsleep. Microsleep in particular occurs during night-time hours, and can be further promoted by monotonous circumstances. Both these situations were present.[3].
The sleepiness and resultant reduced alertness and disorientation meant that the driver failed to notice that the speed of the train had gradually risen to 118 kilometres per hour as a result of the downward track gradient, that he failed to react to a yellow signal[4] and braked insufficiently to achieve the required speed reduction.

For this train, Prorail Rail Traffic Control had set a route via a 1:9 set of points, subject to a maximum speed of 40 kilometres per hour. The setting of this route cannot be identified as a direct cause of the accident. The setting of such a route is a standard process, and there were no deviations. The choice of route is however an ‘underlying’ factor.

As a result of the actions by the driver, as described above, on arriving at these points, the train was not travelling at 40 but at 70 kilometres per hour. Probably as a result of the excessive speed at this set of points, at least one coil on the first wagon behind the locomotive started to shift. The forces which occur when travelling at 70 kilometres per hour through a 1:9 set of points, combined with a coil which is shifted towards the side of the wagon, meant that this wagon began to tilt, and the front wheels started running alongside the track. At that moment, the wagon was still upright, but in the next bend it toppled over completely, after which time, due to the massive deceleration caused, a further nine wagons derailed and toppled over.

3.1.2 Technical and factual underpinning

The factors which influence the occurrence of a derailment include the speed, the (distribution of the) mass, the height of the centre of gravity, the vehicle characteristics (such as suspension) and the characteristics of the infrastructure (such as radius of curvature, cant, etc.).

For the reconstruction of the accident, it proved impossible to precisely determine all the forces. Details on the speed, mass, vehicle characteristics and design of the

[3] See paragraph 3.2.1 for a further description of this form of sleep.
[4] In this case, the signal showed ‘yellow 4’. This means that the speed at the next set of signals must have been reduced to a maximum of 40 kilometres per hour.

infrastructure were available, but details about the actual condition of the infrastructure shortly before the accident were lacking. To nonetheless make some statement about the factors which caused the derailment, a simulation study was carried out on the basis of the traces found.

The traces found at the site of the accident demonstrate that the train derailed in a right-hand bend (right-hand turnout), in other words towards the inside of the bend. The only logical explanation which can be given for this fact is as follows. The derailment began when, in a right-hand bend, due to the high speed, one or more coils shifted entirely to the left-hand side of the wagon. Due to the combination of the high lateral forces to the left (as a result of the excessive speed) and the shift of mass to the left, the right-hand wheels of the first wagon behind the locomotive were raised. As a result, the wheel sets were no longer guided by the rails, and the front bogie was able to derail to the right.

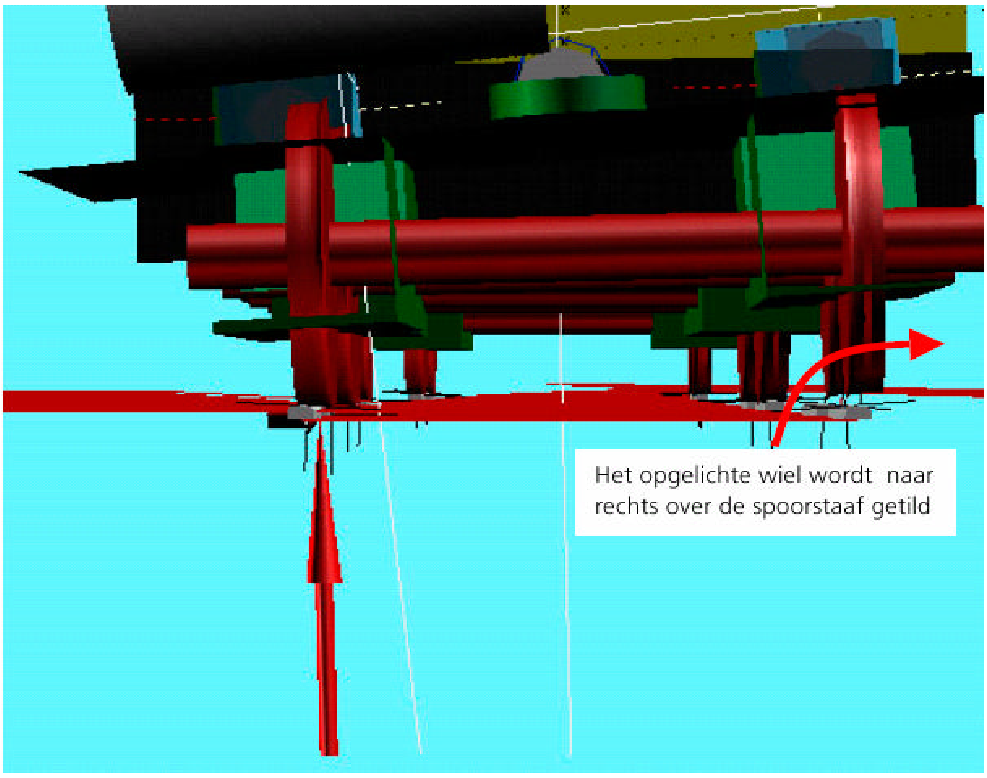

Figure 3 The modelled moment of derailment of the first wagon behind the locomotive. In a right-hand bend, the wagon rotates clockwise around the vertical vehicle axis. Because of the high rotary inertia, this rotation was maintained for a relatively long period, and the bogie was able to derail, on the right-hand side.

In a bend, a wheel can break free from the rail, if the balance of forces is such that the vertical force on the wheel on the inside of the bend becomes zero. The result is a tilting moment. If this continues, the wheel breaks free from the rail, and the vehicle can topple. In the case of the derailment in Apeldoorn, there was a brief tilting moment, as a result of which the right wheels were lifted off the rail. The wagon did not tilt further, but the front wheel sets ended up to the right of the rail, due to the turning of the wagon[5] to the right.

Speed
At the moment of derailment, the train was travelling at approximately 70 kilometres per hour where a maximum speed of 40 kilometres per hour was permitted. The high lateral

[5] In a right-hand bend, the wagon rotates clockwise around the vertical vehicle axis. Because of the high rotary inertia, this rotation is maintained for a relatively long time.

forces generated as a result in the bend of points 23a were a major contributing factor to the derailment. The speed may therefore be identified as primary factor for the derailment. The implemented simulation study, however, demonstrated that other factors must also have played a role. Because if the only deviation had been speed (i.e. without deviations in load, securing and infrastructure), in theory, in this specific situation, at this set of points, this train would only have derailed at a speed of approximately 100 tot 110 kilometres per hour.

Load
Traces of sliding on the first wagon indicate that at least one coil on the first wagon behind the locomotive had shifted (almost) entirely to the left, whereupon it slid to the right, and fell off the wagon, on the right-hand side. The simulation study demonstrated that if the coils shift to the left-hand side of the wagon, at a speed of approximately 70 kilometres per hour, the train does derail in the manner indicated by the traces found at the accident location. On this basis, it is probable that the traces of sliding (to the left) as found at the site occurred prior to the derailment. This shift to the left contributed to the fact that in the right-hand bend, the forces were applied to the left-hand wheels, as a result of which the right-hand wheels were raised, and the bogie was able to derail.

Coils start to shift if the lateral acceleration power exceeds the maximum frictional force. In this case, the frictional force was relatively low, because the coils had been coated with an oil layer. Estimates of the frictional force of oiled steel on steel[6] range from 0.01 to 0.1. At such values, at a speed of 70 kilometres per hour, on passing through a set of points (of the 1:9 type), the coils are bound to shift.

Effective securing is aimed at preventing the tilting and lateral shift of coils. It has been noted that many of the coils were insufficiently secured. Examination of trace evidence has demonstrated that the coils on the first wagon behind the locomotive were secured with two securing arms per coil, whilst 4 arms per coil were available. The separation between the front coil and the securing arms was within the required standard (15 mm); it was no longer possible to determine the situation with the back coil. Investigation of other wagons (both derailed and non-derailed wagons) showed that in at least 11 of the 21 wagons, the separation between the securing arms and coils was too large, or that the coils were only partially (two arms) or entirely not secured.

Infrastructure
In general, it can be stated that the condition of the infrastructure influences the occurrence of a derailment. A range of track-related parameters (such as distortion, cant, etc.) may either increase or decrease the risk of derailment.

Because no information was available in respect of the actual state of the infrastructure shortly before the accident, it was not possible to determine any deviations in respect of the design. For this reason, in the simulation study, the design data for the infrastructure were assumed. In that situation (no infrastructural deviations), the derailment could be explained in accordance with the facts: due to the excessively high speed (70 kilometres per hour) and the shifted cargo (evidence of sliding to the left and to the right on the first wagon), in a right-hand bend, this wagon derailed on the right-hand side (wheel tracks to the right of the rails).

The fact that the derailment can be explained without any track irregularities does not mean that there were no deviations on the track. However, it does suggest that even if there had been deviations, these would not have been of decisive importance.

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[6] VDI guideline 2700 (German standard): steel on oiled steel 0.01-0.1. Triboregister Bouwdienst Rijkswaterstaat 1995: steel on oiled rubber 0.02.

Two indications were discovered, which suggest possible deviations in the track. Firstly, it was noted that halfway between points 23a and 23b, the left-hand rail has subsided. This is very probably consequential damage and was not the cause of the derailment. The subsidence was discovered after the first identifiable damage due to the derailment. That this is consequential damage can be explained, given the severe load placed on the rails during the derailment (with peaks exceeding 200 kN; the specified load-carrying capacity of the rails).
Secondly, it was noted that shortly before the accident, (planned) maintenance was carried out on the superstructure, between points 23a and 23b. During this maintenance, a number of sleepers and part of the ballast were replaced. A number of other sleepers, according to the maintenance contractor's timetable, were due to be checked during the weeks after the accident. This could have meant that the lateral resistance of the track was not at the optimum level, as a result of which the track could shift sideways due to the massive lateral forces, leading to a 'kink' in the curvature of the bend. However, no traces of such a kink were discovered.

In the two weeks between the work and the derailment on 30 April, at least ten trains had travelled over the same section of track. This led to no problems or reports of track irregularities. This is an indication that before the steel train passed over it, the track demonstrated no extreme irregularities. However, as we have already stated, this does not mean that there can have been deviations which increased the risk of derailment.

3.1.3 Conclusions on the immediate cause

- It may be concluded that the derailment was firstly caused by the excessive speed of the goods train. The shifting of the load is probably a second, additional factor. Both factors are further analysed in paragraphs 3.2 and 3.3 respectively.

- The setting of a route over a 1:9 point with a maximum speed of 40 kilometres per hour may not be identified as an immediate cause of the accident. Setting such a route is a standard process, and there were no deviations. However, the choice of route was an 'underlying' factor, and as such is discussed in paragraph 3.4.

- To what extent any deviations in the infrastructure increased the risk of derailment can no longer be determined, because of the absence of details concerning the current state of the infrastructure shortly before the accident. It may however be stated that the derailment can also be explained, even without any track deviations.

3.2 Underlying causes insufficient speed control

3.2.1 Driving behaviour of driver

Insufficient control of the speed of the train played a key role in the occurrence of the accident in Apeldoorn. In fact, insufficient control of speed breaks down into two aspects: the violation of the maximum speed (118 as opposed to 95 kilometres per hour) and the non-timely reduction of speed (speed at the points was 70, where a maximum of 40 kilometres per hour was permitted).

The background for both the violation of the maximum speed and the non-timely reduction of speed can be derived to the driving behaviour of the driver[7]. In respect of the following points, the driving behaviour deviated from the desired and required behaviour in this situation:

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[7] As registered by Automatic Journey Registration (ARR) in the locomotive.

- For a period of at least 5 minutes (approximately 10 kilometres), the driver failed to notice that the speed of the train had risen from 95 to 118 kilometres per hour, as a result of a downward gradient. Even before Stroe, the speed had risen to above 95 kilometres per hour, on a number of occasions.
- The driver missed the signal ‘yellow 4’, and only started to brake following the ATB cab signal (signal which sounded several seconds after passing the signal).
- The driver first only started to brake gently, whereas this could never have been sufficient to slow the train to 40 kilometres per hour, by the next signal.
- The driver reacted to a set of signals which were not intended for his own train.

On the basis of this information and on the basis of the statements of the driver, it may be deduced that there was evidence of reduced alertness on the part of the driver, as a result of sleepiness. There may even have been ‘microsleep’. The driver stated that he had temporarily ‘slipped off’ and was not alert. This statement is supported by the facts outlined above, which suggest that the driver had no full understanding of the situation at that moment. Nonetheless, it is not the case that the driver fell asleep, because he continued to operate the deadman’s handle.

Microsleep is a short period of sleep (up to 30 seconds) during which it is not possible to respond to external impulses. This short-term sleep is followed by a period of ‘sleep-induced drowsiness’ during which it is possible to respond, but less rapidly and accurately. There is then clearly a reduced capacity to drive. The fact that even during this period the driver continued to operate the deadman’s handle is entirely consistent with microsleep. During a period of sleep-induced drowsiness, the person is able to continue to implement routine actions. The occurrence of microsleep need not necessarily be a consequence of lack of sleep. No indications were found to suggest that the driver was lacking sleep. The driver also underwent psychological and physical examinations, and prior to the derailment felt entirely well. No direct link can be established between the physical condition of the driver at that moment, and the occurrence of microsleep.

There are two important factors which could explain this form of sleep. Firstly, the moment is particularly decisive. Microsleep occurs relatively often amongst staff working irregular shifts and above all at times which are unfavourable for the biorhythm, such as after midnight. Secondly, monotony is an important factor. This was a monotonous journey, with monotonous noise, a simple task (as long as the track section is free, only ‘monitoring tasks’) and the fact that the driver was alone; in combination, all of these facts certainly can promote sleepiness.

3.2.2 Technical aids

To control the speeds of trains, maximum speeds are set, and the system of signals was developed. The signals monitor the speed in the sense that they indicate when a driver is required to reduce speed or stop.
The general maximum speeds are related to track sections and specific locations. All trains must comply with these location-specific speeds. Quite apart from these location-specific speeds, deviating maximum speeds may for example apply for goods trains. For goods trains, the maximum speed is in part dependent on the available braking percentage[8] (which determines the required braking distance). For the ‘accident train’, a train-related maximum speed of 95 kilometres per hour applied, whilst the track section speed for the Amersfoort – Apeldoorn route was set at 130 kilometres per hour.

The driver is responsible for complying with the maximum speed and complying with signals. To support this compliance, the ATB protection system has been introduced on the vast majority of the Dutch railway network. This system monitors the track section

[8] The braking percentage is calculated according to the braking capacity available and the total train weight. The level of the braking percentage determines the maximum speed of the train.

speeds[9] and speeds indicated by signals. If the speed rises above the track section speed, or if a signal indicates that the speed must be reduced for example to 40 kilometres per hour, the ATB system in the train indicates that it is necessary to brake. If the driver fails to react by braking, the system will automatically halt the train completely, by initiating emergency braking.

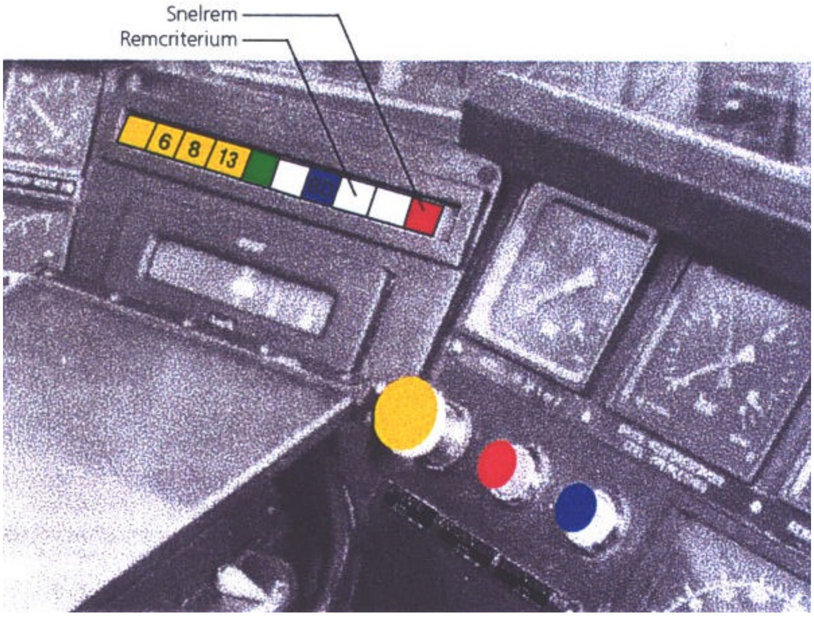

Figure 4 The workstation of a driver with ATB cab signalling

The ATB system has been designed such that neither the excessive train speed nor the insufficiently rapid reduction in speed could have been prevented. The current ATB system[10] in fact only monitors the ‘track-related’ maximum speeds, and not the ‘train-related’ maximum speeds. With a goods train such as the derailed train in question, this means that the ATB system does not respond to a violation of the maximum speed of 95 kilometres per hour, but only intervenes at 130 kilometres per hour (the track-related maximum speed). This means a margin of 35 kilometres per hour within which the technical systems do not respond to a violation of maximum speed by the train[11]. In addition, the system is ‘satisfied’ if the driver initiates any braking, as long as braking is continued until the required speed is reached. The system does not check whether braking is sufficiently hard to achieve the required speed before the next signal.

Alongside the ATB system, there is a second technical tool which is set to act as a safety net in the event of human failure. This is the deadman’s handle, which is intended to check for the presence of the driver and his ability to react[12]. The derailment in Apeldoorn demonstrates that this tool does not offer sufficient assistance in the event of reduced alertness as a result of (micro)sleep, because the operation of the ‘deadman’s handle’ is a routine action.

3.2.3 Business operation Railion

[9] In as much as the track section speed matches the ‘speed ceilings’ in the ATB system 40, 60, 80, 130 or 140 kilometres per hour. If the two do not match, the next ‘speed ceiling’ above the track section speed is monitored.
[10] This is the first generation ATB systems. The new generation does not suffer these limitations.
[11] In theory, this margin can be far greater. There are for example trains with a maximum speed of 60 kilometres per hour. If such a train is travelling on a track section with a maximum speed of 140 kilometres per hour, a margin of 80 kilometres per hour is the result.
[12] Standard sheet M-001, page 42

The above arguments demonstrate that the driving behaviour of a driver can deviate from the desired driving behaviour, for example as a result of the influence of sleep. In addition, the ATB system is unable to prevent a train considerably exceeding specific train-related maximum speeds, and the deadman's handle is not always able to prevent a driver being hindered by particular forms of sleep.

The risk of sleep is particularly relevant for the transport of goods by rail, because a large proportion of this transport takes place during night-time hours. These are specifically the moments that are unfavourable for the biorhythm, as a result of which in particular amongst people working irregular shifts, forms of sleep such as microsleep can occur. The risk of violating the maximum speed is greater when transporting goods than transporting passengers. Goods trains, after all, often have a permitted maximum speed which (for example as a result of the available braking capacity) is lower than the permitted speed on a given section of track. The ATB system only checks the 'track-related' maximum speed and not the 'train-related' maximum speed. Because as speed increases, the braking distance increases quadratically, without the ATB system intervening, the maximum train speed can be exceeded to the extent that at a set of points, the critical derailment speed is reached. As a general rule of thumb, Prorail states that the critical derailment speed at a set of points is one and a half to two times the maximum speed. Specifically for the set of points in question (points 23b), Prorail has issued a general derailment indication of 82 kilometres per hour; twice the design speed of 41 kilometres per hour[13].

Because the related risks of derailment due to a violation of maximum speed and (micro)sleep are inherent in goods transport, according to the legal standards, this risk should be part of the operator's safety management system[14]. The necessity of such inclusion is underlined by the fact that previous accidents or incidents have occurred whereby the maximum speed was violated (for example: derailment of goods train at Etten-Leur, 20 May 1999) and/or (micro)sleep of the driver was a cause (for example: passing through signal at red in Arnhem on 5 April 2003).

In a risk inventory and evaluation submitted by Railion Nederland N.V., 'excessively high speed' is identified as a 'form of failure' which can result in derailment, collision or the passing of a signal at red. 'Inattentiveness' is also named as a possible 'cause of failure'. The risk of reduced alertness as a result of sleepiness of drivers is not expressly notified in the Risk Assessment and Evaluation in question. For these risks, there is also no action plan with specific management measures.

Railion itself in no way supervises compliance with maximum speeds. No speed checks are carried out and other possible tools, such as an analysis of the train's journey registration (ARR), are not used.

Supervision of drivers is another means of enabling the operator to manage the process of train driving and to monitor and influence the driving skills of the drivers. Supervision of the driver involved in the accident did not comply with the statutory standards imposed[15] nor with the policy of the operator itself. The policy of Railion provides for annual, professional re-instruction of every driver, including a test, as well as supervision

[13] This is a general fact. Specific characteristics of a train may mean that the derailment speed is higher or lower. The simulation undertaken indicates that in this specific case (this train at this set of points), there was a higher derailment speed of 100 tot 110 kilometres per hour.

[14] Standard sheet V-001, art. 1.3.1: "The operator carries out an inventory of safety-critical activities in his business operation, and carries out a risk analysis."

[15] Standard sheet M-014 requires reinstruction in a cycle of 3 years or less for the entire scope of the task of (amongst others) drivers. Reinstruction must be concluded with an examination. It must be determined whether the normal method of task implementation is adequate, and whether knowledge concerning rarely-occurring events and changes to regulations and task implementation are adequate.

of drivers by a technical supervision specialist, during one shift each year. In approximately five years active service as a fully-authorised driver, the driver in question had only one written recorded interview with the team leader (in 2000), was supervised on only one occasion during a journey by a fellow driver (not recorded in writing) and received re-instruction on just two occasions. Railion also makes no use of such resources as the train's journey registration, to gain an indication of the driving behaviour of drivers. Railion has indicated that it does not use general journey registration (ARR) for preventive monitoring, because this is too time-consuming and costly.

3.2.4 Supervision

The Transport and Water Management Inspectorate (IVW) generally speaking supervises the railway system. Part of this supervision involves supervision of operators. In this respect, the Inspectorate carries out audits amongst operating companies and passes judgement on the safety management system, and the degree to which this system is complied with, in practice.
In the framework of extending the safety certificate, in 2003, the IVW carried out an audit. This audit resulted in an extension of the safety certificate (issued on 28 March 2003), on condition that a number of further specified points be solved. One of these points related to the professional guidance and supervision of drivers. This had been insufficiently developed within Railion. As part of the audit, the risk inventory and evaluation was also requested, but no substantive comments were issued in that respect.

The investigation into incidents and accidents is also part of the supervision of the railway sector. The IVW operates a structure for investigating accidents and incidents. Research has shown that accidents and incidents have occurred in the past, whereby excessive speed and/or micro(sleep) sleep played a role.

Another component of supervision of the railway system relates to implementation of inspections. Before 30 April 2003, the IVW had no programme for inspections of compliance with maximum speeds by goods trains.

3.2.5 Conclusions on speed management

- The ATB system was not designed to monitor the maximum train speed and to check whether braking is sufficiently powerful. As a result, trains are able to far exceed certain maximum speeds. With any reduction in the capacity to act on the part of a driver, through certain forms of sleep (such as microsleep), the deadman's handle does not in all cases result in the train being stopped.

- Although the risks of speed violations and (micro)sleep are inherent in the transport of goods by rail, the operator has insufficiently systematically analysed the related risks. In addition, the operator was not able to demonstrate operation of an action plan relating to these risks.

- Railion does not sufficiently supervise the driving behaviour of drivers, and fails to supervise compliance with maximum speeds, by goods trains. Supervision and periodic assessment of drivers is also not up to the standard set by the company itself, and set by relevant regulations.

- In issuing a safety certificate to Railion, IVW did request the risk assessment and evaluation, but issued no comments concerning shortcomings present in the document. Furthermore, IVW operates no inspection programme including inspection of compliance with maximum speeds by goods trains.

3.3 Underlying causes insufficient securing of the load

3.3.1 Coefficient of friction oiled steel on steel

The lateral shift of the load probably influenced the derailment. Coils of steel were able to shift because they were insufficiently secured. Some of the securing arms on the wagons were not used, whilst others were incorrectly used (with considerable separation between coil and securing arm). It is not certain that even if all securing arms had been correctly used, that in this deviating situation of 70 kilometres per hour rather than 40 kilometres per hour, the coils would not have shifted. It is however a clear fact that a lateral shift of coils represents a risk, and that the securing of the load on at least 11 of the 21 wagons was insufficient.

The risk of lateral shift of goods is determined on the one hand by the speed and radius of the bend around which the vehicle is travelling, and on the other hand the coefficient of friction and the securing of the goods. On the first wagon to derail in Apeldoorn, oiled steel was being transported in a wagon, with a steel cradle. The fact that the coils were oiled is of particular importance in this connection, because it unfavourably influenced the coefficient of friction. Paragraph 3.2.1 indicates that with oiled steel on steel, the coefficient of friction is between 0.01 and 0.1, whilst for steel on steel without a lubricant, a coefficient of friction three times as high (approximately 0.3) is assumed. With these values, the possibility cannot be automatically excluded that coils will shift during transport. A simple calculation provides an indication that even if the maximum speed is not exceeded, the shifting of the coils is a possibility[16]. This is irrespective of the weight of the coil. This underlines the importance of a critical risk inventory and evaluation of the risks of transport of this type, by the operator and the forwarder.

3.3.2 Legislation and regulations

The general starting principle in the Railways Act is the responsibility of the operator for damage as a result of the implementation of a service, unless that damage arose through no fault of their own (article 1). In addition, the forwarder also bears individual responsibility for the correct loading and securing of goods. According to article 55 of the ARV (General Transport Regulations), the forwarder must load a cargo in such a way that no risk can arise for persons or goods. The Board believes that both the operator and the forwarder bear responsibility. The operator is responsible for the provision of loading instructions to the forwarder, to guarantee safe transport, and the forwarder is responsible for implementing these loading instructions, as correctly as possible. Everyone is responsible for carrying out a risk inventory and evaluation for the loading process, because in that process, both the products and the positioning of the load (forwarder's knowledge) and the vehicle and transport route (operator's knowledge) are essential.

In railway legislation and the underlying regulations, there are no specific instructions relating to the securing of goods. The correct securing of goods is only referred to in the IVW standard sheet M-013, which deals with technical inspections for the operator. This sheet states 'The technical inspection also includes an evaluation of the load to determine that this is unable to move in a manner which endangers railway safety. The loading instructions for appendix II of the RIV apply'. The RIV (Règlement International de

[16] If a coefficient of friction of 0.05 is assumed, this means that in the case of a bend with a radius of 200 metres, the coil would in theory, if not secured, already start to shift at a speed of 36 kilometres per hour. In this calculation, no account has been taken of the dynamic forces and suspension of the wagon, and it is assumed that the track demonstrates no cant. The calculation is then based on the assumption that the 'sliding threshold' is the moment at which the centrifugal force is equal to the maximum frictional force. To be able to determine the precise 'sliding threshold', tests would be necessary, for example for determining the precise coefficient of friction.

Véhicules) is a collection of international agreements between railway companies brought together within the UIC (Union Internationale des Chemins de fer). Regulations relating to loading and securing are laid down in Annex II book 1 of the RIV. For the transport of coils, with a unit weight exceeding 10 tonnes, the following is laid down: 'crosswise to the wagon, the goods must be secured against shifting and against tilting. Goods must be supported to at least the centre of gravity, if the width is less than 4/10th of the cross-section'. In other words, reference is made to both the risk of shifting and of tilting. As concerns the prevention of shifting, no other further requirements are imposed on securing, neither in relation to the securing arms (number and strength) nor the maximum separation between coil and securing arms. No attention is focused to the coefficient of friction as a critical parameter, in these regulations. The regulations would appear to assume the transport of non-oiled steel.

3.3.3 Business operation Railion

Railion and Corus have entered into a contract for the transport of coils by rail. In implementation of this contract, Railion provides wagons to Corus. In the contract with Corus, Railion included 'loading instructions' for the loading of these wagons, constructed specifically for the transport of coils.
These loading instructions deal primarily with the maximum weights of the coils and their distribution across the wagon. In the version dated 1 June 2002, no reference is made to the securing of the coils on wagons of the 'Shimmns' type. In a version dated May 2003, it is stated in the introduction 'that the coils must be enclosed using the arms mounted on both sides of the cradle'. This version also states that the separation between coil and securing arms on both sides may not be more than 3 centimetres, in total.

Alongside the general loading instructions, the 'Shimmns-ttu operating instructions' have been included. These instructions are specific to a new type of wagon (introduced in 2002) for the transport of coils. These instructions do contain a number of details about securing. It is specified that every coil must be enclosed with all four securing arms. In the derailed train, a number of wagons of this new type were included, but the first derailed wagon was of an older type (late 1970s). In respect of the old type of wagons, such operating instructions are not available.

In none of the instructions nor the loading instructions is reference made to the effects of the transport of oiled coils on the coefficient of friction, and the resultant importance of sound securing.

Following the introduction of a new type of coil wagon ('shimmns TTU'; in 2002), Corus identified problems with the operation of the securing arms. Operation allegedly required more force than permitted according to Health and Safety at Work standards. However, because of the high transport demands, use of these wagons was very much desirable. In response to a request for advice from Corus, Railion informed the company in writing that this type of wagon could be temporarily deployed without using the securing arms, until the problem was solved. In this letter, Railion indicated that it would accept the risks for its own account. According to Railion, this decision was based on studies by the Deutsche Bahn, and a recommendation based on those studies, which indicates that securing of coils up to a speed of 90 kilometres per hour is not necessary, because of the high frictional force. In this study, however, non-oiled coils were assumed, whilst Corus in fact transported oiled coils. As explained at the start of this paragraph, the oil layer has a major effect on the coefficient of friction. It was also suggested by the operator that coils with a weight of 10 tonnes or more will not or hardly shift, because of their high weight. However, the moment at which a coil starts to shift is primarily determined by the coefficient of friction, and is not dependent on weight.

In principle, such decisions on loading and securing are beyond the scope of the supervisor, because the rules in question are based on private law. The Dutch government is not responsible for supervision. This applies both for the requirements on loading and the requirements relating to the construction of railway wagons. The rules for such work are laid down by the railway companies in Europe (combined in the UIC) and those same companies (were) are also responsible for the admission of rolling stock. This latter task is now the responsibility of the IVW. However, it is not laid down with retroactive effect, for older rolling stock, so that in respect of the derailed wagons, there was neither supervision on the construction of the wagon (including the securing mechanism), nor on the method of loading the wagon.

The operator is required in law to carry out a ‘technical inspection’ of (goods) trains prior to departure. As demonstrated in Standard sheet M-013, this also includes an inspection of the loading. However, the inspection in the Standard sheet is limited to ‘visible defects’ which was interpreted by both the operator and by IVW such that during the inspection, closed wagons need not be opened. In practice prior to April 2003, the hoods of coil wagons therefore remained closed, during inspection. In consultation between forwarder and operator, after 30 April 2003, the decision was taken to randomly open hoods, to check the correctness of loading and securing.

3.3.4 Business operation Corus

As forwarder, Corus has a statutory responsibility for the safe loading of wagons. The starting principle in implementing this responsibility is the loading instructions as provided by the operator. In respect of the loading of coils, the Logistics and Transport department did carry out a risk inventory and the evaluation for the internal process, but this is focused primarily on working conditions and does not deal with safety risks ‘outside the gates’. The difference between oiled and non-oiled steel is not discussed in the work instructions for the loading process.

Within Corus, the Logistics and Transport department is responsible for organising the transport on the Corus site and to the customers. This department enters into contracts with operators for the transport of raw materials and products by road, water and rail.

In respect of rail transport, Corus has entered into a contract with Railion. Part of this contract is a set of loading instructions, including those for coil wagons. The department where loading takes place (in this case production unit Hot Rolled Steel 2) is responsible for a translation of these loading instructions into work instructions. The method of securing as discovered on the derailed train deviated in a number of respects from these work instructions.

During loading at Hot Rolled Steel 2, work is carried out in a fully-continuous process, by 5 shifts, each of 20 men. The final loading of wagons is carried out by a group of three to four employees, of whom one is responsible, and signs for inspection of the loading.

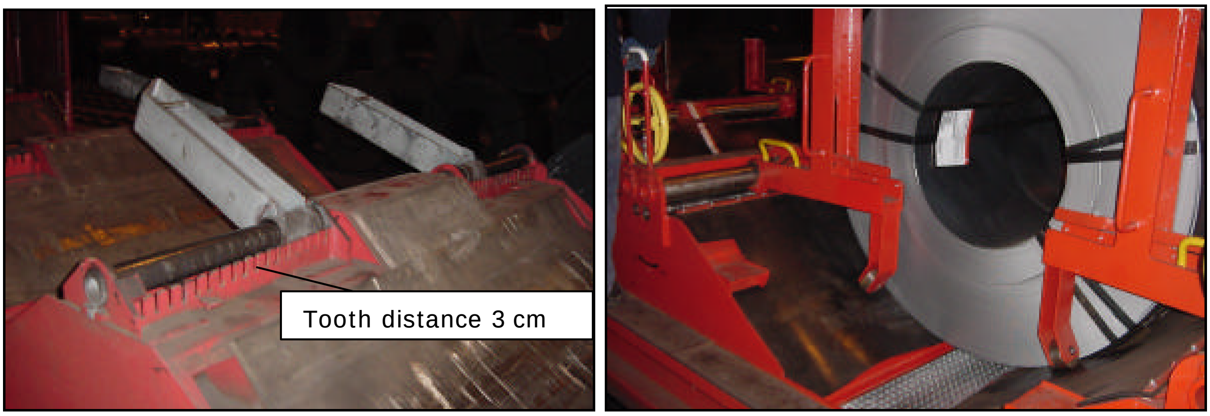

Figure 5 Different types of securing arms (tooth mechanism and slide mechanism)

The workplace instructions at Hot Rolled Steel 2 applicable at the time of the accident, state that coils/strips must be secured to the wagon ‘by lowering the two securing beams as closely as possible on each side of the package’. This instruction conceals two uncertainties. Firstly, not two but four arms are available if (as is the case with the derailed wagon) two coils are placed on a single wagon. The newest type of coil wagon at least has four securing arms for each coil, irrespective of the number of coils transported on the wagon. The workplace instructions suggest that the use of two arms is sufficient. Secondly, the workplace instructions refer to the term ‘package’. From interviews, it emerged that employees understood the term ‘package’ only to refer to a combined quantity of strips (narrow coils). The suggestion made by the workplace instructions, therefore, is that in the case of a single wide coil, the use of securing arms is not necessary.

The suggestion that the securing of single coils is not necessary is further strengthened by two factors. Firstly, during interviews, employees suggested that wagons are in use at Corus which do not have any securing arms. This also strengthens the idea that the securing of coils is not so important. Secondly, for a new type of coil wagon, Railion issued temporary permission to not use the securing arms (see also under ‘business operation Railion’). This fact also strengthens the impression that the securing of coils is not so important.

When the employees have loaded a wagon, the hood of the wagon is closed. No independent inspection is carried out by the forwarder, for the correctness of the loading and securing.

3.3.5 Supervision

As already stated in the previous paragraphs, following the loading process, there is no further inspection of whether the loading has actually been carried out in accordance with the applicable rules. Neither the forwarder nor the operator carry out any inspection in this respect.
The IVW also fails to carry out any structural inspection of the loading and securing method for goods. Supervision by government on the loading of trains is limited, because the rules for the construction of goods wagons and the loading thereof do not have the status of legislation. After all, the RIV is a collection of mutual agreements between railway companies.

3.3.6 Conclusions on loading

- Both the operator and the forwarder have a statutory responsibility for the safety of the load. The Board believes that the operator is responsible for the provision of loading instructions to the forwarder, that guarantee safe transport, and that the forwarder is responsible for ensuring that these loading instructions are implemented as accurately as possible. Each is responsible for sound risk assessment and evaluation. In these instructions, sufficient attention should be paid to the risk that oiled coils may shift laterally, as a consequence of a low coefficient of friction.

- Railion is insufficiently aware of the risk of shifting coils, and the importance of sufficient securing thereof. The loading instructions from Railion are insufficient in terms of instructions for the securing of coils, and the temporary permission granted to Corus to not use securing arms was not based on any accurate, demonstrable risk assessment. Railion does not check whether the loading and securing comply with the relevant rules, and has furthermore reached no agreements with Corus concerning the responsibility for checking the load.

- Corus is insufficiently aware of the risk of the shifting of goods, and the importance of sufficient securing thereof. The work instructions in this respect can be understood in several ways, and there is no independent inspection[17] as to whether the instructions are in fact correctly implemented.

- The Transport and Water Management Inspectorate carries out no structural supervision of the loading method for goods wagons. This relates to the fact that many rules for the loading of wagons are sector-based agreements, and not part of legislation.

3.4 Additional factor: route control

3.4.1 Choice of route

At Apeldoorn, the steel train was routed via track 105. Track 105 does not run alongside a platform and in practice is little used. This route takes in points 23A, for right-hand turnout. The maximum speed on this track is 40 kilometres per hour. The main track through Apeldoorn station is track 104; via points 23A with left-hand turnout. The maximum permitted speed along this track is 60 kilometres per hour.

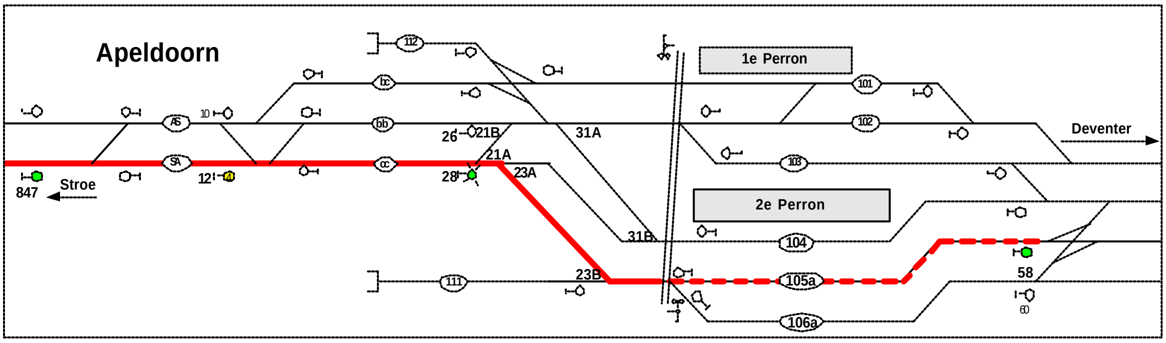

Figure 6 The Apeldoorn track complex: the red line shows the selected route for the goods train. The train came to a halt in front of the dotted section.

The setting of the route via track 105 with a set of 1:9 points and a maximum speed of 40 kilometres per hour cannot be viewed as an immediate cause of the accident. Setting of such a route is a standard process, and there were no deviations. However, if a route had been selected, along the direct track (track 104), the risk of derailment as a result of excessive speed would have been reduced. This is because Prorail indicates that the design of the infrastructure is so robust, that generally speaking, on a set of points of this type, a train will only derail at a speed of between one and half and two times the set maximum speed. If we do not take into account the shifting of the load, this means that via track 105, generally speaking, the likelihood of derailment only occurs at a speed of approximately 80 kilometres per hour, and via track 104 only at around 120 kilometres per hour. This means that in this respect, track 104 offers a substantially higher safety margin.

The route via track 105 was set by the automated route control system. This means that the traffic controller did not manually select this route.

[17] Irrespective of the shift loading the wagons.

It emerged in the investigation that Railion requested a route for this train, via track 104 (the main track) and that Prorail Rail Traffic Control was supplied a plan from the planning department of NS Passengers, in which track 105 was selected. It remains unclear how track 105 was eventually included in the plan. One possible reason for selecting this route may have been ‘rust running’. Rust running is a rule introduced by Prorail Rail Traffic Control, in which it is stated which tracks must be travelled at least once every 24 hours, in order to prevent rust formation on the track (and the related detection problems). This rule also applied for track 105. Because track 105 does not run alongside a platform, it seems an obvious solution to use the goods train for rust running. The question as to whether rust running truly was the reason for selecting this route, could no longer be answered.

For Railion, the route provided was a deviation from the route they themselves had requested. Railion was not aware of this fact. Despite the fact that Railion is not in favour of sending heavy goods trains along neighbouring tracks, the goods operator does not maintain a record which routes have been planned for Railion trains, and the extent to which these routes match the requested routes.
As concerns the use of goods trains for rust running, there were contacts between Railion and Prorail Rail Traffic Control, but these contacts did not result in any clear agreements[18].

It should further be added that a driver must always take account of the possibility of deviating routes, which may be made necessary as a result of delays, track work, etc.

3.4.2 Neighbouring track

Track 105 (the route set for the steel train) was a less frequently-travelled track, with a low maximum speed, a so-called neighbouring track. The railway manager has opted to deal with such neighbouring tracks differently from frequently-travelled, through tracks (so-called main tracks) in two respects.

Firstly, given a lack of funds for completing overdue maintenance, in practice, the quality level for neighbouring tracks has often not been raised to the level of the maintenance specifications, but instead (less strict) safety specifications are assumed. These safety specifications outline the minimum conditions necessary for safe usability.

Secondly, the general condition of the main line is for example monitored by means of measurement by a measuring train. As a result, recent details are always available for the main line, concerning rail position, cant, wear, etc. However, for reasons of cost, measuring trains do not travel on secondary tracks such as track 105 in Apeldoorn, as a result of which knowledge of the quality of this track is not as advanced.

Even the maintenance contractor has no measurement data in respect of the condition of this track. It is however known that in the weeks prior to the accident on the track (between points 23a and 23b), planned maintenance was carried out; a number of sleepers were replaced and the ballast at this location replenished. Railinfrabeheer pointed out that the maintenance contractor is not expected, after completing such minor maintenance tasks, to register the extent to which the track complies with the safety standards imposed.

3.4.3 Conclusions on route control

[18] After 30 April 2003, according to a publication from Railion, agreement was in fact reached with Prorail Rail Traffic Control on the question as to which trains may or may not be eligible for rust running.

- On track 104 (main line), a train is less likely to derail as a result of excessive speed, than on track 105 (neighbouring line).

- Railion had in fact requested a route via track 104. It remains unclear how neighbouring line 105 was in fact placed in the automatic system for route control.

- Railion was not aware of the fact that the route offered deviated from the requested route. Railion does not maintain structural records of which routes are offered in practice and to what extent these deviate from the requested routes.

- Prorail has no detailed measurement data about neighbouring tracks, because the decision has been taken not to run the measuring train on these tracks.

4 CONCLUSIONS

4.1 Conclusions on the immediate cause

- It may be concluded that the derailment was firstly caused by the excessive speed of the goods train. The shifting of the load is probably a second, additional factor. Both factors are further analysed in paragraphs 3.2 and 3.3 respectively.

- The setting of a route over a 1:9 point with a maximum speed of 40 kilometres per hour may not be identified as an immediate cause of the accident. Setting such a route is a standard process, and there were no deviations. However, the choice of route was an ‘underlying’ factor, and as such is discussed in paragraph 3.4.

- To what extent any deviations in the infrastructure increased the risk of derailment can no longer be determined, because of the absence of details concerning the current state of the infrastructure shortly before the accident. It may however be stated that the derailment can also be explained, even without any track deviations.

4.2 Conclusions on speed management

- The ATB system was not designed to monitor the maximum train speed and to check whether braking is sufficiently powerful. As a result, trains are able to far exceed certain maximum speeds. With any reduction in the capacity to act on the part of a driver, through certain forms of sleep (such as microsleep), the deadman’s handle does not in all cases result in the train being stopped.

- Although the risks of speed violations and (micro)sleep are inherent in the transport of goods by rail, the operator has insufficiently systematically analysed the related risks. In addition, the operator was not able to demonstrate operation of an action plan relating to these risks.

- Railion does not sufficiently supervise the driving behaviour of drivers, and fails to supervise compliance with maximum speeds, by goods trains. Supervision and periodic assessment of drivers is also not up to the standard set by the company itself, and set by relevant regulations.

- In issuing a safety certificate to Railion, the Transport and Water Management Inspectorate (IVW) did request the risk assessment and evaluation, but issued no comments concerning shortcomings present in the document. Furthermore, IVW operates no inspection programme including inspection of compliance with maximum speeds by goods trains.

4.3 Conclusions on loading

- Both the operator and the forwarder have a statutory responsibility for the safety of the load. The Board believes that the operator is responsible for the provision of loading instructions to the forwarder, that guarantee safe transport, and that the forwarder is responsible for ensuring that these loading instructions are implemented as accurately as possible. Each is responsible for sound risk assessment and evaluation. In these instructions, sufficient attention should be paid to the risk that oiled coils may shift laterally, as a consequence of a low coefficient of friction.

- Railion is insufficiently aware of the risk of shifting coils, and the importance of sufficient securing thereof. The loading instructions from Railion are insufficient in terms of instructions for the securing of coils, and the temporary permission granted to Corus to not use securing arms was not based on any accurate, demonstrable risk assessment. Railion does not check whether the loading and securing comply with the relevant rules, and has furthermore reached no agreements with Corus concerning the responsibility for checking the load.

- Corus is insufficiently aware of the risk of the shifting of goods, and the importance of sufficient securing thereof. The work instructions in this respect can be understood in several ways, and there is no independent inspection[19] as to whether the instructions are in fact correctly implemented.

- The Transport and Water Management Inspectorate carries out no structural supervision of the loading method for goods wagons. This relates to the fact that many rules for the loading of wagons are sector-based agreements, and not part of legislation.

4.4 Conclusions on route control and infrastructure

- On track 104 (main line), a train is less likely to derail as a result of excessive speed, than on track 105 (neighbouring line).

- Railion had in fact requested a route via track 104. It remains unclear how neighbouring line 105 was in fact placed in the automatic system for route control.

- Railion was not aware of the fact that the route offered deviated from the requested route. Railion does not maintain structural records of which routes are offered in practice and to what extent these deviate from the requested routes.

- Prorail has no detailed measurement data about neighbouring tracks, because the decision has been taken not to run the measuring train on these tracks.

4.5 Final conclusion

The Board believes that in every process and in particular in the process of goods transport by rail, safety must at all times be managed, guaranteed and continuously improved. To achieve this objective, the parties involved must at least assess and evaluate the safety risks of their primary processes, and effective measures must be taken to manage those risks (safety management system). In addition, the government also bears responsibility for ensuring that operators comply with the legislation and regulations imposed, and in that connection for imposing requirements on the way in which operators implement their own responsibility. The Board has been forced to recognise that a number of these conditions have not been fulfilled:

- The safety management system of Railion demonstrates several shortcomings in respect of the control of speed and load. Risks within the primary process, such as sleepiness and speed violations have been insufficiently identified and are insufficiently managed. There is too little supervision of the driving behaviour of drivers; for example, journey registration records are not used. There is also insufficient demonstrable knowledge present concerning the risks of the transport of oiled coils. Finally, Railion has no insight into the degree to which the routes

[19] Irrespective of the shift loading the wagons.

offered deviate from the routes requested (in part based on safety). These shortcomings lead the Board to conclude that in the business operation of Railion regarding the control of speed of goods trains and the loading safety receives insufficient attention.

- In addition, the investigation shows that there is a major gap in the focus on the safety of goods transport by rail. The coefficient of friction between the goods and the wagons and the resultant securing requirements are critical parameters for the safe transport of goods. This aspect was not adequately included in the primary process at the forwarder Corus[20].

- Supervision by the Transport and Water Management Inspectorate was insufficient. In the most recently held audit at Railion, it went unnoticed that the risk inventory and evaluation, and the measures based thereupon, demonstrate shortcomings. The IVW also operates no inspection programme including compliance with maximum speeds by goods trains.

[20] Since the accident, Corus has introduced improvements to its work instructions.

5 RECOMMENDATIONS

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;
   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.

2. Railion Nederland N.V. is recommended to better identify the risks of loading processes.
   In that respect, account must for example be taken of the coefficient of friction of oiled steel on steel, and the related risk of the shifting of the steel coils. The result of this inventory and evaluation must be laid down in unequivocal and effective loading instructions.

3. Corus Strip Products IJmuiden is recommended to better identify the risks of the loading process (in particular of oiled coils) on goods wagons. It is also recommended that the loading process be organised such that compliance with the loading instructions agreed with the operator (for example in respect of securing the load) is guaranteed.

4. The Transport and Water Management Inspectorate is recommended to increase the supervision of goods transport.
   Under all circumstances, the Board would recommend 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;
   b) drawing up a structural inspection programme in respect of maximum speeds of goods trains of all operators.

APPENDIX 1 ACCOUNTABILITY STATEMENT

Shortly following the derailment of the goods train in Apeldoorn, investigators of the Council for Transport Safety initiated an investigation at the accident site.

Two investigators from the Council collected all traces and facts at the accident site, shortly following the derailment of the goods train in Apeldoorn. On the basis of the nature of the accident and the considerable damage at the site, the decision was taken to involve a specialist consultant in the investigation of trace evidence, and to instruct this investigator to carry out further technical investigations into the possible causes of the derailment. The consultant, AEA Technology Rail B.V., issued a written report on the results of this investigation.

On the basis of this information, the Council for Transport Safety decided to itself carry out an investigation. An important consideration was the considerable risk run by the environment, passengers and personnel, in the event of derailments of this kind.

The Council investigated the derailment according to the standard method for railway accidents. This standard method means that a broad-based investigation is initiated, in which in essence, apart from a number of details, three aspects are investigated or are reconstructed, as well as possible. These are:

- What would an observer have seen if he had been present at the accident site?
- What actions were carried out prior to the accident, and what communication took place?
- What are the frameworks, rules and standards which applied for the players involved in the accident?

This latter aspect is the most extensive. It deals not only with the formal frameworks, rules and standards, but also their informal counterparts. In order to avoid missing any relevant aspects, the investigation was kept as broad as possible in the initial phase, and no hypotheses were formulated or positions taken up.

For the investigation, use was made of three investigators of the Investigative Office of the Council, an investigator from the Rail Division of the Transport and Water Management Inspectorate (IVW) and a number of specialist, technical consultants (AEA Technology Rail B.V., NedTrain Consulting B.V.) and human factors consultants (Intergo B.V.). The investigation into the role of the Ministry of Transport, Public Works and Water Management was carried out by the Council's investigators. The investigation team operated under the auspices and management of the Council. Once a picture had been obtained of the course of events, on the basis of available information such as photographs, overview drawings of tracks, points and signals, press releases and other sources, a list was drawn up of documents to be requested and persons to be interviewed. The questions to be posed were also formulated in advance. In this case, interviews were held with: the driver of Railion Nederland N.V. involved, the rail traffic controller of Prorail Rail Traffic Control, the loading personnel at Corus, the wagon inspector of Railion Nederland N.V., etc. Reports were made of all these interviews. On the basis of the findings, a new list of persons to be interviewed was drawn up. The new list related to the managers/specialists of those involved directly in the accident. Reports were also drawn up of these interviews. In addition, a number of working visits took place, to gain a greater understanding of the loading process for goods wagons, the operation of goods trains and the setting of routes.

The investigation results were recorded in writing in three sub-investigations. In this process, care was taken to ensure that no positions were taken up and no judgements passed. The sub-investigations for this reason only contained the relevant facts. The sub-investigations, in which the collated facts and their mutual relationship are laid down, were assessed. The sub-investigations were sent to the parties involved Railion Nederland N.V., Corus, Prorail Rail Traffic Control, Prorail Rail Infrastructure and the Ministry of Transport, Public Works and Water Management, whereby these bodies were all invited to verification meetings. During this consultation process, the parties involved were given an opportunity to comment on the facts as determined. As far as possible, any underpinned arguments were entered in the three sub-investigations. The result of the verification meetings was that the bodies involved were notified at an early stage, and agreed with the facts which form the basis for the analysis by the Council's Rail Chamber.

Once the collection of facts had been concluded and the sub-reports and technical investigation report by AEA Rail Technology B.V. were completed, under the auspices and management of the Rail Chamber of the Council for Transport Safety, the draft final report was drawn up. This report was submitted in mid-November 2004 to the parties involved. All parties issued a written response. The reactions from the parties were included in this report, if in the judgement of the Council they were in line with the actual course of events, or if they were the result of a different vision on those events, which following further consideration of the facts by the Council proved relevant.

Finally, the Council drew up a number of recommendations for avoiding similar accidents in the future, and increasing the safety of goods transport.

In connection with the dissolution of the Council for Transport Safety and the transfer of its tasks to the Safety Investigation Board, on 1 February 2005, the report was finally adopted by the Safety Investigation Board.

The composition of the Council for Transport Safety and the Rail Chamber appear below.

COMPOSITION OF THE COUNCIL AND RAIL CHAMBER OF THE COUNCIL FOR TRANSPORT SAFETY (dissolved on 1-2-2005)

	Board		***Rail Chamber***
Chair:	mr. Pieter van Vollenhoven	Chair:	mr. G. Vrieze
	F.W.C. Castricum		drs. F.R. Smeding
	J.A.M. Elias		ir. F.M. Baud
	B.M. van Balen		ir. L.H. Haring
	ms mr. A.H. Brouwer-Korf		ir. W.F.K. Saher
	mr. D.M. Dragt		prof. dr. ir. H.G. Stassen
	mr. J.A.M. Hendrikx		
	ir. K. Nije	Secretary	ir. W. Walta
	prof. dr. U. Rosenthal		
	drs. F.R. Smeding		
	ing. D.J. Smeitink		
	dr. ir. J.P. Visser		
	mr. G. Vrieze		
	prof. dr. W.A. Wagenaar		
General secretary	-		