

## **DERAILMENTS AT RANDSTADRAIL**

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<sup>2</sup> Due to their involvement as a supervisory director and employee, respectively, of HTM and pursuant to Section 15, subsection 2 opening words under c of the Dutch Safety Board Act (Rijkswet Onderzoeksraad voor Veiligheid), Ms A. van den Berg and Mr L.H. Haring did not participate in the investigation into the Randstad-Rail derailments. Ms A. van den Berg left the Dutch Safety Board on 1 December 2007.

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## CONSIDERATIONS

### Introduction

The Dutch Safety Board carried out an investigation into the RandstadRail derailments. This independent investigation was aimed at determining exactly what had happened and its sole purpose was to learn from the events that had taken place and thereby increase levels of safety. The Dutch Safety Board Act expressly excludes issues of guilt and liability.

The following considerations include a summary of the key matters addressed in the report. For comprehensive technical and factual explanations, please see the full report. In addition, the Dutch Safety Board expresses its opinion as part of these considerations, an opinion based on both the investigation in question and on the experience the Board has acquired in other investigations.

### RandstadRail

A new public transport system, RandstadRail is a light rail network which connects The Hague, Rotterdam and Zoetermeer. A large scale project involving the construction of new infrastructure, modification of existing infrastructure, purchase of railway vehicles and establishment of a transport and management organisation was required for its realisation.

### Derailments

Five derailments occurred in the Haaglanden region within a month of RandstadRail's operational launch. Following the derailment at the Forepark stop on 29 November 2006, which resulted in injury to 17 passengers, the railway undertakings ceased operations and the Transport and Water Management Inspectorate formally disallowed these to continue by withdrawing the operating permit. Four more derailments occurred following the resumption of services on sections of the RandstadRail network.

A total of nine RandstadRail derailments occurred. Based on their respective causes, these derailments can be divided into four categories.

1. The derailment of a RandstadRail vehicle belonging to RET on 29 November 2006, which resulted in injury to 17 passengers, took place on a damaged switch close to the Forepark stop in Leidschenveen. The RandstadRail project bureau of the municipality of The Hague had not taken the possibility of damage to the newly installed switches sufficiently into account. These switches remained in use during replacement of the railway section between Zoetermeer and The Hague and sustained damage as a result.
2. On the same day, a RandstadRail vehicle belonging to HTM derailed in a curve close to the Ternoot stop, which is near The Hague's central station. HTM was aware of the risk of derailment in this curve but had underestimated the likelihood of actual occurrence. The curve proved in reality to have less favourable characteristics than HTM had assumed and, in addition, the minimum speed of 50 km/h recommended by the vehicle manufacturer in connection with the guarantee issued could not always be achieved. The risk of derailment on this particular railway section was greater at lower speeds.
3. Three derailments occurred on the Muzenviaduct close to The Hague's central station on a section of worn out railway track, one of which involved a city tram and the other two RandstadRail vehicles belonging to HTM. The abrasion had been caused by a modification to The Hague's city trams and the use of rails with a different hardness, causes that had not been recognised in time by HTM.
4. Five derailments involving RandstadRail vehicles belonging to HTM occurred at a vehicle activated switch in the city tram network. The vehicle activated switch was introduced as part of the RandstadRail project and was of a type new to HTM. The switch is used to change tracks at a railway end point so that the vehicle can subsequently travel the route in the opposite direction. Investigation of the derailments revealed that the drivers of the vehicles had not been able to clearly see whether they had fully passed the switch and had therefore turned too early. Following these derailments, HTM introduced signs and marking at the turning point in question.

The Dutch Safety Board wished to know how no fewer than nine derailments could have occurred within the context of such a large scale project so soon after the launch of operations, and therefore conducted an investigation into this series of accidents. A further consideration in this regard was that the accidents had occurred within a public transport system; a system, in other words, in which passengers place their trust in terms of safety.

## **Other investigations**

A number of involved parties also conducted investigations into (their own respective roles in) the RandstadRail derailments:

- HTM and RET investigated the technical and procedural causes of the derailments with the aim of resolving the problems prior to the resumption of RandstadRail operations;
- The Haaglanden Urban District commissioned Delft University of Technology to investigate the administrative decision making process at RandstadRail, an investigation that resulted in a number of points for improvement that could be incorporated into the administration of future projects;
- An investigation carried out by the Transport and Water Management Inspectorate into the Forepark derailment revealed a number of procedural shortcomings that had to be resolved prior to the resumption of RandstadRail operations;
- Following its investigation into the Forepark derailment, the Transport and Water Management Inspectorate concluded that the operating permit may have been granted prematurely and therefore commissioned the Netherlands Organisation for Applied Scientific Research (TNO) to conduct a further investigation with the aim of formulating improvements that could be incorporated into future projects.

By means of these investigations, the parties involved exercised their own respective responsibilities to learn from the RandstadRail derailments.

## **Dutch Safety Board investigation**

The Dutch Safety Board apprised itself of the results of the investigations referred to and included them in its own investigation. Furthermore, the reason that the Dutch Safety Board carried out its own investigation was twofold. Firstly, the parties involved in RandstadRail had well-organised safety arrangements on paper. In practice, however, internal safeguards had failed to function or had failed to do so adequately, and the parties involved had not sufficiently arranged their respective responsibilities for safety in concrete terms. Secondly, RandstadRail is the result of a network of activities in which each party is responsible for the safety of its part of the project. It was therefore important to investigate the respective roles and responsibilities of all the parties involved. A further consideration in this regard is that more regional projects like RandstadRail are being planned.

## **Safeguards**

Only limited or no external supervision is exercised on projects like RandstadRail: safety is an internal matter for the parties involved. This means that these parties bear considerable responsibility not only for arranging their own safety related obligations in concrete terms but also, as the responsible organisations, for ensuring that the arrangements made are complied with. The Dutch Safety Board has reason to question whether such self regulation and supervision is enough to guarantee safety in a public service such as RandstadRail.

To prevent the launch of RandstadRail operations without a sufficient guarantee of safety, a number of safeguards had been put in place. These safeguards proved to be inadequate in practice, and the Dutch Safety Board wished to ascertain why this was the case. The safeguards in question were:

- Ensuring safety within the project
- Testing and trial runs
- Statement of no objection issued by the Independent Safety Assessor
- Authorisation to commence operations issued by the Transport and Water Management Inspectorate
- HTM's decision as a railway undertaking to commence passenger services.

## **Ensuring safety within the project**

A transport system like RandstadRail is the result of a network of activities in which each party completes its respective part of the project and is responsible for the safety of that part. In addition, the principal (the Haaglanden Urban District for both transport and management and the putting in place of infrastructure) and the end user (HTM as railway undertaking) must each determine the procedures and methods by which the safety of the system as a whole is to be guaranteed and establish responsibilities to this end at the highest levels (administrative and managerial) of their respective organisations.

The Dutch Safety Board notes that activity relating to safety started well: the Haaglanden Urban District and the Rotterdam City Region decided to adhere to the Normative Document for Light Rail Safety, even though doing so had not been made mandatory by the Ministry of Transport, Public Works and Water Management.<sup>3</sup> The Normative Document sets out safety requirements for light rail

<sup>3</sup> The Normative Document for Light Rail Safety constitutes a policy rule formulated by the Dutch Ministry of Transport, Public Works and Water Management and sets out safety requirements for the design, construction and operation of light rail systems. The stipulations of the Normative Document are nominally binding for projects that are (partly) financed by the national government.

systems such as RandstadRail. In this connection, the Haaglanden Urban District prepared safety plans and appointed a Safety Manager. In addition, it was agreed to define the ways in which safety was being guaranteed in so called safety cases, in essence compilations containing evidence that safety requirements had been and were being met. Given this practice, the Dutch Safety Board therefore wondered how it was possible that RandstadRail operations were launched on a system that, given the number of derailments that occurred in quick succession and resulted in the suspension of services, was still fundamentally unsafe.

One of the reasons was that the Haaglanden Urban District did not exercise adequate internal supervision on the implementation of its own safety related action plan, which was based on the Normative Document that Haaglanden had voluntarily adopted. This lack of adequate internal supervision applied to, among other things, realisation of the infrastructure, an activity that the Haaglanden Urban District had outsourced to the RandstadRail project bureau of the municipality of The Hague. In contrast to the other components of the RandstadRail project, such as the vehicles, transport and the safety system, the Haaglanden Urban District retained responsibility for ensuring safety with respect to infrastructure; The Hague's municipal authorities only had to render account to the Haaglanden authorities in relation to the aspects of time and money, not safety. In addition, responsibility for safety had not been anchored at the highest level of the Haaglanden Urban District but had, rather, been placed with the Safety Manager.<sup>4</sup> This individual therefore bore de facto responsibility for demonstrating that the RandstadRail infrastructure was safe and, as a result, was unable to fulfil his actual role, which was to check whether the implementing organisation – in this case the municipality of The Hague – had adhered to the agreed working method and to advise the municipal council in this regard. In practical terms, therefore, the Haaglanden Urban District had placed responsibility for ensuring the safety of the infrastructure with the Safety Manager while, at the same time, this individual had been charged with exercising internal supervision.

Together with the factors specified above, pressure was also being exerted by the Haaglanden Urban District and the participating municipal authorities, including those of The Hague, in terms of the date on which the RandstadRail network would be put into operation. Laying the network had involved the suspension of services on two existing public transport lines, the Zoetermeer City Line (Zoetermeer Stadslijn) and Rotterdam Hofplein Line (Rotterdam Hofpleinlijn), which meant that commuters on these lines had to use replacement buses. In practice, the Haaglanden authorities therefore focused mainly on the aspects of time and money, not safety; indeed, the subject of safety was not a structural and regular item on the agenda of administration meetings.

Pressure to complete the project and the inadequate supervision exercised by the Haaglanden Urban District in terms of safety led to the decision to approve RandstadRail passenger services before the safety of the infrastructure had been properly established. It must be noted in this regard that the decision to approve the infrastructure in terms of safety was not taken at executive level but in consultation between administrative representatives of the parties involved. In addition, this decision was not based on safety criteria such as those set out in a safety case indicating a sufficient guarantee of safety, as the safety cases had not yet been completed. It had been agreed at administrative level that the results of testing and trial runs did not have to be documented. However, not only had the documentation of the safety files not yet been completed: essential chapters on the infrastructure were also unfinished, so that there was in fact no certainty as to its safety.

### **Testing and trial runs**

Testing and trial runs constitute the last safeguard and are used to check whether, among other things, the infrastructure is safe prior to the start of passenger services. The investigation revealed that the testing and trial runs had, to all intents and purposes, not been based on a safety related plan of action (objectives and criteria) and safety case. For this reason, the administrative organisation was unable to indicate whether or not passenger services could commence on the basis of criteria set in advance and were unable to resist pressure from the Haaglanden Urban District to launch RandstadRail operations on the planned date. In addition, indications that railway switches had been damaged and the critical situation in the curve at Ternoot did not receive special attention in the testing and trial runs conducted, which, moreover, were cursory. The brevity of the tests and trial runs was due to the fact that many wished to start RandstadRail passenger services as quickly as possible. Two weeks of testing and trial runs had originally been planned but the operational launch of the system and the trial runs were delayed because work had not been completed and certain parts still had to be tested. As a result, only a few days were ultimately devoted to trial runs based on regular timetables prior to the start of passenger services.

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<sup>4</sup> The situation at HTM, where the line managers concerned were responsible for ensuring the safety of, among other things, the operation and management of infrastructure. HTM's safety coordinator only had a checking role and advised HTM's board in that regard.



### **Statement of no objection issued by the Independent Safety Assessor**

The Haaglanden authorities had engaged an external agency to act as the Independent Safety Assessor (ISA). The ISA was charged with assessing whether the RandstadRail system was sufficiently safe for passenger services to begin.

The ISA did not report to the Haaglanden authorities, however, but to the Safety Manager of the Haaglanden Urban District who was responsible for preparing parts of a properly substantiated safety case. During the project, the ISA had indeed indicated in its interim reports that the parties involved were not paying sufficient attention to safety. These statements never reached the Haaglanden authorities and were therefore never discussed at that level.

The ISA issued a qualified statement of no objection to the use of RandstadRail; in other words, an approval subject to the resolution of a number of outstanding safety related issues ('Yes, provided that ...'). In such a situation, the Dutch Safety Board would have expected the ISA to issue a qualified statement of objection instead; in other words, an objection unless a number of outstanding safety related issues were resolved ('No, unless...' rather than 'Yes, provided that ...'). In formulating its statement in the way that it did, the ISA indicated that passenger services could begin nevertheless, while from the viewpoint of safety it would have been better to unequivocally assert that the outstanding safety related issues referred to would have to be resolved first.

### **Authorisation to commence operations issued by the Transport and Water Management Inspectorate**

Authorisation to commence RandstadRail operations was granted by the Transport and Water Management Inspectorate. This authorisation did not relate, however, to the city tram part – on which eight of the nine derailments occurred – of the RandstadRail network. In addition, the Inspectorate did not specify the frame of reference that would be used for the granting of authorisation in advance. In practice, the Inspectorate focused mainly on visible shortcomings and the ISA statement.

The prevailing legislative and regulatory framework for railway networks (in this case the 1875 Railways Act applied) was less appropriate for a project like RandstadRail. This set of legislation and regulations still assumes that the laying of a railway network, transport on it and its management are in the hands of a single party, which is not the case with regard to RandstadRail. In an effort to ensure safety, the Dutch Ministry of Transport, Public Works and Water Management prepared a Normative Document for Light Rail Safety: a policy document which sets out safety requirements for light rail projects like RandstadRail. This Normative Document was not, however, made a binding part of the funding provided by the Minister of Transport, Public Works and Water Management to the RandstadRail project, even though the minister had previously indicated that the document would indeed be made binding for projects that were in part financed by the national government.

The Transport and Water Management Inspectorate was the external safety supervisor of the RandstadRail project. As the Railways Act had not become effective in 2005 for non primary railway networks such as RandstadRail, the Inspectorate's legal powers were limited. As a result, the supervision exercised by the Inspectorate remained limited to the part of the RandstadRail network that had been designated by the Minister of Transport, Public Works and Water Management as a 'local railway'. The city tram part of the RandstadRail network fell outside the scope of the Inspectorate's supervision. Furthermore, the Inspectorate had to grant authorisation for the commencement of operations on behalf of the Minister of Transport, Public Works and Water Management as a condition for passenger services to begin, and therefore granted authorisation which related only to the local railway part while the RandstadRail network as a whole was not yet safe.

In addition, the Transport and Water Management Inspectorate did not use the Normative Document for Light Rail Safety as the basic starting point in the exercise of its supervision. Logically speaking, this should have been the case, given that the Normative Document comprises policy rules adopted by the Minister of Transport, Public Works and Water Management that apply to projects like RandstadRail. In principle, policy rules must be used as the basic starting point in the exercise of legal powers such as, in this case, the granting of authorisation. Instead, however, the Inspectorate omitted to clarify what the foundation of its supervision would be and what role the Normative Document would play in the exercise of that supervision. The Inspectorate proceeded to grant authorisation while the list of outstanding safety related issues in the ISA statement pointed to serious potential hazards and before the safety cases had sufficiently demonstrated that the RandstadRail system was safe enough to warrant the start of passenger services. The authorisation for the commencement of operations thus granted was, however, taken as a sign by the parties involved that such services could indeed begin. The information and associated criteria used by the Inspectorate to arrive at its decision had not been made known to these parties in advance.



### **HTM's decision as a railway undertaking to commence passenger services**

As a railway undertaking, HTM bears an exceptional responsibility with regard to public transport services. As the last link in the chain, the railway undertaking must ensure the safety of passengers and personnel. It is with the railway undertaking that the outcomes produced by the activities of other suppliers and service providers, such as infrastructure, equipment, safety systems and so on, converge. In addition, HTM has been the de facto manager of the city tram infrastructure for many years and is the prospective manager of the newly built RandstadRail infrastructure.

In the opinion of the Dutch Safety Board, HTM's responsibility as a railway undertaking for the safety of passengers and personnel and, as a (prospective) manager, for the operational safety of the infrastructure obliged it to make sure for itself, i.e. independently of the other parties involved, that transporting passengers on the RandstadRail network would be responsible in terms of safety. Among others, one prerequisite for such transport is safe infrastructure. On this particular point, HTM failed to sufficiently form its own, independent opinion in its decision to commence passenger services.

A question that must be asked is the extent to which a railway undertaking, after having received authorisation to commence passenger services, must ascertain the safety of the transport system. That is to say, is it sufficient for a railway undertaking to take cognisance of the permission granted to its principal to commence such services? In the case of RandstadRail, permission was accompanied by a statement of no objection issued by the ISA and authorisation to commence operations granted by the Transport and Water Management Inspectorate. Or is more required and, if so, how far does the railway undertaking have to go? The question is whether it is realistic to expect a railway undertaking to carry out its own inspection of infrastructure that was built and put in place by third parties.

In the first instance, HTM was entitled to assume that the supplying parties exercised their respective responsibilities to ensure safety properly. In the opinion of the Dutch Safety Board, HTM should – given the fact that the matter concerned public transport – in addition have apprised itself of the way in which the safety of the infrastructure was being ensured in the project, all the more so because realisation was in the hands of a temporary organisation that did not have much technical railway experience. The Dutch Safety Board believes that a railway undertaking should at least verify whether its trust in the judgement of third parties is justified. In the case of RandstadRail, this means that HTM should have taken cognisance of the underlying substantiation of the ISA statement, the authorisation to commence operations and the organisation and results of the tests and trial runs conducted, and subsequently subjected these factors to a critical review. The case was different for the city tram part of the RandstadRail network, since, as manager, HTM could already maintain sufficient oversight.

### **Lessons for future projects**

As was also the case on previous occasions, this investigation revealed the need for clarity about the individual responsibility for safety borne by each of the parties involved. This also applies to the parties' respective expectations of and obligations to others. Properly concluded arrangements in this regard must result in harmonised processes of internal and external control which parties then use to ensure the safety of their contributions to the end product, both internally and vis à vis each other. This does not mean that responsibilities should be divided, since fragmented responsibility can lead to lacunas, a lack of clarity and even the shirking of duties.

Due to the virtual lack of legislation and regulations appropriate to projects like RandstadRail, external supervision as exercised by agencies of the national government cannot play a meaningful backup role in terms of ensuring safety. Regional and local government authorities who are acting as principals of such projects must therefore genuinely recognise that the buck well and truly stops with them when it comes to supervising and ensuring the safety of the given project, and must act accordingly. Other parties involved, such as railway undertakings, must also do so. In addition, railway undertakings must at all times remain aware of their responsibility for the safety of their passengers and personnel, and must make the resources available to translate this responsibility into a practical reality.

In addition to issuing recommendations to the parties involved in the RandstadRail project, the Dutch Safety Board opted to formulate lessons that will be of relevance to parties involved in such projects in future.

These parties include but are by no means confined to:

- Transporters (HTM, RET and future railway undertakings that operate through Mobis, the sectoral association for the group and/or mass transit of passengers by road or rail and the Federation of Dutch Transport Companies [Federatie Mobiliteitsbedrijven Nederland, FMN]);
- Initiators and (delegated) principals (the Haaglanden Urban District, the Rotterdam City Re-

gion and the municipal authorities of The Hague and Rotterdam, the chairmen of city region committees and umbrella organisations, the Interprovincial Consultative Association [Interprovinciaal Overleg, IPO], the Association of Netherlands Municipalities [Vereniging Nederlandse Gemeenten, VNG] and SKVV, the collaborative arrangement for traffic and transport put in place by the authorities of seven city regions);

- The Dutch Ministry of Transport, Public Works and Water Management as policymaker, provider of funds and external supervisor.

Based on its responsibility for the safety of passengers and employees, a railway undertaking must, among other things, verify that the safety of a transport system operated by it is ensured both in terms of its own, internal organisation and in terms of its relationship with suppliers to that system.

Initiators and (delegated) principals must ensure that:

- a. responsibility for safety is explicitly embedded in political and administrative terms;
- b. issues concerning safety and the functioning of safety related safeguards such as testing and trial runs and the findings of an ISA and internal and/or external supervisor are periodically reported at political and administrative level.

In future projects, the parties involved must:

- a. establish individual responsibility in advance as well as the degree to which one is dependent on other parties in the network to make this responsibility an operative reality;
- b. conclude clear agreements with other parties involved concerning what is expected of them to enable the proper exercise of individual responsibility;
- c. adhere to these agreements for the duration of the project in order to ensure safety.

Due to the absence of formal, legal powers relating to all parts of the project, the role and associated limitations of the external supervision exercised by the Transport and Water Management Inspectorate were unclear. To a large extent, the RandstadRail project therefore relied on internal supervision as exercised by the Haaglanden Urban District and, ultimately, by HTM, the railway undertaking. This supervision was likewise unable to function as a safeguard, mainly because factors other than safety, such as the pressure of time, were allowed to dominate.

The authorisation to commence operations granted by the Transport and Water Management Inspectorate confused matters, as it generated the impression among the other parties that the project had been assessed and approved in its totality, whereas formally the authorisation related only to the parts of the network, namely those outside The Hague itself, that fell within the scope of the Inspectorate's supervision. In addition, it was not clear which criteria the Inspectorate was using in the exercise of its supervision.

In 2002 the Ministry of Transport, Public Works and Water Management prepared a Normative Document for Light Rail Safety in order to establish clear and uniform basic principles for the safety of light rail systems. In the opinion of the Dutch Safety Board, that Normative Document does indeed constitute a sound foundation from which to ensure safety, but it had not been made binding and was ultimately not sufficiently used.

As the last link in the chain, a railway undertaking also has a duty to conduct its own assessment of safeguards and adhere to the agreements concluded. A legal foundation will have to be put in place to enable the proper functioning of government supervision.

#### Recommendations

The Dutch Safety Board therefore recommends that the Ministry of Transport, Public Works and Water Management:

- a. ensure that regional railway projects such as RandstadRail be placed within the operative scope of the Railways Act (augment Section 94 of the said Act);

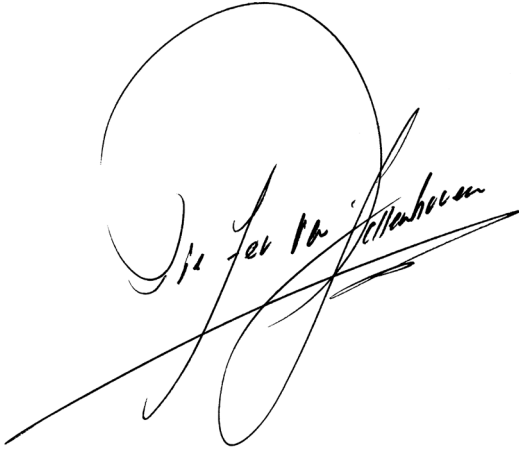
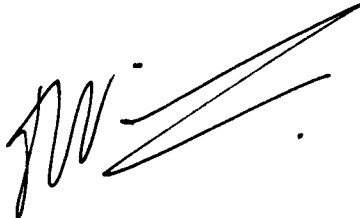
Explanatory note: This would mainly concern linking the legislation to the desired allocation of responsibilities and reviewing the role of the Minister of Transport, Public Works and Water Management in that regard.

- b. establish the Normative Document for Light Rail Safety as binding in law and thereby make its use as an instrument to ensure safety mandatory.

Explanatory note: This would involve establishing which safety related stipulations would in any case be mandatory for projects like RandstadRail.

Prof. Pieter van Vollenhoven  
Chairman of the Dutch Safety Board

M. Visser  
General Secretary

A handwritten signature in black ink, appearing to read 'Pieter van Vollenhoven', written over a large, faint circular stamp or watermark.A stylized handwritten signature in black ink, consisting of several sharp, sweeping strokes.

## LIST OF TERMS AND ABBREVIATIONS

<b>0-9</b>	900 and 700	Reference to the quality of a rail expressed in terms of tensile strength (N/mm <sup>2</sup> ).
<b>A</b>	AHC	Anti-Head Check profile: regular, cyclical grinding of a rail surface shapes it to a target transverse profile, which optimises wheel/rail contact and minimises contact stresses and therefore reduces head checking and flaking and extends the service life of the rail.
<b>B</b>	Blades	The moving parts of a switch that guide the vehicle from one railway to another. See also Appendix J, 'Railway Switches'.
	Blocking finding	A finding that involves a major safety risk which must be resolved before a system or one of its constituent parts may be put into operation.
	BORR	RandstadRail Administrative Consultation Committee of the Haaglanden Urban District (SGH), the organisational 'atrium' of the BOW (see entry), in which the councillors for traffic and transport of the municipalities directly involved in the RandstadRail project are represented.
	BOStrab	Verordnung über den Bau und Betrieb der Straßenbahnen, a German law governing regulations for tram, metro and light rail operations.
	BOVV	Administrative Consultation Committee of the Haaglanden Urban District (SGH), in which all constituent municipalities of the said urban district are represented by their respective councillors for traffic and transport.
<b>C</b>	CEN	The European Committee for Standardization sets standards in other technical fields (with the exception of telecommunications, for which the ETSI sets European standards).
	CENELEC	The European Committee for Electrotechnical Standardization sets electrotechnical standards in order to advance the internal European market for electrical and electronic goods and services.
	Concession	A concession is an exclusive right to operate public transport services in a certain area for a determinate period of time. <sup>5</sup>
	Concession grantor	A concession grantor is the party duly authorised to grant concessions. <sup>6</sup> The parties authorised to grant, alter and withdraw concessions for public transport other than transport by train, with the exception of public transport in a plus region (plusregio) as referred to in Section 104 of the Intermunicipal Statutory Regulations Act that includes the municipality or municipalities of Amsterdam, Arnhem and Nijmegen, Eindhoven and Helmond, Enschede and Hengelo, 's-Gravenhage, Rotterdam or Utrecht, are the Provincial Executives. Concessions in the plus regions are granted, altered or withdrawn by the Executive Committee of the plus region in question. <sup>7</sup>
	Concession holder	A concession holder is a railway undertaking to whom a concession has been granted. <sup>8</sup>
	CVL	Central Traffic Control.
<b>D</b>	DRVR	RandstadRail Service Regulations.

<sup>5</sup> Passenger Transport Act, Section 1 under l.

<sup>6</sup> Ibid. Section 1 under m.

<sup>7</sup> Ibid. Section 20, paragraph 2.

<sup>8</sup> Ibid. Section 1 under n.

	DSP	RET's Strategic Projects Directorate. <sup>9</sup>
<b>E</b>	EBA	The Eisenbahn-Bundesamt (EBA) is the German railway safety supervisor charged with, among other things, approving vehicles, infrastructure and railway undertakings.
	EC	The Executive Committee of the Haaglanden Urban District, which prepares proposals for submission to the General Committee (GC) and is responsible for the administration's day to day affairs and a number of specific duties.
	EN	EN designates the European standards. These standards are set by the CEN (see relevant entry) and published by national standardisation organisations (NEN in the Netherlands).
<b>F</b>	Fail safe	A concept applied to the design of a product to ensure that safety is maintained in the event of a failure. <sup>10</sup>
	FTE	Full time equivalent; in terms of employment, defined as total hours worked divided by average annual hours worked in full-time jobs.
<b>G</b>	GC	The General Committee is the highest administrative body of the Haaglanden Urban District and decides on nearly all matters that require an administrative decision. The Executive Committee (EC) may decide on a number of matters.
	Grooved rail	A rail with a groove; a type often used for tram networks.
	Ground level lines / ground level sections	City tram lines that operate at street level, i.e. are not grade separated by, for example, viaducts.
<b>H</b>	Hofplein Line	Railway line between Rotterdam Hofplein station and The Hague's central station. The line was opened at the beginning of the 20th century and continued on to Scheveningen via The Hague HS station until the 1950s. It has been part of the RandstadRail network since 2006 and is operated by RET. In 2010 the Hofplein Line will be connected from a location close to the former Kleiweg station to the Erasmus Line by newly built underground infrastructure so that RandstadRail passengers will be able to travel between The Hague's central station and Slinge metro station in Rotterdam without changing lines. Passenger services involving a change of metro lines at Rotterdam's central station will commence on this connection in the autumn of 2009.
	HTM	Formerly NV Haagsche Tramweg-Maatschappij and now HTM Personenvervoer NV, an independent public transport company that operates bus, tram, light rail and closed transport services.
<b>I</b>	Interface	The interface between different subsystems.
	ISA	Independent Safety Assessor.
	ISP	Integral Safety Plan.
	IVW	Transport and Water Management Inspectorate (IVW in Dutch)
<b>K</b>	Klammer Test	The Klammer Test [railway bracket test?] as described in the basic documentation on switches is performed to check the position of the bolts and thereby identify any damage.
	Krakeling'	Part of the Zoetermeer City Line (ring line) within the municipality of Zoetermeer, with a figure-of-eight shape.

<sup>9</sup> The Strategic Projects Directorate has since been abolished. The RandstadRail project in the Rotterdam City Region is now the responsibility of the general manager of RET.

<sup>10</sup> Source: NEN-EN 50129:2003 and BS EN 50129:2003, 'Railway applications - Communication, signalling and processing system - Safety related electronic systems for signalling'.

<b>L</b>	Light rail	The Dutch Ministry of Transport, Public Works and Water Management defines 'light rail' as a railborne mode of public transport that occupies a place between non express train services on the one hand and tram and metro services on the other, and that is designed for commuting distances that range from 10 to 40 kilometres. <sup>11</sup> See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services' for further details.
	Lorry mounted crane	A lorry mounted crane (often abbreviated in Dutch to krol) can be a digging machine or hoisting crane mounted on a vehicle equipped with rubber wheels for road transport and flanged railway wheels for rail transport, for example. <sup>12</sup>
	Low floor tram	A low floor tram is one that has a low floor extending across 70% to 100% of its total length. A low floor is 35 cm above the rail head at most. Low floor trams are more accessible to, for example, wheelchair users and passengers with perambulators due to the absence of steps. <sup>13</sup>
<b>M</b>	Management delivery	In the project realisation phases, it is usual for the contractors performing the work to purchase the required materials themselves. In the case of a management delivery, project management purchases the materials and makes them available to the contractors.
	Metro	A type of railway vehicle operated on an urban or regional transport system that comprises numerous stations and fully dedicated railway lanes, i.e. free of other traffic and often underground in central urban areas. See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services' for further details.
	Multiple unit tram	A tram comprising several carriages.
<b>N</b>	Normative Document / normative framework	Within the RandstadRail context, these terms refer to the Normative Document for Light Rail Safety.
	Notified Body (NoBo)	A Notified Body (NoBo) is an organisation authorised by the government of an EU Member State to assess projects subject to European legislation and regulations in terms of interoperability.
	NS	Dutch Railways (NS) is a company whose core business is rail transport (NS Reizigers and NS Hispeed) and the operation of railway stations (NS Poort).
•	OC	Order in Council, an implementation decree belonging to an Act.
	Openable switch	A switch can be classified as 'openable' if it meets two conditions: - the switch is not or only barely damaged during an opening movement; - the opening movement generates a message in the safety system. See also Appendix J, 'Railway Switches'.
	Opening a switch	A switch is opened when it is passed by a railway vehicle travelling in a direction other than the set direction of travel. Passage of the railway vehicle presses the switch blade (and possibly movable point) into another position. See also Appendix J, 'Railway Switches'.
	OSP	Operational Safety Plan.
	OTP	Modification, Testing and Trial Runs.
	OV	Public Transport.

<sup>11</sup> Source: [www.kpvv.nl](http://www.kpvv.nl).

<sup>12</sup> Source: [www.railpedia.nl](http://www.railpedia.nl), consulted on 18 September 2008.

<sup>13</sup> See Appendix N, 'Low Floor Trams and Consequences for Handling'.

<b>P</b>	PMT	Project Management Team, a coordinating consultative body established by both urban districts (SGH and SRR) that formed part of the organisational structure of the RandstadRail project as set up by the urban districts referred to.
	Point	The part of a railway switch at which two rails converge to form a sharp point. See also Appendix J, 'Railway Switches'.
	PoRR	RandstadRail Project Bureau; set up by the municipality of The Hague for the performance of work relating to the RandstadRail project in Haaglanden jurisdiction.
	ProRail	ProRail is the infrastructure manager of a large part of the Dutch railway network.
	PVR	The Clearance Profile (PVR in Dutch) refers to the area around a railway in which no permanent objects may be present; in other words, the area required by the railway vehicle to travel without hitting anything.
<b>R</b>	RandstadRail	This term refers to the transport system bearing the product name RandstadRail (a new public transport system connecting The Hague, Zoetermeer and Rotterdam) as well as the RandstadRail project (the realisation of this transport system). In this report RandstadRail refers to the transport system, unless stated otherwise.
	RDHL	Primary and Secondary Railways Service Regulations.
	Redundancy	This term refers to the duplication or triplication of system components to ensure that the system as a whole continues functioning properly in the event of a component failure.
	RegioCitadis	The RegioCitadis is a tram with a low floor extending across 70% of its length and that is operated by HTM on the RandstadRail network. This type of tram belongs to the Citadis series, a series of low floor trams operated in several European cities.
	Remaining point	A finding relating to an issue that has not yet been finalised but does not constitute a major risk according to the information available. An example of such a finding is the absence of a signature on a document that has already been approved.
	RET	Rotterdamse Elektrische Tram, a company that operates public transport services in Rotterdam and its environs.
	RijnGouwe Line	The RijnGouwe Line (RijnGouwelijjn) will be a future light rail connection between Gouda, Leiden and seaboard destinations. A pilot was launched at the end of October 2002 involving the operation of light rail vehicles on the existing railway line between Gouda and Alphen aan den Rijn.
	RTK	Regio Tram Kassel.
	RVI	National Traffic Inspectorate, now part of the Transport and Water Management Inspectorate.
<b>S</b>	S49	Designation of a certain type of rail profile, in this case a Vignoles rail (see appropriate entry below).
	Safety case	A safety case is a file containing evidence which proves that safety requirements have been met. See also Appendix E, 'Background to Safety Cases and the Independent Safety Assessor (ISA)'.
	SAT	Site Acceptance Test.
	SGH	Haaglanden Urban District.
	SMP	Safety Management Plan.



SMS	Safety Management System.
SRR	Rotterdam City Region.
STS instruction	An instruction (currently referred to as a direction) is the permission granted to a train driver which is directly related to railway safety. Instructions or directions can be issued in writing or verbally by means of a communications link. In the case of a verbal communication the driver must note and repeat the substance of the direction issued. An STS instruction is an order to pass a stop signal at a maximum speed of 40 km/h.
Substructure	The base on which a railway is laid, which can be a railway dike, tunnel or bridge, for example.
Superelevation	This term refers to the raising of the outer rail or lowering of the inner rail in a curve to ensure cant and thus compensate for the centrifugal force arising from the passage of a railway vehicle through a curve. Superelevation allows railway vehicles to travel through curves at higher speeds. Superelevation is expressed as the difference in height between the two rails in mm. See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services' for further details.
Superstructure	The superstructure is placed on the substructure (see relevant entry) and comprises the ballast bed, rails, sleepers, switches, railway safety and security features and overhead cables.
Switch	A switch is an installation that enables a railborne vehicle to be guided from one railway to another at a railway junction.
Switch machine	A switch machine comprises rods and other mechanical components, electronic contact points and a motor which together enable a switch to alter its position and thereby the direction of travel of a railway vehicle. A switch machine is connected to the movable parts of a switch (blades and possibly points) and is also known as a switch motor or point machine. See also Appendix J, 'Switches'.
<b>T</b>	
Traction feed	The system that supplies the electrical power necessary for the drive of railway vehicles through an overhead cable or third rail.
Train	A type of railway vehicle operated on a regional, national or international transport system that comprises comparatively few stops and a low frequency of services, and is suitable for high speeds. See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services' for further details.
Tram	A type of railway vehicle operated on an urban or regional transport system that comprises numerous stops. A tram network tends to be dense in urban areas. See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services' for further details.
Transition spiral	A transition spiral refers to the distance over which a given degree of superelevation is built up; in other words, the distance over which the transition from a straight and level section of railway to a curved section with superelevation takes place. See also Appendix M, 'Superelevation and Twist'.
TSI	Technical Standard for Interoperability.
Twist	Twist occurs when two rails are not level and can be represented as a plane of which one of the corners has been raised. Twist is built up in a transition spiral. In addition, the more superelevation required the greater the twist. Twist is defined as height 'h' measured over a given length 'l'. See also Appendix M, 'Superelevation and Twist'.

<b>U</b>	UIC	The International Union of Railways (UIC) is an organisation that works to foster international cooperation in the railway sector and promote rail transport. It was established in 1922 for the purpose of standardising and improving the construction of railways principally in the area of international rail transport.
<b>V</b>	Vehicle activated switch	Vehicle activated switches incorporate a spring mechanism and are activated by railway vehicles. Once a railway vehicle has passed, the switch returns to its original position.
	Vignoles rail	A rail profile with a rounded head; used extensively in train networks (see also 'Grooved rail').
<b>W</b>	Wgr	Intermunicipal Statutory Regulations Act.
	Wp	Passenger Transport Act 2000.
<b>Y</b>	Yellow Book of Engineering Safety Management	A handbook published by the British Rail Safety and Standards Board (RSSB) to provide a foundation for the conduct of safety management in railway engineering. <sup>14</sup>
<b>Z</b>	Zoetermeer City Line	A railway service that connects the Zoetermeer stations with The Hague's central station by means of a ring line. The first part of this railway line was opened in 1977. The Zoetermeer City Line (Zoetermeer Stadslijn) has been part of RandstadRail since 2006 and is operated by HTM.

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<sup>14</sup> RSSB (on behalf of the UK Rail Industry), 2000. Engineering Safety Management Issue 3 Fundamentals and Guidance, Yellow Book 3, London.



# 1 INTRODUCTION

## 1.1 REASONS FOR THE INVESTIGATION

RandstadRail is a new public transport system comprising light rail connections between The Hague, Rotterdam and Zoetermeer.<sup>15</sup> Realisation of the RandstadRail network entailed a large scale project involving the construction of new infrastructure, the modification of existing infrastructure, the purchase of railway vehicles and the establishment of a transport and management organisation.

Five derailments occurred within a month of the start of passenger services in the Haaglanden region. After the derailment at the Forepark stop on 29 November 2006, which resulted in injury to 17 passengers, the railway undertakings ceased operations and the Inspectorate for Transport and Water Management formally stopped passenger services on The Hague section of RandstadRail by withdrawing authorisation to operate on that part of network.<sup>16</sup> A further four derailments occurred after the resumption of services on parts of the RandstadRail network. Operations were suspended for almost a year and were resumed on parts of the network at the beginning of 2007; all of RandstadRail has been back in operation since October 2007.

The Dutch Safety Board carried out an investigation into the following nine RandstadRail derailments:

1. On 29 November 2006, a RandstadRail vehicle belonging to RET derailed at a switch close to the Forepark stop in Leidschenveen;
2. Also on 29 November 2006, a RandstadRail vehicle belonging to HTM derailed in a curve near the Ternoot stop close to The Hague's central station;
3. On 3 and 4 November 2006, RandstadRail vehicles belonging to HTM derailed on the Muzenviaduct in the neighbourhood of The Hague's central station;
4. On 24 November 2006, 24 and 26 January 2007, 25 May 2007 and 20 July 2007, RandstadRail vehicles belonging to HTM derailed at vehicle activated switches in the city tram network.

The Dutch Safety Board's independent investigation was aimed at discovering the exact course of events and their outcomes. The investigation's sole purpose was to learn from these events in order to increase levels of safety. The Dutch Safety Board Act expressly excludes the issues of guilt and liability.

The following considerations played a part in the Dutch Safety Board's decision to carry out an investigation into the RandstadRail derailments:

- The number of derailments:
  - Several derailments took place within the first months of operations.
  - The high number of derailments that occurred in relatively quick succession and the ensuing cessation of passenger services on large parts of the RandstadRail network could erode trust in the transport system.
- The number of passengers injured and damage caused:
  - 17 passengers sustained injury as a result of the Forepark derailment, of whom two were hospitalised.
  - The damage caused by the derailments (including the replacement transport that had to be arranged as a result) was estimated as amounting to 30 million euros.<sup>17</sup>
- The nature of the derailments:
  - At Forepark a direction of travel had been set at a switch that proved to be broken.
  - At Ternoot a vehicle derailed in a curve without there being a switch or other point of discontinuity and without an external cause. Such derailments are extremely uncommon in a railway system.

<sup>15</sup> Chapter 2 provides background information about RandstadRail as a transport system and project, including the RandstadRail phases and timeline.

<sup>16</sup> RET continued operations on the Rotterdam Hofplein Nootdorp section.

<sup>17</sup> This amount comprised two parts:

- Approximately 10 million euros, excluding any future costs and the costs incurred by the municipality of The Hague (source: letter from the Haaglanden Urban District to the Dutch Safety Board dated 18 October 2007);
- Approximately 20 million euros in claims for damages for direct and indirect damage submitted by RET and HTM to the authorities of the Haaglanden Urban District (source: letter from the Rotterdam City Region and RET to the Dutch Safety Board dated 17 July 2008).

- There were no points of discontinuity or external causes either with respect to the derailments that occurred near The Hague's central station. Rail degradation was shown to have been a factor, which prompted the question as to whether the same problem might occur elsewhere on The Hague's city tram network.
  - The derailments at the vehicle activated switches had a recurring character.<sup>18</sup>
- The background to and context within which the RandstadRail project was executed:
- Not much experience has as yet been acquired in the Netherlands with light rail systems. Because similar projects are being planned, it is of considerable interest to wider society to learn from the RandstadRail derailments.
  - The initiative to undertake light rail projects rests primarily with regional and local authorities which, in general, have as yet only limited experience with railway projects. The lessons that can be learned from the RandstadRail incidents are therefore important to them too.

#### *Other investigations*

A number of the parties involved also conducted their own investigations into (their own respective roles in) the RandstadRail derailments:

- HTM and RET investigated the technical and procedural causes of the derailments with the aim of resolving the problems at issue prior to resuming RandstadRail operations;<sup>19</sup>
- The Haaglanden Urban District commissioned Delft University of Technology to carry out an investigation into the administrative decision making process at RandstadRail. This investigation yielded a number of points for improvement that could be incorporated into the administration of future projects;<sup>20</sup>
- The investigation carried out by the Inspectorate for Transport and Water Management revealed a number of technical and procedural shortcomings that had to be resolved prior to the resumption of RandstadRail operations;<sup>21</sup>
- Based on its investigation into the Forepark derailment, the Inspectorate for Transport and Water Management concluded that the authorisation to commence operation had possibly been granted prematurely. The Inspectorate therefore commissioned the Netherlands Organisation for Applied Scientific Research (TNO) to conduct a further investigation with the aim of formulating improvements that could be incorporated into future projects.<sup>22</sup>

By means of these investigations, the parties involved exercised their own respective responsibilities to learn from the RandstadRail derailments.

The Dutch Safety Board apprised itself of the results of the investigations referred to and included them in its own investigation. The reason that the Dutch Safety Board proceeded with its own investigation was twofold. Firstly, the parties involved in RandstadRail had well-organised safety arrangements on paper. In practice, however, internal safeguards had failed to function or had failed to do so adequately, and the parties involved had not sufficiently arranged their respective responsibilities for safety in concrete terms. Secondly, RandstadRail is the result of a network of activities in which each party is responsible for the safety of its part of the project. It was therefore important to subject the respective roles and responsibilities of all the parties involved in this network to investigation.

## 1.2 PURPOSE OF THE INVESTIGATION

The purpose of the Dutch Safety Board's investigation was to learn from the derailments referred to for the benefit of similar projects carried out in the future. The technical, administrative and organisational complexity of the RandstadRail project, as well as the pressure the project was under, already became clear in a preliminary exploration of the issues involved. Further investigation was therefore carried out to determine whether and, if so, the extent to which these factors played a role in the derailments.

The investigation's primary question was:

<sup>18</sup> This recurring character was confirmed by the further derailments involving RandstadRail vehicles belonging to HTM that occurred during the course of the investigation, on 25 May, 20 July and 27 July 2007.

<sup>19</sup> Chapter 5 and Appendices I, L, O and P address the findings of these investigations more closely.

<sup>20</sup> Delft University of Technology, Het RandstadRail-project: Lightrail, Zware opgave (onafhankelijk onderzoek RandstadRail Haagse deel), version of 26 February 2008, published on 27 March 2008.

<sup>21</sup> Inspectorate for Transport, Public Works and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

<sup>22</sup> Netherlands Organisation for Applied Scientific Research (TNO), Onderzoek naar de handelswijze van Inspectie VenW inzake RandstadRail, Delft, April 2007.

How was it possible that so many derailments occurred within such a short time after the start of RandstadRail operations?

The investigation's secondary questions were:

1. What actually happened during the RandstadRail derailments? How could the vehicles have gone off the rails and what were the underlying causes?
2. How was safety management structured, planned and conducted during the design, realisation and operational phases? Was there a connection between the safety management conducted and the derailments and, if so, what was the nature of this connection?
3. What factors influenced the safety management conducted in relation to RandstadRail?
4. How was external supervision concerning RandstadRail safety exercised by the Inspectorate for Transport and Water Management?

### 1.3 SCOPE AND METHOD OF THE INVESTIGATION

The Dutch Safety Board's investigation focused on the following elements:<sup>23</sup>

- the facts and immediate causes of the derailments. The Dutch Safety Board incorporated the results of the investigations carried out by the Inspectorate for Transport and Water Management, HTM and RET into the derailments into its own investigation;
- the roles, duties and responsibilities of the parties involved based on applicable legislation and regulations, agreements concluded and relevant standards/guidelines;
- the safety management conducted: the derailments served as the starting point of an analysis into the safety management conducted in relation to RandstadRail;
- the circumstances under which the parties involved in RandstadRail operated and the influence these circumstances had on the safety management conducted;
- the external supervision exercised in relation to RandstadRail.

As all of the RandstadRail derailments occurred in Haaglanden jurisdiction, the investigation focused on the parties involved in this area. A number of issues such as the assistance provided after the derailments and the potential, indirect consequences of the suspension of operations for the safety of passengers were not included in the investigation.

Further in terms of investigative scope, the analysis also focused mainly on the period prior to the start of RandstadRail operations. It was in this preceding period that the requirements relating to RandstadRail were formulated, the design was prepared, safety analyses were performed, modification work was carried out and, finally, testing and trial runs were conducted (see Appendix C2 for an overview of project phases).

Finally, the Dutch Safety Board did not consider the roles played by the traffic controllers of HTM and RET and the metro drivers of RET in its investigation into the Forepark derailment, as these roles had already been comprehensively addressed in the investigation carried out by the Inspectorate for Transport and Water Management.<sup>24</sup> In addition, the Inspectorate's investigation report already set out learning points with respect to those particular roles.<sup>25</sup>

### 1.4 READER'S GUIDE

This report is structured as follows. Chapter 2 provides factual information about RandstadRail as a transport system and as project. Chapter 3 describes the assessment framework used by the Dutch Safety Board in its investigation. This assessment framework consisted of three parts: the applicable legislation and regulations, the standards and guidelines available and the way in which, in the opinion of the Dutch Safety Board as formulated partly on the basis of internationally accepted safety considerations, the parties involved should have organised their respective responsibilities in relation to safety. Chapter 4 describes the parties involved, their relationships with each other and their responsibilities.

Chapter 5 contains the analysis of the derailments in terms of the facts and immediate and underlying causes, and the part played by safety management in this regard. Chapter 6 details the analysis of RandstadRail safety management in terms of the way it was structured and conducted,

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<sup>23</sup> Appendix A sets out the justification for the Dutch Safety Board investigation.

<sup>24</sup> Inspectorate for Transport, Public Works and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

<sup>25</sup> These learning points led to improvement measures. See Appendix S for the measures taken by the Haaglanden Urban District and HTM (partly) as a result of the Forepark derailment.

also with respect to the decision to allow RandstadRail operations to begin. Chapter 7 describes the broader context applicable to RandstadRail as a transport system and project, as well as the administrative context within which the project was carried out. Chapter 8 contains the analysis of the external supervision exercised in relation to RandstadRail.

The conclusions and recommendations based on the Dutch Safety Board's investigation into the RandstadRail derailments are given in Chapters 9 and 10.

The appendices contain more in depth analyses of the derailments as well as further explanation of a number of specific subjects. The present report refers to these appendices where relevant.



## 2 FACTUAL INFORMATION ABOUT RANDSTADRAIL

This chapter contains factual information about RandstadRail insofar as this information is relevant to analysis of the derailments and the safety management conducted. A distinction is maintained between RandstadRail as a transport system and RandstadRail as a project, the latter being the activities that were performed to realise the former.<sup>26</sup>

### 2.1 THE RANDSTADRAIL TRANSPORT SYSTEM

RandstadRail is a light rail network connecting The Hague, Zoetermeer and Rotterdam. 'Light rail' is an umbrella term for transport systems that in occupy a place between train services on the one hand and tram and metro services on the other.<sup>27</sup> RandstadRail is a combination of low floor tram and metro services that operate on existing (tram/metro) railway lines, new railway infrastructure and modified (previously train) railway lines. Since the start of passenger services in October 2006, the RandstadRail network has been used by HTM to operate new, low floor trams of the RegioCitadis type and by RET to operate specially modified metro vehicles. The purpose of RandstadRail is to improve accessibility in the Rotterdam and Haaglanden regions.



Figure 1 – RandstadRail vehicles<sup>28</sup>

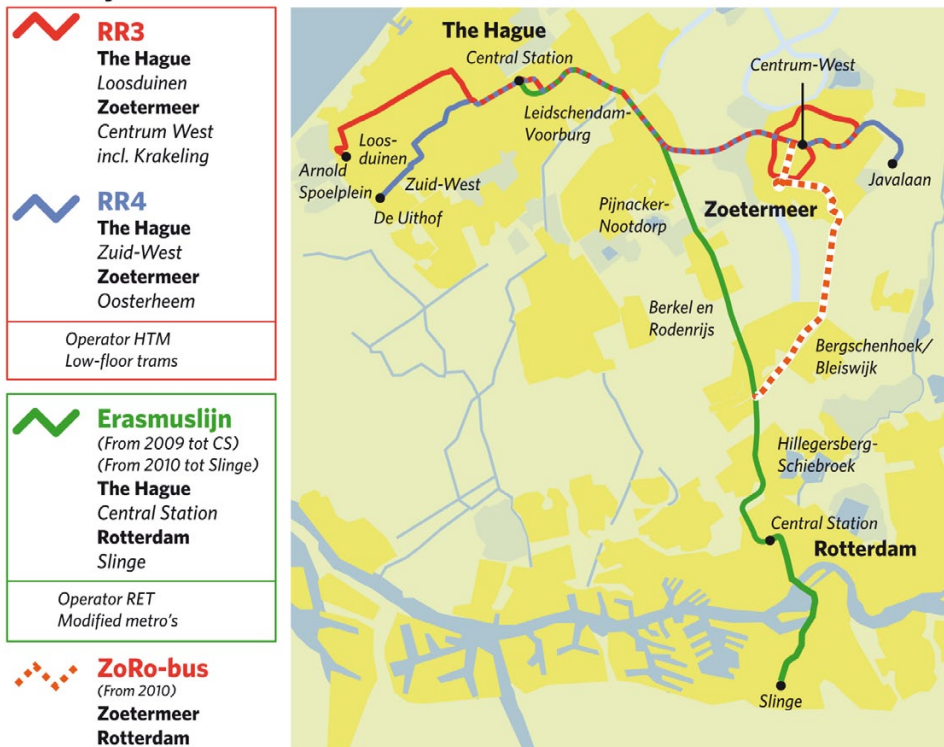
RandstadRail is a product name for public transport services operated by HTM and RET on the RandstadRail network within the Haaglanden and Rotterdam regions on the instructions of the Haaglanden Urban District and Rotterdam City Region. RandstadRail is therefore not a transport company or other kind of organisation. RandstadRail's various lines are indicated on the following map.

<sup>26</sup> In this report, RandstadRail is used to refer to the transport system unless stated otherwise.

<sup>27</sup> See Appendix B, 'Characteristics of Tram, Metro, Train and Light Rail Services'.

<sup>28</sup> Source: [www.randstadrail.nl](http://www.randstadrail.nl).

## Railway sections



©Dutch Safety Board - RandstadRail / Railway sections

Figure 2 – RandstadRail lines<sup>29</sup>

Light rail is a relatively new concept in the Netherlands, certainly as regards the combination of different types of rolling stock and infrastructure as is the case with RandstadRail. Besides RandstadRail, two light rail projects are currently in operation in the Netherlands: the Nieuwegein Line (Nieuwegeinlijn) from Utrecht to Nieuwegein and IJsselstein (express tram service) and the Rijn-Gouwe Line (RijnGouwelijn) between Alphen aan den Rijn and Gouda (first phase; launched as a pilot to acquire experience with light rail operations). In addition, there are many plans – some more concrete than others – for light rail networks elsewhere in the Netherlands, including that of the Rotterdam City Region to convert the Hoekse Line (Hoekse Lijn), the current NS line between Schiedam and Hoek van Holland, into a light rail line and connect it to the Rotterdam metro network. For regional authorities, light rail is a way of improving the operation of unprofitable regional railway lines by ‘downscaling’ these lines<sup>30</sup> or converting them into tram lines, for example.<sup>31</sup> The combined trend towards decentralisation and (national) divestment of unprofitable lines is opening up opportunities for light rail services, and the expectation is indeed that the number of light rail projects initiated and commissioned by regional and local public transport authorities will increase in the coming decades.

## 2.2 THE RANDSTADRAIL PROJECT

The Rotterdam City Region and Haaglanden Urban District acted as joint principal for the realisation of RandstadRail. The first RandstadRail initiatives date from 1989 and the plan became definitive when the financing was arranged in 2002. From 2003 to 2006, a plan was prepared and construction work started. The building phase involved new construction and the modification of existing railway lines. The new construction part of the building phase started in 2002. Major new construction projects in Haaglanden concerned the section through Beatrixlaan, the Oosterheem Line (Oosterheemlijn), the garages in Zichtenburg and Leidschendam, Leidschenveen station, the Schenkstrook flyover, various underpasses and a sunk railway section in Pijnacker. The modification part of the building phase concerned work on existing railway lines that could not be performed while the

<sup>29</sup> Source: [www.randstadrail.nl](http://www.randstadrail.nl).

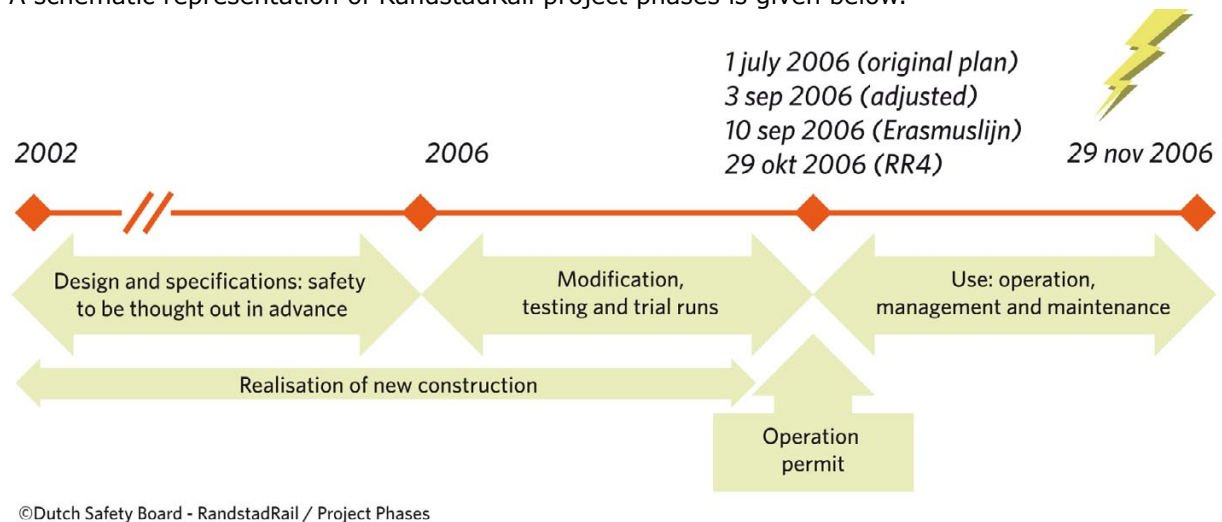
<sup>30</sup> ‘Downscaling’ in this case is used to refer to a railway line that is removed from the primary railway network and converted into a local, metro or tram line.

<sup>31</sup> This involves switching from heavy rail services on the line in question to tram services and can also refer to the replacement of bus services by tram services.

lines in question were still being used by NS trains. The new constructions were also connected to the existing railway network during the modification part of the building phase.

Actual modification work began in June 2006 after NS had ceased passenger services on the Hofplein Line and Zoetermeer City Line. These lines were removed from the primary railway network by the Minister of Transport, Public Works and Water Management, after which the previous infrastructure manager transferred management of these lines to the Haaglanden Urban District (Zoetermeer City Line and part of the Hofplein Line) and Rotterdam City Region (the other part of the Hofplein Line) and the lines were modified for RandstadRail purposes. The originally planned operational launch of the Zoetermeer City Line on 3 September 2006 did not take place because work had not yet been completed. RandstadRail operations did, however, begin on the Hofplein Line from Rotterdam to Nootdorp on 10 September 2006. RandstadRail services were introduced in phases in Haaglanden in the period September November 2006. During this time, RandstadRail had to deal with various technical malfunctions and a number of derailments until services were suspended on 29 November 2006. The Hague Loosduinen Zoetermeer 'Krakeling' line (RR3) was not yet in use at that time.

A schematic representation of RandstadRail project phases is given below.<sup>32</sup>



©Dutch Safety Board - RandstadRail / Project Phases

Figure 3 – RandstadRail project phases

The RandstadRail project encompassed the RandstadRail transport system as a whole, which comprised existing railway infrastructure, rolling stock, traffic control, process execution and management, safety and telecommunications in relation to the entire RandstadRail network.

The modification of a number of existing railway lines was necessary to enable RandstadRail operations. This concerned part of The Hague city tram network, the Zoetermeer City Line and the Hofplein Line. New infrastructure was also built as part of the RandstadRail project. Both modification and new construction formed part of the Haaglanden realisation project (uitvoeringsproject RandstadRail) that was outsourced by the Haaglanden Urban District to the municipality of The Hague.<sup>33</sup> The following work took place at the start of the project in Haaglanden:<sup>34</sup>

- construction of a new connection between the city tram network at the Ternoot stop and the primary railway network (including the new Beatrix viaduct);
- construction of a new grade separated crossing in Schenkstrook to enable RandstadRail vehicles to make use of the two outer railways at The Hague's Laan van Nieuw Oost Indië (NOI) station; the four other railways form part of the primary network;
- a new railway section of approximately 3.5 km from the Seghwaert stop in Zoetermeer to the Zoetermeer Oosterheem district;
- modification of the placement of railways at various stops and curves of the city tram network;

<sup>32</sup> See Appendix C2 for a more detailed account of the RandstadRail lifecycle.

<sup>33</sup> With regard to the modification and new construction work to be carried out in the Rotterdam region, the authorities of the Rotterdam City Region and those of the municipality of Rotterdam agreed that project implementation would rest with the municipal authorities; the Rotterdam municipal authorities placed project implementation internally with RET.

<sup>34</sup> Haaglanden Subproject Funding Decision (Subsidiebeschikking Deelproject Haaglanden) of 11 December 2002.

- relocation and construction of various structures (viaducts, tunnels and bridges);
- construction of new stops and the modification of existing ones to make them suitable for the vehicles that would be stopping at them:
  - the platforms along The Hague Laan van NOI-Leidschenveen stretch were built to feature both a low section (for the low floor vehicles of HTM) and a high section (for the high floor vehicles of RET);
  - high platforms were built at all stops along the Leidschenveen-Rotterdam Hofplein stretch;
  - low platforms were built at all stops along the Leidschenveen-Zoetermeer stretch.

The Ministry of Transport, Public Works and Water Management financed 95% of the costs for the work referred to by making funds available to the Haaglanden Urban District and Rotterdam City Region. Approximately 400 million euros was made available to each administration, which therefore meant a total budget in excess of 800 million euros.

Choices were made during the design and building phases of the RandstadRail project which resulted in the following additions:

- replacement of the rails of the entire Zoetermeer City Line (36 km of railway);
- replacement of virtually all the switches of the former Zoetermeer City Line and Hofplein Line by three types of switch:<sup>35, 36</sup>
  - switches on The Hague Laan van NOI-Leidschenveen stretch, which would be used by both HTM trams and RET metros, were replaced by a type that could be used by both categories of vehicle;<sup>37</sup>
  - switches on the Leidschenveen-Rotterdam Hofplein stretch, which would be used only by RET vehicles, were replaced by a metro specific type;
  - switches on the Leidschenveen-Zoetermeer stretch, which would be used only by HTM vehicles, were replaced by a tram specific type;
- realisation of a new railway safety system from The Hague's central station to Zoetermeer and Rotterdam Hofplein;
- realisation of a new power supply (750V instead of 1500V) on the stretches from The Hague's central station to Zoetermeer and Rotterdam Hofplein.<sup>38</sup>

In addition to project implementation, the future railway undertakings and infrastructure managers of RandstadRail (HTM and RET) had to do the following to make the operation, management and maintenance of RandstadRail possible:

- purchase new vehicles (50 RandstadRail vehicles for HTM and 21 RandstadRail vehicles for RET) and modify existing metros (RET) to make them suitable for temporary use (i.e. in the expectation of new vehicles) between The Hague's central station and Hofplein station;
- train hundreds of drivers (both tram and metro drivers as well as new drivers);
- reorganise traffic control centres;
- test the system and the vehicles;
- conduct trial runs in accordance with what would become the regular timetable;
- properly structure their respective organisations and formulate procedures.

The timeline of the RandstadRail project was broadly as follows:

1989	Initial ideas based on the second Traffic and Transport Structure Plan (Structuurschema Verkeer en Vervoer, SVV-II)
1990	Establishment of RandstadRail Project Office
1993	First plan (HTM, RET, NS, Westnederland <sup>39</sup> )

<sup>35</sup> Replacement of the switches was necessary to enable trams and metros, which have different wheel profiles, to use the same rails. The original plan had been to modify the railway infrastructure of The Hague's city tram network, though a decision was later made to install a type of switch in the outer areas that could be used by both trams and metros. That type of switch was used on all railway sections used by both trams and metros. On railway sections used only by trams or metros, new switches specific to the vehicle category were used.

<sup>36</sup> The four switches at The Hague's central station and the switch at Rotterdam Hofplein were not replaced because they were due for removal within a few years as part of a planned alteration of layout. The switch machines were, however, replaced by machines from the manufacturer that had also supplied the switches installed on railway sections used by both categories of vehicle. These switches are only used by RET vehicles.

<sup>37</sup> To make this possible, the decision was made to use switches with movable rather than fixed points and a special switch blade. See Appendix J for an explanation of both types of switch.

<sup>38</sup> The original decision had been to base services between The Hague and Zoetermeer on visibility. In order to ensure the reliability of these services also in limited visibility conditions, however, the decision was later made to install a railway safety system on this section as well.

<sup>39</sup> Now part of Connexion.

1996	Modified plan (Haaglanden Urban District, Rotterdam City Region, Province of South Holland, Ministry of Transport, Public Works and Water Management)
1997-1999	Various modifications (including whether or not to operate a bus service between Zoetermeer and Rotterdam)
2002	Ministry of Transport, Public Works and Water Management makes funds available
2003	Haaglanden Urban District outsources RandstadRail design and build to the municipality of The Hague
2004	April: HTM orders RandstadRail vehicles using a loan from the municipality of The Hague. Haaglanden Urban District expresses its intention to grant the concession for transport to HTM subject to the agreement of the Ministry of Transport, Public Works and Water Management
2005	September: Haaglanden Urban District grants HTM the concession for transport and the management of RandstadRail in Haaglanden
2006	June September: modification, testing and trial runs 10 September: launch of Nootdorp Rotterdam (Erasmus Line) operations by RET 29 October: launch of The Hague Zoetermeer Oosterheem (RR4) operations by HTM 3 and 4 November: RandstadRail (HTM) derailments at The Hague's central station 24 November: RandstadRail (HTM) derailment on a vehicle activated switch 29 November: Ternoot derailment (HTM) 29 November: Forepark derailment (RET) 29 November: RandstadRail passenger services are suspended with the exception of those on the Nootdorp Rotterdam Hofplein section (Erasmus Line) 10 December: planned launch of The Hague Loosduinen Zoetermeer 'Krakeling' operations (RR3) cancelled due to derailments of 29 November 2006
2007	January October: extension of testing and trial runs 24 and 26 January: RandstadRail (HTM) derailments on vehicle activated switches 12 February: resumption of The Hague central station The Hague Monstersestraat operations and launch of Monstersestraat Loosduinen (RR3) operations 16 May: resumption of The Hague central station The Hague Monstersestraat operations and launch of The Hague central station The Hague Uithof (RR4) operations 3 September: resumption of The Hague Nootdorp (Erasmus Line) operations 8 October: resumption of The Hague central station Zoetermeer Oosterheem (RR4) operations 20 October: resumption of The Hague central station Zoetermeer Seghwaert (RR3) operations 27 October: resumption of operations on the last RandstadRail section, namely the entire Zoetermeer 'Krakeling' (RR3) stretch





### 3 ASSESSMENT FRAMEWORK

The assessment framework is used to check investigative findings and comprises the following three parts:

- a. a description of the relevant legislation and regulations applicable to the sector in which the incident or series of incidents occurred;
- b. a description of additional standards, guidelines and insights generated by the sector concerned itself;
- c. a description of the general assessment framework for safety management.

The first two parts of the assessment framework are sector specific and, in terms of their particulars, depend to a large extent on the type of incident being investigated. The third part of the assessment framework is more general and defines the expectations of the Dutch Safety Board with respect to the way in which the parties involved organise and exercise their individual responsibility for safety. These three parts are further explained in this chapter.

#### 3.1 LEGISLATION AND REGULATIONS<sup>40</sup>

##### 3.1.1 *Intermunicipal statutory regulations act*

The Intermunicipal Statutory Regulations Act makes it possible for municipal authorities to establish cooperative arrangements in public law on a voluntary basis for the performance of their duties. The Act contains provisions concerning, among other things, the setting up, alteration and discontinuation of municipal cooperative arrangements and the related financing. Municipal authorities can transfer their duties and powers to such cooperative arrangements which, in addition, may have a legal personality.

Prior to 1 January 2006, urban districts were based on the Government in Transition Framework Act. On 1 January 2006, the Intermunicipal Statutory Regulations Plus (Amendment) Act entered into force and added a 'Plus Regions' chapter to the Intermunicipal Statutory Regulations Act. So called plus regions like the Haaglanden Urban District and Rotterdam City Region can be established at the joint request of the municipalities concerned and if the Provincial Executive, which is responsible for the day to day administration of a province, is of the opinion that establishing such a plus region is necessary to deal with spatial zoning issues such as housing, business establishment, traffic and transport, recreation or urban green areas.<sup>41</sup>

##### 3.1.2 *2000 Passenger Transport Act*

The 2000 Passenger Transport Act contains provisions relating to the operation of market forces in, among other things, public passenger transport on public roads and railways. Operating public passenger transport services without holding an appropriate concession is forbidden.<sup>42</sup> The concession grantor (in the case of RandstadRail, the urban districts) is the party duly authorised to grant concessions.<sup>43</sup> The concession holder is the railway undertaking to whom a concession has been granted.<sup>44</sup> The conditions attached to a concession may relate to, among other things, ensuring a reasonable level of safety for passengers and personnel in public transport networks.<sup>45</sup>

The 2000 Passenger Transport Act includes provisions concerning the tendering for concessions.<sup>46</sup> The obligation to call for tenders that forms part of the concession granting procedure (other than a concession relating to train services) comes into effect at a time specified by an order in council.<sup>47</sup> In addition, the Act limits the activity of transport companies on which the municipal authorities of the four largest cities (The Hague, Amsterdam, Rotterdam and Utrecht) have a controlling influence.<sup>48</sup>

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<sup>40</sup> This section describes the legislation and regulations most relevant to the derailments. Appendix D specifies additional legislation and regulations relating to safety and applicable to RandstadRail.

<sup>41</sup> Intermunicipal Statutory Regulations Act, Section 106, paragraph 1.

<sup>42</sup> 2000 Passenger Transport Act, Section 19.

<sup>43</sup> Ibid. Section 1, subparagraph m in conjunction with Section 20, paragraph 2.

<sup>44</sup> Ibid. Section 1, subparagraph n.

<sup>45</sup> Ibid. Section 32, paragraph 2, subparagraph h.

<sup>46</sup> Ibid. Chapter III.

<sup>47</sup> Ibid. Section 61.

<sup>48</sup> 2000 Passenger Transport Act, Section 69.



### 3.1.3 Railways Act and legislation and regulations governing city trams

The new Railways Act came into force, together with implementation legislation based on it, on 1 January 2005. Influenced by EU regulations which are introducing market forces into the railway sector, the Railways Act is based on the principle of separation between management of the railway infrastructure and the transport conducted by means of that infrastructure. In addition, the Railways Act serves as the foundation for numerous regulations and decrees in which requirements relating to railways are further elaborated.

The new Railways Act maintains a distinction between primary railways, secondary railways and exceptional railways. Furthermore, the Railways Act only applies once a given railway has been designated as being subject to the said Act by Royal Decree.<sup>49</sup> The Act specifies the cases in which a given railway is designated as belonging to one of the three categories.<sup>50</sup>

The Explanatory Memorandum to the new Railways Act indicates that the Act is focused mainly on primary railway networks, i.e. those used by trains;<sup>51</sup> indeed, the Act came into force only in relation to primary railway networks. The sections that concern local and exceptional railways, which could be of importance to light rail systems, do not apply.<sup>52</sup> Section 94 of the Act, for example, which makes it possible to establish regulations governing secondary railways, has not come into effect.

The old 1875 Railways Act and Secondary and Tram Railways Act therefore still apply to all non primary railways. Also in this case, a given railway must first be designated as being subject to the said legislation and regulations for them to apply.<sup>53</sup> In this connection, an appropriately tailored set of regulations must apply to every railway category: the Primary and Secondary Railways Service Regulations (RDHL) apply to secondary railways such as the RandstadRail light rail network, the Metro Regulations apply to city railways such as the Rotterdam metro network and the Tram Railways Regulations apply to inter local tram networks.

No set of regulations is available, however, for city trams that only transport passengers within a single municipality because the Secondary and Tram Railways Act does not apply to this particular railway category.<sup>54</sup> By virtue of the Municipalities Act, municipal authorities are therefore free to regulate city tram operations by means of municipal byelaws. Only a handful of municipal councils in the Netherlands have actually exercised this right, and those of The Hague and Rotterdam are not among them.

The sets of regulations differ in terms of the degree to which they set requirements for the railway category in question. A secondary railway, for example, must be closed off to other traffic in a certain way<sup>55</sup> and a city railway (metro system) is in principle not allowed to have level crossings with other traffic.<sup>56</sup>

The Hague central station The Hague Laan van NOI–Zoetermeer RandstadRail sections, together with the Leidschendam Rotterdam branch (the old Hofplein Line and Zoetermeer City Line and the new Zoetermeer-Oosterheem Line), were designated by the Minister of Transport, Public Works and Water Management as secondary railways within the meaning of the Secondary and Tram Railways Act.<sup>57</sup> In summary, the following legislation and regulations apply to these railway sections:

- 1875 Railways Act
- Secondary and Tram Railways Act
- Primary and Secondary Railways Service Regulations (RDHL), with amendments for RandstadRail<sup>58</sup>.

Legislation and regulations governing railways therefore do not apply to RandstadRail sections that form part of The Hague city tram network but were not designated as one of the railway categories within the meaning of the Secondary and Tram Railways Act. This particular category of railway is subject to the following legislation and regulations:

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<sup>49</sup> Railways Act, Section 2, paragraph 1.

<sup>50</sup> Ibid. Section 2, paragraphs 2 and 3.

<sup>51</sup> Explanatory notes to Section 2 of the Railways Act.

<sup>52</sup> For example Railways Act, Section 2, paragraphs 2 and 3, which relate to secondary and exceptional railways.

<sup>53</sup> Secondary and Tram Railways Act, Section 1, paragraph 1.

<sup>54</sup> Ibid. Section 8, paragraphs 1 and 4.

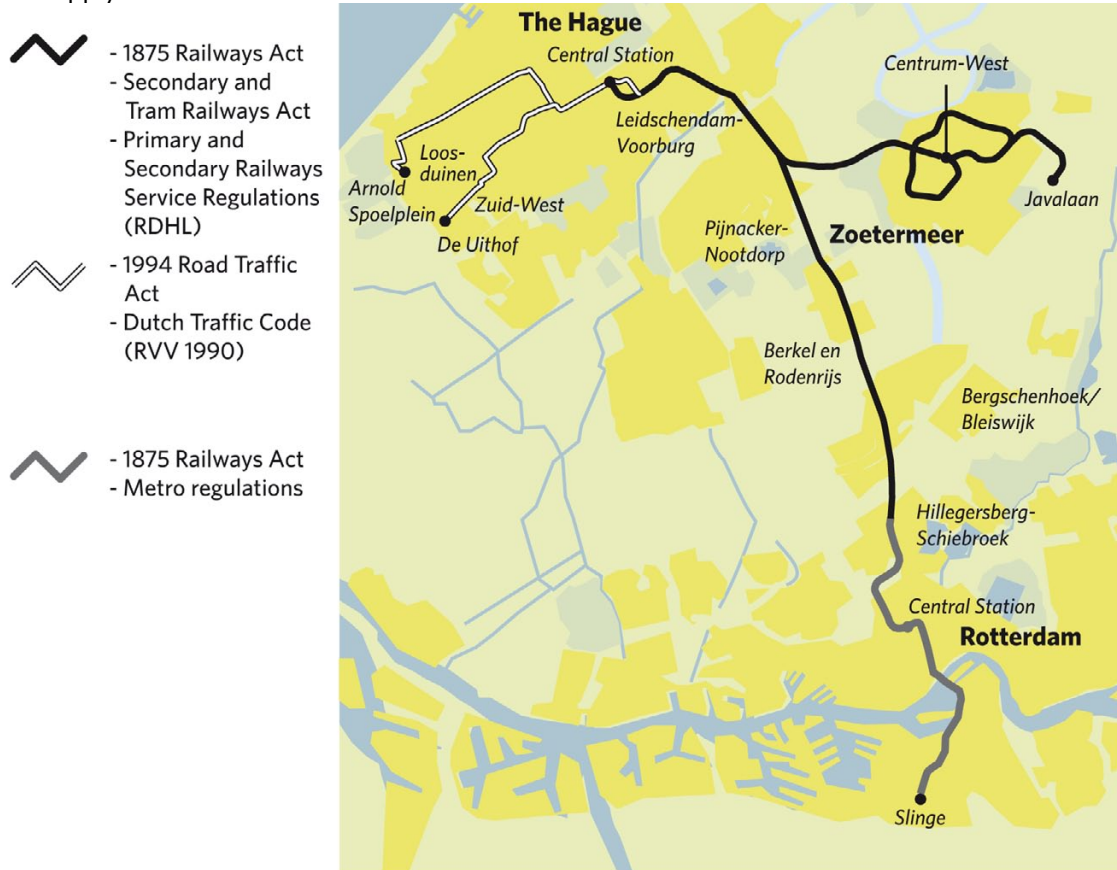
<sup>55</sup> Primary and Secondary Railways Service Regulations (RDHL), Sections 18 and 19.

<sup>56</sup> Metro Regulations, Section 17.

<sup>57</sup> Designation Order of 23 May 2006, Government Gazette (103), 2006. Order in Council, September 2006.

- 1994 Road Traffic Act
- Dutch Traffic Code.

Finally, the metro sections in the Rotterdam region were designated as city railways. The Staten Tunnel (Statentunnel), which is currently under construction and which will in time be used by RandstadRail vehicles, will likewise be designated as city railway. The 1875 Railways Act and the Metro Regulations will therefore apply to that section. The map below indicates the legal regimes that apply to each RandstadRail section.



©Dutch Safety Board - RandstadRail / Legal regimes

Figure 4 – Legal regimes applicable to each RandstadRail section

### 3.1.4 1875 Railways Act

The old 1875 Railways Act focuses on the entrepreneurs and managers of a railway service. The Act assumes that the laying, management and use of a railway network will remain in the hands of a single party.

The provisions aimed at entrepreneurs involved in (railway) infrastructure contain tolerance obligations.<sup>59</sup>

Further provisions are aimed at entrepreneurs involved in the actual operation of the railway service (operating the railway vehicles).<sup>60</sup> To operate such services, these parties must adopt regulations that require the approval of the Minister of Transport, Public Works and Water Management.<sup>61</sup> For RandstadRail, HTM and RET jointly prepared the RandstadRail Service Regulations (Dienstreglement/-voorschrift RandstadRail, DRVR). Among other things, these regulations set out rules for drivers of light rail vehicles with a view to ensuring safety. The RandstadRail Service Regulations only apply to RandstadRail sections that have been designated as secondary railways. For the parts of The Hague city tram network used by RandstadRail vehicles, HTM modified the Tram Driver Handbook. This handbook is not law but, rather, part of HTM's own internal regulations and, like the RandstadRail Service Regulations, also sets out rules for drivers of RandstadRail vehicles,

<sup>59</sup> 1875 Railways Act, Sections 4 and 5.

<sup>60</sup> 1875 Railways Act, Section 6, paragraph 2.

<sup>61</sup> Ibid. Section 6, paragraph 1.

though ones that are tailored to driving on the city tram network.

In addition, the 1875 Railways Act contains provisions about starting a service: operations may only begin after authorisation has been granted by the Minister of Transport, Public Works and Water Management. The granting of such authorisation is preceded by a government inspection of the railway and associated structures.<sup>62</sup> No authorisation is required for putting new vehicles into operation. The 1875 Railways Act only stipulates that new vehicles must undergo inspection before being put into operation.<sup>63</sup>

The 1875 Railways Act grants the power to attach rules to an Order in Council concerning actual operation of the service (operating the railway vehicles), rail traffic safety<sup>64</sup> and the closing off of railway lines for safety and security purposes.<sup>65</sup> These rules are specified in the Primary and Secondary Railways Service Regulations (RDHL).

The 1875 Railways Act also contains provisions aimed at railway service entrepreneurs, which state that these parties must bear the costs of closing off railway lines for safety and security purposes<sup>66</sup> and of the fencing that must be placed along these lines.<sup>67</sup>

Finally, the 1875 Railways Act contains provisions aimed at all parties. These provisions concern the distances that must be kept from railways in the case of, for example, construction and digging work.<sup>68</sup>

The 1875 Railways Act does not apply in cases where the 2000 Passenger Transport Act applies.<sup>69</sup>

### *3.1.5 Primary and Secondary Railways Service Regulations*

The Primary and Secondary Railways Service Regulations originally assumed that the laying out, management and operation of a railway network would remain in the hands of a single party. The regulations were specially amended for RandstadRail, however.<sup>70</sup> The amendments came into force on 13 October 2006.

The Regulations contain provisions relating to (railway) infrastructure,<sup>71</sup> rolling stock,<sup>72</sup> vehicle operation (train and yard services)<sup>73</sup> and personnel.<sup>74</sup> These regulations are aimed at managers of a railway service in relation to issues concerning vehicle operation, rolling stock and personnel, and at the Executive Committees of the Haaglanden Urban District and Rotterdam City Region in relation to (railway) infrastructure. The Executive Committees of the Haaglanden Urban District and Rotterdam City Region have a number of powers pertaining to (railway) infrastructure,<sup>75</sup> including the authority to grant exemptions in relation to railway vehicle axle loads and determine boundaries in the case of railway junctions.

RandstadRail (railway) infrastructure that was designated as secondary railway must meet the requirements of the Primary and Secondary Railways Service Regulations. Among other things, these requirements concern stations and stops, railways and associated structures, barriers and fencing and crossing points.<sup>76</sup> The Executive Committees of the Haaglanden Urban District and Rotterdam City Region must ensure that the railway network and its associated permanent facilities are properly maintained so as to enable safe railway services.<sup>77</sup>

RandstadRail rolling stock must meet the requirements set out in the Primary and Secondary Railways Service Regulations concerning, among other things, construction (wheels) and axle load, the

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<sup>62</sup> Ibid. Section 7, paragraphs 1 and 2.

<sup>63</sup> Ibid. Section 7, paragraph 3.

<sup>64</sup> Ibid. Section 27.

<sup>65</sup> Ibid. Section 33.

<sup>66</sup> Ibid. Section 33.

<sup>67</sup> Ibid. Section 35.

<sup>68</sup> Ibid. Sections 34 to 41 inclusive.

<sup>69</sup> Ibid. Section 69a.

<sup>70</sup> Bulletin of Acts and Decrees 2006, 463.

<sup>71</sup> Primary and Secondary Railways Service Regulations (RDHL), Chapter II.

<sup>72</sup> Ibid. Chapter III.

<sup>73</sup> Ibid. Chapter IV.

<sup>74</sup> Ibid. Chapter VI.

<sup>75</sup> Ibid. Section 11.

<sup>76</sup> According to Section 31a of the Primary and Secondary Railways Service Regulations, provisions concerning fixed signals and verbal communication links as well as a number concerning crossing points, among others, do not apply to RandstadRail.

<sup>77</sup> Primary and Secondary Railways Service Regulations, Section 17 in conjunction with Section 11.

place of the driver in the train, carriage combinations, train signals, brakes and speed.<sup>78</sup>

Before rolling stock is put into operation, it must be inspected and approved by the management of the railway company concerned. The approval and the date on which it was given, as well as the date on which the rolling stock was put into operation, must be recorded in a register.<sup>79</sup> In addition, rolling stock must undergo periodic inspection and maintenance according to a timetable approved by the railway company's management in order to ensure that the trains can be operated safely at all times.<sup>80</sup>

The parties that perform train and yard services must satisfy provisions relating to, among other things, the place of the driver in the train, carriage combinations, train signals, brakes, speed, method of operation on a double railway track, train movements, timetables and personnel.<sup>81</sup>

The Primary and Secondary Railways Service Regulations also contain provisions relating to accidents and other irregularities.<sup>82</sup>

### 3.1.6 *Secondary and Tram Railways Act*

Pursuant to the Secondary and Tram Railways Act, a permit in the form of a concession granted by the Crown is required for the laying of a secondary railway network and the operation of services on that network.<sup>83</sup> The Act does not specify, however, the object and scope of the required concession or the regulations that can be attached to it.

The Act addresses managers with the stipulation that the operation of a railway service is not allowed without a concession.<sup>84</sup> It does not define, however, what is meant by 'managers'.

In addition, the Act obliges railway company entrepreneurs to operate services in accordance with the timetable adopted.<sup>85</sup>

The Act also grants the power to attach rules to an Order in Council relating to, among other things:

- ensuring safety and orderly rail traffic;
- announcing the start and the scheduling of a railway service (operating the vehicles);
- the publication of rates.

Moreover, the Secondary and Tram Railways Act serves as the foundation for provisions in the Primary and Secondary Railways Service Regulations concerning the railway service (operating the vehicles) and the use of secondary railways that deviate from a number of provisions of the 1875 Railways Act.<sup>86</sup>

Finally, the Act gives Provincial Executives the power to establish regulations governing the railway service and the use of tram railways that have been laid out on public roads.<sup>87</sup> Furthermore, subject to the approval of the Crown, municipal councils can likewise establish regulations in the event that exceptional circumstances of a local nature make such regulations necessary for the operation of the railway service and the use of secondary or tram railways.<sup>88</sup>

### 3.1.7 *Dutch Civil Code*

The Dutch Civil Code contains provisions relating to agreements concerning domestic public passenger transport services.

Transporters that operate domestic public passenger transport services according to a timetable are liable vis à vis a passenger for damage or injury to, or the death of, that passenger resulting from an accident that occurred during the transport of that passenger. This liability also applies in the case of shortcomings or improper functioning with regard to the means of transport or equipment

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<sup>78</sup> Ibid. Sections 33 and 42.

<sup>79</sup> Ibid. Section 44.

<sup>80</sup> Ibid. Section 46.

<sup>81</sup> Ibid. Chapters IV and VI.

<sup>82</sup> Ibid. Chapter V, Part II.

<sup>83</sup> Secondary and Tram Railways Act, Section 2, paragraph 1.

<sup>84</sup> Ibid. Section 3.

<sup>85</sup> Ibid. Section 5, paragraph 4.

<sup>86</sup> Secondary and Tram Railways Act, Section 2, paragraph 1.

<sup>87</sup> Ibid. Section 7, paragraph 1.

<sup>88</sup> Ibid. Section 7, paragraph 2.

operated by the railway undertaking, and in the case of physical or psychological shortcomings on the part of the driver of the means of transport.<sup>89</sup>

### 3.1.8 *General Terms and Conditions governing City and Regional Public Transport Services*

The General Terms and Conditions governing City and Regional Public Transport Services (Algemene voorwaarden openbaar stads- en streekvervoer) apply to the transport agreements that passengers conclude with regard to city and regional public transport services and regional public transport services by rail.<sup>90</sup>

Among other things, these General Terms and Conditions contain provisions relating to the obligations of the railway undertaking. The railway undertaking is obliged, for example, to transport a passenger and his or her hand luggage safely and in accordance with the timetable and General Terms and Conditions.<sup>91</sup>

In addition, the General Terms and Conditions contain provisions relating to timetables, rates, payment, validity of a ticket or travel pass, hand luggage, animals and bicycles, obligations of a passenger, liability of the railway undertaking, complaints and disputes and found objects.

### 3.1.9 *Working conditions legislation*

Employers and employees have a number of obligations pursuant to the Working Conditions Act. The employer must ensure the safety and health of employees in relation to all aspects associated with work and must conduct a policy aimed at realising the best possible working conditions.<sup>92</sup> In addition, the employer must organise the work in such a way as to ensure that the safety and health of an employee is not adversely affected. In the first instance, the employer must strive to the greatest extent possible to prevent or limit hazards and risks to the safety or health of an employee at the source of such hazards and risks. The employer must make effective and appropriate personal protective equipment available to an employee (if prevention or restriction at the source is not possible and/or inadequate).

Pursuant to the Working Conditions Act, an employer is also obliged to take measures to protect third parties from potential hazards that may be present on the company's premises or in its immediate environment.

In carrying out their professional duties at their respective places of work, employees are obliged to ensure their personal safety and health, as well as that of other persons present, to the best of their ability and in accordance with the training they have received and the employer's instructions.<sup>93</sup>

## 3.2 STANDARDS AND GUIDELINES

### 3.2.1 *Normative Document for Light Rail Safety*

In 2002 the Minister of Transport, Public Works and Water Management prepared the Normative Document for Light Rail safety (hereinafter to be referred to as the 'Normative Document') and accompanying User Instructions. The Normative Document sets out safety requirements relating to the design, construction and operation of light rail systems. In addition, it is not based on legal regulations but, rather, refers to itself as a policy rule which can be deviated from if proper substantiation for doing so is provided.<sup>94</sup> The Normative Document is binding<sup>95</sup> for projects financed by the national government or for those that primarily make use of heavy rail infrastructure.<sup>96</sup> For other projects, the principal can declare the Normative Document applicable on a voluntary basis.<sup>97</sup> Declaring the Normative Document applicable in a binding sense is, at least nominally, one of the preconditions set by the Minister of Transport, Public Works and Water Management for a project to be eligible for funding from the national government.

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<sup>89</sup> Dutch Civil Code, Section 8:105, paragraphs 1 and 3 in conjunction with Section 8:100.

<sup>90</sup> The General Terms and Conditions governing City and Regional Public Transport Services were filed with the District Court of The Hague under number 82/2007 on 29 October 2007.

<sup>91</sup> General Terms and Conditions governing City and Regional Public Transport Services, Article 2, paragraph 1.

<sup>92</sup> Working Conditions Act, Section 3.

<sup>93</sup> Working Conditions Act, Section 11.

<sup>94</sup> Normative Document for Light Rail Safety, version 5.0 as at 25 November 2002, p. 3.

<sup>95</sup> Infrastructure used by heavy rail vehicles (mainly primary railways).

<sup>96</sup> Normative Document for Light Rail Safety, version 5.0 as at 25 November 2002, p. 3.

<sup>97</sup> Ibid. version 5.0 as at 25 November 2002, p. 3.



The Normative Document lists a number of items and associated activities that must serve as the foundation for the safety of a light rail project. In order, these are: clearly formulated risk criteria, a risk analysis, an Integral Safety Plan (ISP), a consolidated safety case and an Operational Safety Plan (OSP).<sup>98</sup> It also specifies the risk bearers, namely: passengers, unauthorised persons, signed crossing point users, crossing point users, persons with suicidal tendencies, the wider environment and road traffic.

The Normative Document had not been made binding for RandstadRail in spite of the funding the project received from the national government. The Haaglanden Urban District and Rotterdam City Region did, however, voluntarily opt to use it as the foundation for safety management. Chapter 6, which addresses safety management, describes the way in which the Haaglanden Urban District and Rotterdam City Region, as RandstadRail initiators and principals, translated the Normative Document into practical organisation and concrete action.

### *3.2.2 Regulations relating to an Independent Safety Assessor (ISA)*

In accordance with the Normative Document for Light Rail Safety, an independent assessment of the safety management conducted and safety related measures taken must be carried out by an Independent Safety Assessor (ISA).<sup>99</sup> This party may not have any relationship whatsoever with principal's work or the author of the safety case.

For projects subject by law to European regulations relating to interoperability, this assessment must be carried out by a Notified Body (NoBo). A NoBo is an organisation that has been accredited by the government of a European Member State to perform such assessments. In addition, this accreditation applies throughout the EU. In their turn, the authorities of the Member State in question monitor the quality of the NoBo and European standards and directives apply to the accreditation granted.

For projects not subject to mandatory European regulations, assessments can be carried out by either a NoBo or an ISA. The ISA is selected by the principal. The Normative Document for Light Rail Safety recommends consultation with the supervisor in the selection of an ISA. In contrast to NoBos, ISAs are not accredited. In practice, organisations that have been granted NoBo accreditation are considered capable of operating as ISAs. In addition, an ISA can apply for accreditation from the Dutch Accreditation Council.

No regulations apply to the work of an ISA. An ISA can, however, choose to apply certain standards and guidelines in the performance of its duties. The quality of an ISA's work is not subject to (legal) supervision.

### *3.2.3 Technical standards for railways and city trams*

The Dutch railway and tram sector has developed its own standards and guidelines. These are based in part on national or international standards which were deemed sound as frames of reference and subsequently translated into standards appropriate to individual railway or tram companies.

UIC standards developed by the international railway sector are the ones mainly used with regard to railways. Many of these standards are converted into European standards (EN standards) and a number of them are even translated into Technical Standards for Interoperability (TSIs). In addition, (more stringent) national standards may be used.

A comprehensive set of guidelines has been established for city trams in Germany and Germany is indeed an international leader in this respect. Many other countries therefore consider the provisions of the *Verordnung über den Bau und Betrieb der Straßenbahnen (BOStrab)*, a German law governing regulations for tram, metro and light rail operations, as constituting the definitive standard and adhere to them accordingly. For RandstadRail, this means that HTM uses BOStrab (adapted in some places to the specific situation in The Hague) as the frame of reference for its city tram network. For the part of RandstadRail network that was designated as secondary railway, HTM adheres to Dutch railway legislation (Secondary and Tram Railways Act, 1875 Railways Act and RDHL). HTM established the foregoing in its own management and maintenance standards and is free to establish such standards itself because no supervision is exercised on The Hague's city tram network.

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<sup>98</sup> Appendix E contains background information relating to the assessment of safety by means of safety cases and assessment by an ISA.

<sup>99</sup> Appendix E contains background information relating to the assessment of safety by means of safety cases and assessment by an ISA.

The situation applicable to Dutch primary railways can be considered by way of comparison. In this case, too, the manager concerned developed its own standards, virtually all of which are based on UIC and EN standards. In terms of applicability these standards range from mandatory to voluntary, some of them even being simply 'informative' in nature. Although the manager is authorised to establish its own standards, the Minister of Transport, Public Works and Water Management can by means of an Order in Council require that certain conditions be met. Standards apply, for example, with respect to ultrasonic investigation. The minister can use an Order in Council to specify the minimum measuring frequency in relation to the load. If the manager wishes to deviate from these parameters, it must obtain ministerial approval. In practice, the Inspectorate for Transport and Water Management carries out this duty.

### 3.3 ASSESSMENT FRAMEWORK FOR SAFETY MANAGEMENT

Past experience has shown that the structure of a safety management system and the way in which the system is implemented by an organisation and its employees in practice play a crucial role in managing and continuously improving safety. The Dutch Safety Board recognises that the framework used to assess the way in which an organisation assumes its responsibility for safety and acts on this responsibility in concrete terms must be appropriate to the kind of organisation in question. Aspects such as the specific nature of an organisation and its size are important and must duly be taken into consideration. That having been said, although the way in which an opinion is formed is based on the particulars of a case, the broader, underlying philosophy remains the same.

In principle, different perspectives can be used to review and assess the way in which an organisation assumes its responsibility for safety and acts on this responsibility in concrete terms. In other words, there is no universal handbook that applies to all situations.

With reference to the broader, underlying philosophy, however, the Dutch Safety Board selected the following five focal areas that must in any case form a part of proper safety management:

1. Insight into risks as the foundation for a safety policy
2. Demonstrable and realistic safety policy
3. Implementation and enforcement of safety policy
4. Refinement and tightening of safety policy
5. Management control, involvement and communication

The Dutch Safety Board is of the opinion that the priorities set out above are justified, given that they are included in numerous national and international laws and regulations as well as in a large number of widely accepted and implemented standards. A more comprehensive description of these priority areas is given in Appendix F.



## 4 THE PARTIES INVOLVED AND THEIR RESPONSIBILITIES

This chapter specifies the key parties involved in RandstadRail and describes their respective roles and responsibilities. Appendix G describes the other parties involved and their responsibilities. The figure below provides an overview of the parties involved and their relationships with each other.

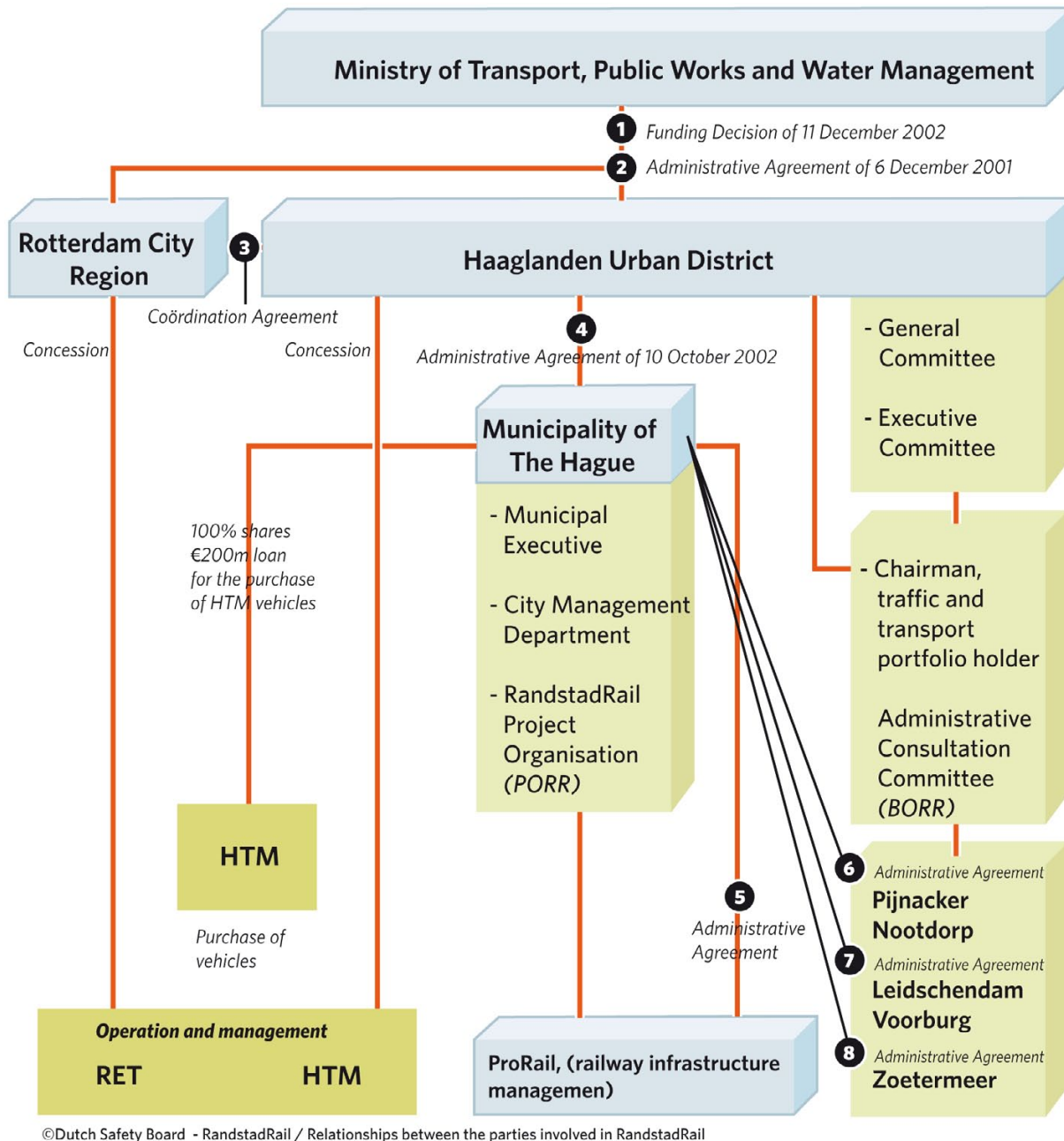


Figure 5 – Relationships between the parties involved in RandstadRail<sup>100</sup>

### 4.1 THE HAAGLANDEN URBAN DISTRICT AND ROTTERDAM CITY REGION

As principals, the Haaglanden Urban District and Rotterdam City Region are jointly responsible for RandstadRail as a whole and individually responsible for RandstadRail within their respective jurisdictions. As all of the derailments occurred in Haaglanden jurisdiction, the main focus in terms of individual responsibility will be on the role played by the Haaglanden Urban District.

<sup>100</sup> Based on Municipality of the Hague, *Stand van zaken Randstadrail*, Council Announcement, Municipal Executive meeting of 30 January 2007, reference rm 15 (2007).

The Haaglanden Urban District was formed in 1992 and is a cooperative body established in public law involving the municipalities of Delft, The Hague, Leidschendam-Voorburg, Midden-Delfland, Pijnacker-Nootdorp, Rijswijk, Wassenaar, Westland and Zoetermeer. Its object is the promotion of regional interests. The Intermunicipal Statutory Regulations Plus (Amendment) Act came into force on 1 January 2006 and gave urban district-based cooperative arrangements a permanent character.

Among other things, the duties of the Haaglanden Urban District's authorities concern traffic and transport. In 2005, 75% of the Haaglanden Urban District's budget was devoted to those two issues. Within this context, the General Committee must adopt a regional traffic and transport plan which includes a properly formulated public transport policy.<sup>101</sup> Pursuant to the Passenger Transport Act 2000, the Haaglanden Urban District's Executive Committee is responsible for granting, changing or withdrawing concessions for the operation of public passenger transport services.<sup>102</sup>

#### 4.1.1 *Project structure for the realisation of RandstadRail*

In the RandstadRail Administrative Agreement, the Haaglanden Urban District and Rotterdam City Region undertook vis-à-vis the Minister of Transport, Public Works and Water Management to implement the RandstadRail subprojects as described in the Agreement for their own account and risk. The Haaglanden Urban District undertook to implement the 'Haaglanden' subproject while the Rotterdam City Region undertook to carry out the 'Boor Tunnel' and 'Other Rotterdam' subprojects. In relation to the Minister of Transport, Public Works and Water Management, the authorities of both jurisdictions were jointly and severally responsible for the coordination and integration of the subprojects.<sup>103</sup>

Pursuant to the Coordination Agreement concluded by the two sides, both the Haaglanden Urban District and the Rotterdam City Region were responsible – individually for projects within their jurisdiction and jointly for projects defined as joint subprojects – for the timely preparation and realisation of subprojects and the constituent parts of these subprojects.<sup>104</sup>

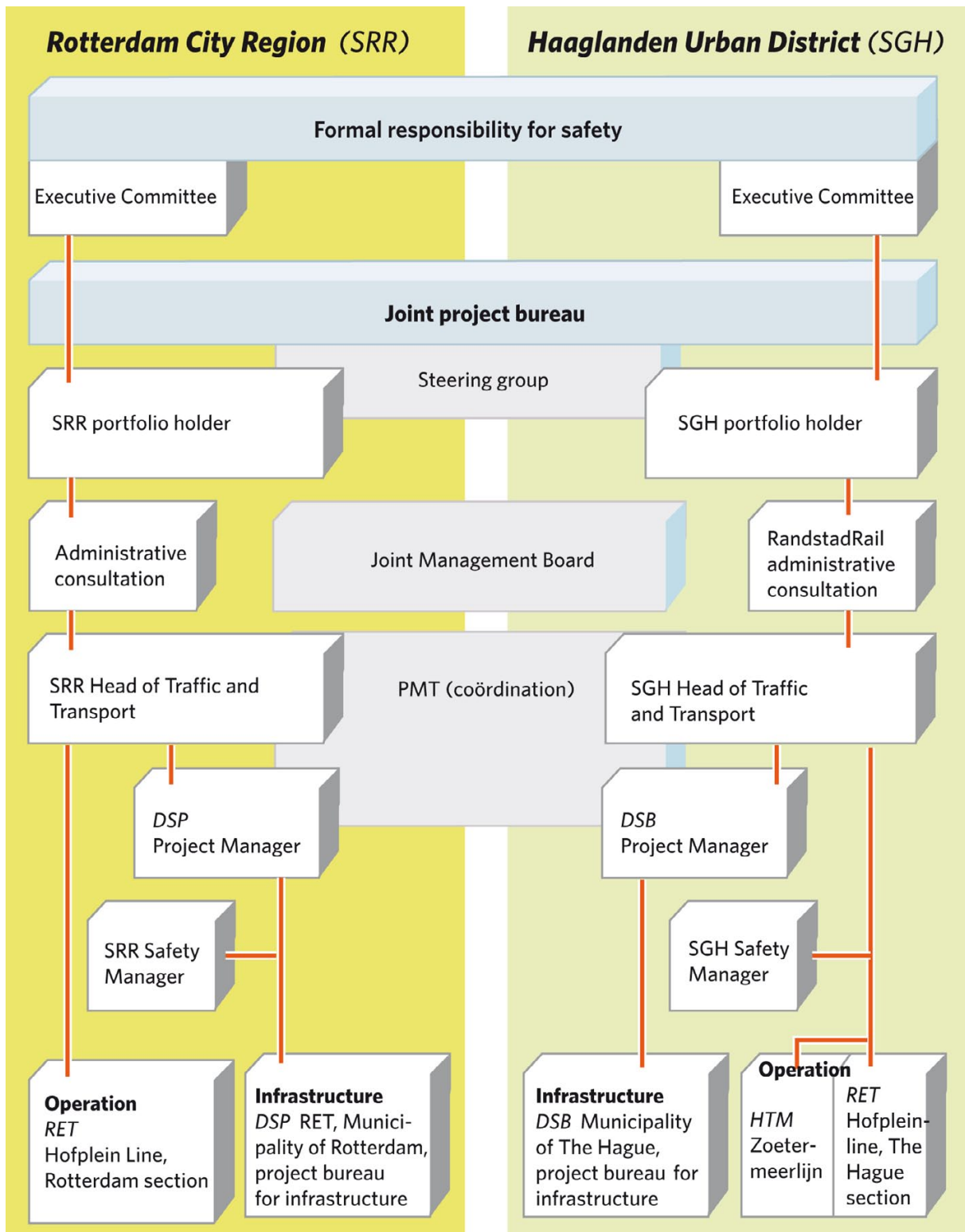
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<sup>101</sup> Haaglanden Urban District Intermunicipal Statutory Regulations Act (*Gemeenschappelijke regeling stads-gewest Haaglanden*), Section 10.

<sup>102</sup> 2000 Passenger Transport Act, Section 20, paragraph 1.

<sup>103</sup> Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management and the authorities of the Haaglanden Urban District and Rotterdam City Region of 6 December 2001, Article 4.1.

<sup>104</sup> Haaglanden Urban District-Rotterdam City Region Coordination Agreement, April 2002, Articles 3.3 and 3.4.



©Dutch Safety Board - RandstadRail / Organisational structure of the RandstadRail project

Figure 6 – Organisational structure of the RandstadRail project<sup>105</sup>

<sup>105</sup> Based on the RandstadRail Integral Safety Plan (ISP), version 4.1, definitive from 18 May 2006.

The Coordination Agreement defined a joint project structure for the preparation and realisation of the subprojects. In this connection, a steering group, joint management board and Project Team were established:<sup>106</sup>

- The steering group comprises the portfolio holders for traffic and transport of the Haaglanden Urban District and Rotterdam City Region and is charged with supervising project progress and implementation of the Coordination Agreement by the parties. In addition, the steering group is duly authorised to represent the Haaglanden Urban District and Rotterdam City Region in the matters referred to.<sup>107</sup>
- The joint management board comprises managers appointed from the Haaglanden Urban District and Rotterdam City Region as well as an independent chairman and is charged with guiding the Project Management Team. In addition, the board is responsible for implementation of the Coordination Agreement and is duly authorised to represent the Haaglanden Urban District and Rotterdam City Region in the matters referred to.<sup>108</sup>
- The Project Management Team (PMT) comprises the project managers of the Haaglanden Urban District and Rotterdam City Region and is charged with preparing the decisions of the joint management board and implementing the decisions taken by that body and the steering group.<sup>109</sup>

When concluding the Coordination Agreement, the Haaglanden Urban District and the Rotterdam City Region agreed that they would realise the parts of the subprojects within their respective jurisdictions<sup>110</sup> and, furthermore, that the preparation and realisation of joint subprojects would take place under the responsibility of the Project Management Team (PMT).<sup>111</sup> Among other things, joint subprojects concern system components such as the provision of travel information, power supply, switches and safety systems.<sup>112</sup> These subprojects were to be realised jointly by the Haaglanden Urban District and Rotterdam City Region or by the authorities in whose jurisdiction the subproject was located.<sup>113</sup> In practice, the joint project bureau did not function in this way. The PMT was used as a consultative body in which the Haaglanden Urban District and Rotterdam City Region coordinated key issues. In formal terms, each region then had to take the relevant decisions. Since all switches that had to be replaced were in the jurisdiction of the Haaglanden Urban District, the municipality of The Hague (RandstadRail Project Bureau) was responsible for ensuring replacement. The supply of power was a joint project. The project manager for this project was made available by RET.

The Haaglanden Urban District and Rotterdam City Region undertook to submit a progress report to the Project Management Team at least once a quarter.<sup>114</sup>

In addition, pursuant to the Administrative Agreement, the Haaglanden Urban District and Rotterdam City Region were obliged to further elaborate the RandstadRail Schedule of Requirements that was forwarded together with the application for funding<sup>115</sup> and, by virtue of the decisions concerning this application,<sup>116</sup> were obliged to submit the more detailed RandstadRail Schedule of Requirements to the Minister of Transport, Public Works and Water Management for approval.

The Haaglanden Urban District and Rotterdam City Region were jointly responsible for the preparation of a RandstadRail Schedule of Requirements. In addition, it was agreed that changes to the Schedule of Requirements would be periodically adopted by the Project Management Team.<sup>117</sup>

#### *4.1.2 Role as principal for the realisation of RandstadRail infrastructure*

Pursuant to the RandstadRail Administrative Agreement, the Haaglanden Urban District was responsible vis-à-vis the Minister of Transport, Public Works and Water Management for the reali-

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<sup>106</sup> See Appendix H for a more comprehensive description of duties and responsibilities.

<sup>107</sup> Haaglanden Urban District-Rotterdam City Region Coordination Agreement, April 2002, Appendix 2.

<sup>108</sup> Ibid. Appendix 2.

<sup>109</sup> Ibid. Appendix 2.

<sup>110</sup> Ibid. Article 9.4.

<sup>111</sup> Ibid. Article 10.1.

<sup>112</sup> Ibid. Article 1.5.

<sup>113</sup> Ibid. Article 10.6.

<sup>114</sup> Ibid. Article 9.1.

<sup>115</sup> Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management and the Haaglanden Urban District and Rotterdam City Region of 6 December 2001, Article 6.

<sup>116</sup> Haaglanden Subproject Funding Decision of 11 December 2002, Article 13 and Rotterdam Subproject Funding Decision.

<sup>117</sup> According to various reports of the Project Management Team, for example that of 23 February 2006, point 5.

sation of RandstadRail's Haaglanden subproject and jointly responsible for the coordination and integration of subprojects with the Rotterdam City Region.<sup>118</sup>

By virtue of the decision concerning funding, the Haaglanden Urban District, together with the Rotterdam City Region, was responsible for ensuring that the design of the infrastructure was submitted to the Inspectorate for Transport and Water Management and assessed in terms of safety prior to the actual construction of that infrastructure.<sup>119</sup> In addition, the Haaglanden Urban District, together with the Rotterdam City Region, was responsible for ensuring that progress of the RandstadRail project was reported to the division for the province of South Holland of the Directorate-General for Public Works and Water Management.<sup>120</sup> Moreover, the Haaglanden Urban District had to keep the Minister of Transport, Public Works and Water Management fully informed about the organisation, planning and results of all practical tests, and make all knowledge acquired in that regard available to the minister.<sup>121</sup>

Furthermore, pursuant to the Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management and the Haaglanden Urban District and Rotterdam City Region, the Haaglanden Urban District was responsible for putting well-defined measures in place to ensure that safety risks to the various groups involved remained confined to the bandwidths specified in the Normative Document.<sup>122</sup> Pursuant to the said agreement, the Haaglanden Urban District and the Rotterdam City Region were also responsible for submitting a Schedule of Requirements to the Minister of Transport, Public Works and Water Management.<sup>123</sup>

For the sections of the RandstadRail network located within Haaglanden jurisdiction that were designated as secondary railway, the Haaglanden Urban District was responsible for ensuring that the requirements of the Secondary and Tram Railways Act were met; that is, for obtaining a concession from the Crown for the laying of those sections.<sup>124</sup>

In addition, for the sections of the RandstadRail network located in Haaglanden jurisdiction that were designated as secondary railway, the Haaglanden Urban District was responsible for ensuring that the requirements of the Primary and Secondary Railways Service Regulations (RDHL) as specially adapted for RandstadRail were met, among other things with respect to stations and stops, railways and associated structures, barriers and fencing, and crossing points.<sup>125</sup>

The Haaglanden Urban District and the Rotterdam City Region decided to use the Normative Document for Light Rail Safety as the principal guide in the design, construction and operation of RandstadRail. As a result of this decision, the Haaglanden Urban District and the Rotterdam City Region were responsible, in terms of the whole and their respective parts, for:

- preparing the Integral Safety Plan (ISP);
- making an inventory of and analysing safety risks, and for establishing safety requirements;
- maintaining a hazards log;
- preparing a safety case and having this assessed by an Independent Safety Assessor (ISA);<sup>126</sup>
- coordinating activities relevant to safety and concluding agreements in this regard between the parties involved;
- preparing an Operational Safety Plan (OSP).

Pursuant to the Integral Safety Plan (ISP) prepared by the Haaglanden Urban District and Rotterdam City Region, safety cases had to properly demonstrate how the established safety requirements were to be met prior to operation of the RandstadRail system. Moreover, these safety cases had to be assessed by an Independent Safety Assessor (ISA). The Haaglanden Urban District and

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<sup>118</sup> Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management, the Haaglanden Urban District and Rotterdam City Region of 6 December 2001, Article 4.1.

<sup>119</sup> Haaglanden Subproject Funding Decision of 11 December 2002.

<sup>120</sup> Ibid. Article 20.

<sup>121</sup> Ibid. Article 15.

<sup>122</sup> Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management, the Haaglanden Urban District and Rotterdam City Region of 6 December 2001, Appendix 1: Scope, Part A, RandstadRail in the Haaglanden Urban District, p. 27.

<sup>123</sup> Administrative Agreement concerning the Financing of RandstadRail concluded between the Minister of Transport, Public Works and Water Management, the Haaglanden Urban District and Rotterdam City Region of 6 December 2001, Article 6.1.

<sup>124</sup> Secondary and Tram Railways Act, Section 2, paragraph 1.

<sup>125</sup> According to Article 31a of the Primary and Secondary Railways Service Regulations (RDHL), provisions relating to fixed signals and verbal communication links, as well as a number concerning crossing points, do not apply to RandstadRail. A number of other provisions also do not apply.

<sup>126</sup> Appendix E contains background information relating to the assessment of safety by means of safety cases.



Rotterdam City Region were jointly responsible for the appointment of the ISA and for completing the 'consolidated' safety case prior to the start of operations which showed that the infrastructure and rolling stock were functioning properly together.

The Haaglanden Urban District was responsible for the instruction issued to the municipality of The Hague for the construction of RandstadRail infrastructure. It was agreed that the municipality of The Hague would have construction work carried out for the account and risk of the municipality and that the Haaglanden Urban District would immediately pass on the contributions of the Minister of Transport, Public Works and Water Management to the municipal authorities.<sup>127</sup> In the agreement concluded between the Haaglanden Urban District and the municipality of The Hague, it was furthermore agreed that the former would only be authorised to issue instructions to the latter insofar as these related to the said agreement.<sup>128</sup> At the same time, however, the Haaglanden Urban District also agreed that it would retain responsibility for the management, maintenance, operation and safety of RandstadRail.<sup>129</sup>

In addition to the joint project bureau (Haaglanden Urban District-Rotterdam City Region), the Haaglanden Urban District established its own organisation, the RandstadRail Administrative Consultation Committee (BORR), for realising the RandstadRail project.<sup>130</sup> This committee was established pursuant to the agreement concluded between the Haaglanden Urban District and the municipality of The Hague to keep the municipalities concerned involved in developments relating to and the progress of the RandstadRail project. The BORR comprised the councillors for traffic of the Haaglanden municipalities directly involved in RandstadRail.

The BORR served as the forum in which the Haaglanden municipal authorities involved coordinated RandstadRail-related matters with the municipality of The Hague. Among other things, the Integral Safety Plan (ISP) and Operational Safety Plan (OSP) were discussed. In addition, the BORR had to monitor the performance of the agreement concluded with the municipality of The Hague – i.e., the BORR had to ensure that the municipality of The Hague was having the work carried out in accordance with the Administrative and Coordination Agreements.<sup>131</sup>

#### *4.1.3 Role in the purchase and approval of rolling stock*

The Haaglanden Urban District formulated the Schedule of Requirements for the new low-floor vehicles to be purchased.<sup>132</sup>

The Purchase of Low-Floor Rolling Stock Advisory Committee set up by the RandstadRail Administrative Consultation Committee was responsible for monitoring HTM's activity in relation to the latter's purchase of new rolling stock and, in addition, was charged with advising the BORR about purchase prices. In its purchasing activity, HTM adhered to the Schedule of Requirements for rolling stock, which was aimed at ensuring the compatibility of the vehicles with the infrastructure and safety. The advisory committee's duties in this regard were to monitor the tendering procedures in terms of due care and transparency and, above all, to ensure that the best product would be obtained for the lowest price.<sup>133</sup>

#### *4.1.4 Role as principal for transport (concession grantor)*

As concession grantor, the Haaglanden Urban District and Rotterdam City Region were responsible for selecting the railway undertakings that would operate RandstadRail passenger services.<sup>134</sup> RET and HTM were chosen. The Haaglanden Urban District and Rotterdam City Region were also responsible for specifying the terms and conditions that would govern the operation of transport services. These terms and conditions were set out in the concessions and one of them obliged RET and HTM to meet the requirements detailed in the Operational Safety Plan (OSP) prepared by the Haaglanden Urban District and Rotterdam City Region (see Chapter 6, 'Safety Management').

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<sup>127</sup> Haaglanden Urban District-Municipality of The Hague Agreement, Article 2.

<sup>128</sup> Ibid. Article 3.3.

<sup>129</sup> Ibid. Article 6.3.

<sup>130</sup> The Dutch Safety Board did not find any decision establishing the duties and responsibilities of this committee. The BORR's set of responsibilities was inferred from its actual activities.

<sup>131</sup> The Haaglanden Urban District was only authorised to issue instructions to the municipality of The Hague insofar as these were necessary for the fulfilment of the former's obligations pursuant to the Administrative and Coordination Agreements (Article 3.3 of the Haaglanden Urban District-Municipality of The Hague Agreement).

<sup>132</sup> The RandstadRail Administrative Consultation Committee adopted the definitive version of the Schedule of Requirements for low-floor vehicles on 26 March 2003. The Executive Committee of the Haaglanden Urban District did so in the middle of May 2003.

<sup>133</sup> According to the Plan of Action for the Supervision of RandstadRail Rolling Stock Purchases for the Haaglanden Region.

<sup>134</sup> 2000 Passenger Transport Act, Section 20, paragraph 2.

#### 4.1.5 Role as principal for infrastructure management

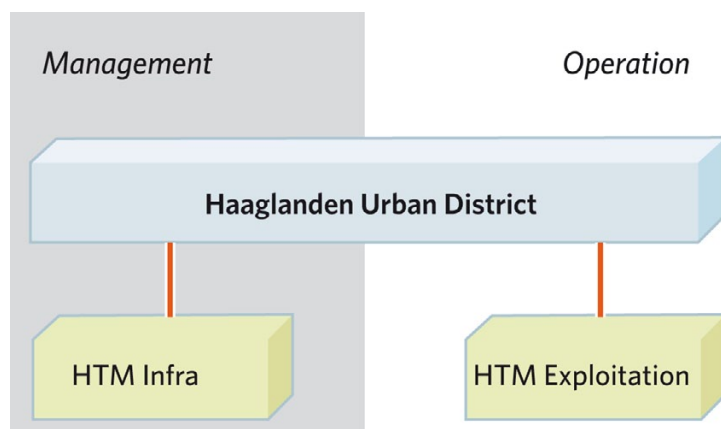
RandstadRail infrastructure within the Haaglanden area comprises railway sections around The Hague's central station, between Zoetermeer and The Hague's central station, the section running from Rotterdam Hofplein to Nootdorp (old Zoetermeer City Line and part of the Hofplein Line) and the part of The Hague's city tram network that is used by RandstadRail vehicles.

The Haaglanden Urban District is responsible for ensuring that the maintenance of RandstadRail infrastructure designated as secondary railway in Haaglanden jurisdiction meets the requirements set out in the Primary and Secondary Railways Service Regulations (RDHL), which stipulate that the Executive Committee of the plus region in which RandstadRail is located, i.e. the Haaglanden Urban District with respect to the part of the RandstadRail network located within Haaglanden jurisdiction, is responsible for maintaining the railways and associated infrastructure in such a way as to ensure that the system as a whole can be operated safely.<sup>135</sup> This maintenance-related obligation only applies to the parts of the RandstadRail network designated as secondary rail, not to the city tram network.

Pursuant to the management agreements concluded between the Haaglanden Urban District and Rotterdam City Region on the one hand and the Minister of Transport, Public Works and Water Management on the other,<sup>136</sup> the Haaglanden Urban District is responsible for the maintenance of RandstadRail sections that are property of the state and located in Haaglanden jurisdiction.<sup>137</sup> Pursuant to the agreements referred to, the Haaglanden Urban District is obliged to ensure, among other things, that RandstadRail infrastructure located in Haaglanden jurisdiction remains in a good state of repair, remains appropriate to its purpose and remains safely and effectively operable.<sup>138</sup> This obligation became effective on the date on which the functional separation of primary railway infrastructure and RandstadRail infrastructure was established (3 June 2006).

The Haaglanden Urban District delegated the operational management and maintenance of the RandstadRail infrastructure and that of the city tram network to HTM. Based on the Normative Document for Light Rail Safety, the Haaglanden Urban District and Rotterdam City Region were obliged to prepare an Operational Safety Plan (OSP) which set out regulations concerning the safe management of the infrastructure. The terms and conditions governing the concession granted specify that HTM must comply with the OSP.

The next figure shows the organisational structure for the phase following realisation of RandstadRail.



©Dutch Safety Board - RandstadRail / Management and operational phase

Figure 7 – Organisational structure for the management and operation of RandstadRail in Haaglanden<sup>139</sup>

<sup>135</sup> Primary and Secondary Railways Service Regulations (RDHL), Article 17 in conjunction with Article 11.

<sup>136</sup> Agreement concerning the management of RandstadRail of 11 December 2002 and the further agreements of 29 May 2006 which primarily regulate the consequences of ownership by Rail Infra Trust instead of the state (as provided for in the management agreement).

<sup>137</sup> Agreement concerning the management of RandstadRail of 11 December 2002, Appendix 1.

<sup>138</sup> Ibid. Article 6.3.

<sup>139</sup> The Haaglanden Urban District also has a relationship with RET as concession holder/operator for the part of the Hofplein Line (and shared section) in Haaglanden jurisdiction.



#### 4.1.6 Role of the ISA engaged by the Haaglanden Urban District and Rotterdam City Region

The duty of the Independent Safety Assessor (ISA) engaged by the Haaglanden Urban District and Rotterdam City Region was to independently verify whether the safety of the RandstadRail transport system was sufficiently guaranteed. The Integral Safety Plan (ISP) prepared by the Haaglanden Urban District and Rotterdam City Region stipulates that the assessment of safety must take place on the basis of safety cases and be performed by an ISA.<sup>140</sup>

Safety cases, which are prepared by the principal, must demonstrate that safety requirements have been met. The ISA must issue a final opinion on the consolidated safety case and take other safety cases that have already been assessed into account when forming this opinion. In addition, when assessing the safety cases already assessed by other ISAs, the ISA must focus on scope and aspects relating to integration.<sup>141</sup>

The ISA's final opinion must be a fair and accurate reflection of the confidence the ISA has in the safety of the system assessed and must be based on the evidence made available, the performance of various assessments, and consultation with the project bureau and safety authority.<sup>142</sup>

The advice given by the ISA is limited to two areas:<sup>143</sup>

- advice concerning the organisation and performance by the project bureau of activities designed to ensure safety and relating to the presentation of evidence in this regard;
- advice concerning the handling and resolution of issues revealed in the findings that may result in the withholding of authorisation to commence operations.

Four opinions are possible with respect to the conclusion (statement) that must be given in the assessment report:<sup>144</sup>

- the ISA concludes that the system meets the safety requirements, specifying all preconditions that must be met;
- the ISA concludes that the system will meet the safety requirements if certain recommendations are implemented;
- the ISA doubts whether the system meets the safety requirements, making a review of safety-related basic principles necessary;
- the ISA concludes that the system does not and will not meet the safety requirements, making a change to the design necessary.

No regulations apply to the work of the ISA. The ISA can, however, voluntarily adopt to apply certain standards and guidelines to its work (see section 3.2.2).

## 4.2 MUNICIPALITY OF THE HAGUE

The municipality of The Hague has the following roles with respect to RandstadRail:

- a member municipality of the Haaglanden Urban District;
- a contractor for the preparation and construction of RandstadRail infrastructure in Haaglanden jurisdiction;
- a shareholder/owner of HTM.

### 4.2.1 Role as a member municipality of the Haaglanden Urban District

The municipality of The Hague is a member of the Haaglanden Urban District and, as such, holds seats in the General and Executive Committees. The mayor of The Hague is also the chairman of the Haaglanden Urban District.

### 4.2.2 Role as a contractor for the preparation and construction of RandstadRail infrastructure in Haaglanden jurisdiction

The Haaglanden Urban District outsourced the preparation and construction of RandstadRail infrastructure in the Haaglanden area to the municipality of The Hague. To that end, the Haaglanden Urban District and the municipality of The Hague concluded an agreement in May 2003. It was agreed that The Hague would have construction work carried out for the account and risk of the municipality and that the Haaglanden Urban District would immediately pass on the contributions of the Minister of Transport, Public Works and Water Management to the

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<sup>140</sup> RandstadRail Integral Safety Plan (ISP), version 3.2, 24 October 2003, p. 20.

<sup>141</sup> ISA RandstadRail Offer, part of ISA assignment, 23 June 2004, point 3.6.

<sup>142</sup> Ibid. points 3.1 and 3.2.

<sup>143</sup> Ibid. point 3.2.

<sup>144</sup> Ibid. point 3.3.4.

municipal authorities.<sup>145</sup> The municipality of The Hague set up a temporary RandstadRail Project Bureau (PoRR) for the execution of construction work.

Pursuant to this agreement, the municipality of The Hague was responsible for the preparation and construction of infrastructure as specified for Haaglanden in the Administrative Agreement concluded with the Minister of Transport, Public Works and Water Management and for the planning set out in that agreement. The municipality of The Hague was also responsible for duly taking into account the Schedule of Requirements<sup>146</sup> and the documents adopted by virtue of the Coordination Agreement concluded between the Haaglanden Urban District and the Rotterdam City Region.<sup>147</sup>

Pursuant to the agreement referred to, the municipality of The Hague was responsible for, among other things:<sup>148</sup>

- the preparation and construction of the infrastructure encompassed by the Haaglanden Subproject;<sup>149</sup>
- granting assignments to consultants and contractors;
- coordinating the preparation and construction of infrastructure with the Rotterdam City Region and the municipality of Rotterdam.

It was furthermore agreed that the municipality of The Hague was free to organise the work in a manner of their own choosing, with due observance of safety requirements and requirements that could reasonably be set with respect to effective management and operation.<sup>150</sup>

Following its completion, the municipality of The Hague was responsible for transferring the Haaglanden Urban District infrastructure to the future manager, HTM.<sup>151</sup> The Haaglanden Urban District did, however, remain responsible for safety (see section 4.1).

#### 4.2.3 Role as shareholder/owner of HTM

The municipality of The Hague is the sole shareholder of HTM, which is a public limited company established under the laws of the Netherlands (NV). By law, supervision of a company must be exercised by its Supervisory Board. Although shareholders of larger companies were accorded greater powers some years ago, the supervisory role exercised by the municipal authorities as a shareholder remains limited and indirect. The annual general meeting of shareholders adopts the financial statements and appoints supervisory directors based on recommendations made by the Supervisory Board. The articles of association of some companies accord a number of other, more far-reaching powers within the parameters of the law.<sup>152</sup> Examples in this regard are the approval required for major investments by HTM and the direct appointment of one supervisory director.<sup>153</sup>

### 4.3 HTM AND RET

HTM fulfils the following roles with respect to RandstadRail:

- RandstadRail railway undertaking in Haaglanden (with the exception of the Erasmus Line, for which RET is the railway undertaking);
- operational manager of RandstadRail in Haaglanden;
- in some cases, supervisor of the construction of railway technology in the RandstadRail project based on assignments issued by the municipality of The Hague.

In addition, HTM carried out work as a subcontractor commissioned by the municipality of The Hague.

The Hague is the sole shareholder of HTM Personenvervoer NV, HTM's parent company.<sup>154</sup> By virtue of an agreement concluded in 1926 with HTM via N.V. Haagsche Buurtspoorwegen, the municipality of The Hague were full guarantors of HTM Personenvervoer NV's operating result. Based on its public duty, the municipality of The Hague provided loans to HTM, both directly and by acting as guarantor with respect to other financial institutions, which made it possible for HTM to lend from market parties at more favourable rates.<sup>155</sup>

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<sup>145</sup> Haaglanden Urban District-Municipality of The Hague Agreement, Article 2.

<sup>146</sup> Ibid. Article 5.1, paragraph 1.

<sup>147</sup> Ibid. Article 5.1, paragraph 1.

<sup>148</sup> Article 3.1 of the agreement.

<sup>149</sup> The reference in this case is to the Haaglanden Subproject as described in the funding decision of the Minister of Transport, Public Works and Water Management.

<sup>150</sup> Haaglanden Urban District-Municipality of The Hague Agreement, Article 3.3.

<sup>151</sup> Ibid. Article 3.7.

<sup>152</sup> Municipality of The Hague, Toezicht op gemeentelijke deelnemingen, reference BSD/2005.910 - RIS126820, 12 April 2005.

<sup>153</sup> HTM 2006 Annual Report, April 2007.

<sup>154</sup> 67% in HTM itself and 99.8% of the shares of N.V. Haagsche Buurtspoorwegen, which holds the remaining 33% of the shares in HTM. The figures are taken from a proposal of the Municipal Executive of The Hague, reference rv 177, 15 November 2006.

<sup>155</sup> This applied during the RandstadRail derailments of 29 November 2006, though this financial relationship changed as from 1 July 2007. The municipality of The Hague is no longer the guarantor of HTM Personenvervoer NV's operating result nor the direct or indirect guarantor for loans of HTM Personenvervoer NV.

RET is involved in the Haaglanden area as a railway undertaking on the Erasmus Line, which currently runs between The Hague's central station and Rotterdam Hofplein and, from 2009, will run between The Hague's and Rotterdam's respective central stations. In addition, the municipality of Rotterdam had delegated the actual preparation and realisation of RandstadRail in the Rotterdam region to RET, which therefore also had to ensure that the project would be ready for operation in accordance with the Schedule of Requirements.<sup>156</sup>

#### 4.3.1 Role as railway undertaking (concession holder)

##### *Role of HTM*

HTM Personenvervoer NV is an independent public transport company that operates bus, tram, light rail and closed transport services.

HTM was engaged by the Haaglanden Urban District as the party responsible for the purchasing process concerning new RandstadRail rolling stock to be used in the Haaglanden region. HTM's activities in this connection were supervised by the Purchase of Low-Floor Rolling Stock Advisory Committee.<sup>157</sup> In addition, the engagement meant that HTM was responsible for proper adherence to the tendering procedure. In that connection, HTM had to observe the 'Main Specifications for Rolling Stock', 'System Specifications for Rolling Stock' and 'Functional Schedule of Requirements' already adopted by the Haaglanden Urban District as well as the other decisions taken by the BORR of the Haaglanden Urban District with respect to the rolling stock.<sup>158</sup>

The original plan had been that the Haaglanden Urban District would itself purchase new rolling stock as, at the time, it was still uncertain whether HTM would be granted a transport concession for RandstadRail. When HTM was indeed granted the concession, the Haaglanden Urban District decided that HTM would itself purchase the rolling stock and that it would legally and economically become the property of HTM.<sup>159</sup>

HTM is responsible for ensuring that the new railway vehicles meet the requirements set out in the Primary and Secondary Railways Service Regulations (RDHL) in terms of, among other things, construction (wheels) and axle load, the place of the driver in the train, carriage combinations, train signals, brakes and speed.<sup>160</sup> Rolling stock must be inspected and approved by the management of the railway company before it is put into operation and the statement of approval must be recorded in a register.<sup>161</sup> In addition, rolling stock must undergo periodic maintenance and close inspection according to a schedule approved by the management of the railway company to ensure that it and other yard parts can be operated safely at all times.<sup>162</sup> Other railway engines and carriages used for RandstadRail services must be reviewed according to a schedule adopted by the management of the railway company. Such reviews must in particular ensure that the vehicles are free of shortcomings and/or malfunctions that could jeopardise traffic safety.<sup>163</sup>

HTM has a Rail Concession for the operation of public passenger transport services by tram and express tram.<sup>164</sup> This concession is valid from 1 January 2006 up to and including 2016 and encompasses all transport by tram and express tram in the Haaglanden area, with the exception of The Hague Central Station-Rotterdam Hofplein connection (the former Hofplein Line, now the Erasmus Line), which was granted in a separate concession to RET. The stops between The Hague Laan van NOI and Leidschenveen are jointly served by HTM and RET. This shared section is specified in both transport concessions.

Pursuant to the concession granted, HTM is obliged to transport RandstadRail passengers and is responsible for ensuring compliance with the terms and conditions attached to the concession.<sup>165</sup> Among other things, the concession sets out requirements concerning the safety of the rolling stock used and the professional competence of the personnel engaged. In addition, it specifies requirements relating to timetables, accessibility, sub-suppliers, rates, travel passes and tickets, and quality.

HTM must comply with the regulations established by the Haaglanden Urban District and Rotterdam City Region in the Operational Safety Plan (OSP).<sup>166</sup> Pursuant to this plan, HTM is responsible for the realisation and maintenance of the transport process and management and maintenance of its light rail vehicles. HTM is also responsible for the safe execution of the transport process in accordance with the established timetable.<sup>167</sup>

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<sup>156</sup> Letter to the general manager of RET of 17 July 2002.

<sup>157</sup> According to the Plan of Action for the Supervision of RandstadRail Rolling Stock Purchases for the Haaglanden Region.

<sup>158</sup> Explanatory notes to the draft principle decision of the Municipal Executive of The Hague taken on 17 February 2004 to provide a loan in the amount €200 million to HTM for the purchase of RandstadRail rolling stock.

<sup>159</sup> Explanatory notes to the draft principle decision of the Municipal Executive of The Hague taken on 17 February 2004 to provide a loan in the amount €200 million to HTM for the purchase of RandstadRail rolling stock.

<sup>160</sup> Primary and Secondary Railways Service Regulations (RDHL), Articles 33 and 42.

<sup>161</sup> Ibid. Article 44.

<sup>162</sup> Ibid. Article 46.

<sup>163</sup> Ibid. Article 55.

<sup>164</sup> Rail Concession 2006-2016, adopted by the Executive Committee of the Haaglanden Urban District on 21 September 2005.

<sup>165</sup> With the exception of passengers on The Hague Central Station-Rotterdam Hofplein section.

<sup>166</sup> Compliance with the OSP is a condition attached to the concession.

<sup>167</sup> Rail Concession 2006-2016, Article 25, paragraph 3.

In addition, the OSP stipulates the following duties and obligations:<sup>168</sup>

- HTM is responsible for maintaining the rolling stock in a safe state that meets the approval requirements.
- HTM must have a safety assurance system in place and ensure the safety of rolling stock and execution of the transport process in regulations.
- HTM must draw up a safety plan each year.
- HTM must prepare an annual report and submit this report to the Haaglanden Urban District within three months of the end of the year to which it relates.
- HTM must carry out regular inspections and audits.
- HTM must record the findings of inspections, audits and investigations as well as the measures taken on the basis of those findings.
- HTM must record and analyse safety-related shortcomings and implement appropriate changes and improvements to correct them.
- HTM must report safety-related shortcomings to the Haaglanden Urban District every quarter within a month of the end of the quarter under review.
- HTM must have its safety system assessed by an Independent Safety Assessor (ISA).
- HTM may discontinue 'exchange operations' in full or in part if, in its opinion, these are insufficiently safe.<sup>169</sup> In that event, HTM must inform the Haaglanden Urban district immediately.
- HTM is obliged to perform all activities within its scope of authority that enable safe railway operations.

#### *Role of RET*

During realisation of RandstadRail, RET was a public service organisation of the municipality of Rotterdam. As from 1 January 2007, RET was made an independent public limited company established under the laws of the Netherlands (NV). RET operates public transport services in the Rotterdam region.

RET was granted concessions to operate light rail public transport services by the Haaglanden Urban District and Rotterdam City Region on the Rotterdam Hofplein-The Hague Central Station RandstadRail section (Erasmus Line). A part of that section (Nootdorp-The Hague Central Station) lies within Haaglanden jurisdiction. Pursuant to those concessions, RET is responsible for, among other things, ensuring that the transport services provided comply with the stipulations of the OSP adopted by the Haaglanden Urban District and Rotterdam City Region.<sup>170</sup> To ensure operational compliance with the concessions, RET was also obliged to apprise itself of all railway characteristics and associated infrastructure involved in the transport services to be provided and relevant to those concessions.<sup>171</sup>

#### *Roles of HTM and RET*

By virtue of the Dutch Civil Code, railway undertakings engaged in operating domestic public transport services, in this case HTM and RET, are liable for damage or injury suffered by a passenger, as well as for the death of a passenger, as a result of an accident that occurred during the transport of that passenger.<sup>172</sup> Transporters may not absolve themselves of this responsibility by invoking the improper functioning of the means of transport or other equipment used.<sup>173</sup>

In addition, pursuant to the General Terms and Conditions governing City and Regional Public Transport Services applicable to public transport agreements, HTM and RET are obliged to transport a passenger and his or her hand luggage safely, in accordance with the established timetable and the said general terms and conditions.<sup>174</sup>

As employers, HTM and RET are responsible for the working conditions within their respective organisations by virtue of the Working Conditions Act. Among other things, this means that HTM and RET must organise the work they carry out in such a way as to ensure that the safety and health of their employees are not adversely affected. To the greatest extent possible, HTM and RET must undertake efforts to prevent or limit hazards and risks to the safety and/or health of their employees at the source of those hazards and risks.<sup>175</sup> Pursuant to the Working Conditions Act, HTM and RET must also take measures to protect third parties from potential hazards that may be present on company premises or in the immediate environment of their respective companies.

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<sup>168</sup> Ibid. Article 25 paragraph 3.

<sup>169</sup> The reference in this case is to the operation by RET of the Erasmus Line section of RandstadRail in Haaglanden jurisdiction.

<sup>170</sup> Hofplein Line Concessions granted by the Haaglanden Urban District and Rotterdam City Region, Article III.2.

<sup>171</sup> Ibid. Article XI.1.

<sup>172</sup> Dutch Civil Code, Section 8:105, paragraph 1.

<sup>173</sup> Ibid. Section 8:105, paragraph 3.

<sup>174</sup> General Terms and Conditions governing City and Regional Public Transport Services, Article 2, paragraph 1.

<sup>175</sup> Working Conditions Act, Section 3.

#### 4.3.2 Role as RandstadRail infrastructure manager

Prior to 1 January 2006, HTM was responsible for the operational management of The Hague's city tram network pursuant to the Haaglanden Tram Concession (Concessie Haaglanden Tram).<sup>176</sup> In 2005, the Haaglanden Urban District extended management of the city tram network by HTM up to and including 2016 by means of the aforementioned Rail Concession issued for the operation of transport services.<sup>177</sup> In that connection, HTM was also assigned the role of infrastructure manager in Haaglanden jurisdiction.<sup>178, 179</sup>

In part as a result of its capacity as infrastructure manager, HTM was involved as a consultant in the design and construction of RandstadRail. By virtue of this role, HTM was responsible vis-à-vis the Haaglanden Urban District and the municipality of The Hague for the information it provided or, as the case may be, omitted to provide concerning RandstadRail.

Pursuant to the concessions granted, HTM was responsible for ensuring compliance with the terms and conditions attached to the concessions for management purposes. This meant that, in terms of management, HTM was also responsible for compliance with the OSP. This plan states that HTM is responsible for, among other things, maintaining the infrastructure in a safe state and that it must also carry out regular inspections and audits.<sup>180</sup> In addition, HTM is obliged to draw up a management plan that specifies the services it will provide to the Haaglanden Urban District, the ways in which quality and safety are to be ensured, and the manner in which it will report on performance to Haaglanden Urban District.

#### 4.3.3 Role as supervisors of the construction of railway technology

The Haaglanden Urban District appointed RET and HTM as supervisors of RandstadRail realisation.<sup>181</sup> This was deemed necessary because RET and HTM were due to become operational managers of RandstadRail infrastructure. It was therefore decided that the respective infrastructure departments of HTM and RET would act as supervisors of the construction of railway technology. The municipality of The Hague was the principal and the supervisor's duty was defined as follows:<sup>182</sup>

The supervisor must ascertain whether delivery and execution complies with the specifications and whether the manner of execution, selection of alternatives, method of inspection, climatological circumstances during execution, resolution of problems encountered during the work and so on will not adversely affect future management and maintenance.

### 4.4 MINISTRY OF TRANSPORT, PUBLIC WORKS AND WATER MANAGEMENT

The Ministry of Transport, Public Works and Water Management fulfils the following roles with respect to RandstadRail:

- policymaker and provider of funds;
- permit provider;
- supervisor.

#### 4.4.1 Role as policymaker and provider of funds

The Dutch Ministry of Transport, Public Works and Water Management consists of directorates-general for Civil Aviation and Maritime Affairs, Water Affairs, Public Works and Water Management and Mobility. The Directorate-General for Mobility develops policy in the areas of accessibility, safety and quality of the living environment and, in its turn, comprises four directorates, including the Railway Directorate, which is charged with ensuring that the Netherlands has an effective, safe and functionally sustainable railway system.

Pursuant to the Broad Special Purpose Grants (Traffic and Transport) Act, the Minister of Transport, Public Works and Water Management is responsible for the funds provided by the national government to the seven plus regions as defined in the Intermunicipal Statutory Regulations Act and to the provinces for purposes of public transport.<sup>183</sup> The minister provided funds for the RandstadRail project in accordance with the regulations set out

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<sup>176</sup> Haaglanden Tram Concession, valid from 1 January 2002 to 1 January 2008.

<sup>177</sup> Rail Concession 2006-2016.

<sup>178</sup> Management of The Hague Central Station-Rotterdam RandstadRail section was originally excepted. A decision of the Executive Committee of the Haaglanden Urban District taken on 13 December 2006 later transferred management of this railway section to HTM as well.

<sup>179</sup> This section describes the responsibilities arising from this role, which became effective only after the formal transfer, via the Haaglanden Urban District, of the infrastructure in Municipality of The Hague jurisdiction (RandstadRail project bureau) to HTM.

<sup>180</sup> Rail Concession 2006-2016, Article 25, paragraph 3.

<sup>181</sup> Haaglanden Urban District Memorandum of 2 February 2005 concerning the transfer of RandstadRail objects and information within the context of the management role of the Haaglanden Urban District and Rotterdam City Region (internal working document, not formally adopted).

<sup>182</sup> Point 5.1 of the aforementioned Memorandum of 2 February 2005.

<sup>183</sup> Broad Special Purpose Grants (Traffic and Transport) Act, Section 3, paragraph 1.

in the Multiannual Programme for Infrastructure and Transport 2002-2006 (Meerjarenprogramma Infrastructuur en Transport 2002-2006, MIT). The city regions agreed with the minister on a lump-sum contribution for RandstadRail. A fixed amount in excess of €413 million was made available to the Haaglanden Urban District.<sup>184</sup> The RandstadRail municipalities within Haaglanden jurisdiction jointly undertook to contribute funds amounting to approximately €23.3 million (2001 price level), as security.

The Minister of Transport, Public Works and Water Management determined that the Normative Document for Light Rail Safety would be binding for light rail projects financed by the national government or that made use primarily of heavy rail infrastructure.<sup>185</sup> Pursuant to this decision, the minister should have made the use of the Normative Document by the Haaglanden Urban District and Rotterdam City Region in relation to the safety of the design, construction and operation of RandstadRail a condition for the release of funds to the project. This was not done, however.<sup>186</sup>

#### 4.4.2 Role as permit provider

Pursuant to the Secondary and Tram Railways Act, the Minister of Transport, Public Works and Water Management is responsible for making recommendations concerning the issue of concessions by Royal Decree for the laying of secondary, city or tram railways and for the operation of services on such networks.<sup>187</sup>

In addition, pursuant to the management agreements concluded with the Haaglanden Urban District and Rotterdam City Region, the Minister of Transport, Public Works and Water Management was obliged to transfer management of The Hague Central Station-Zoetermeer and The Hague Central Station-Rotterdam Hofplein RandstadRail sections to the authorities of those regions for a period of 30 years.

Pursuant to the Secondary and Tram Railways Act, the Minister of Transport, Public Works and Water Management is responsible for designating railways according to secondary (for example light rail), city (for example metro) and tram categories.<sup>188</sup>

The Minister of Transport, Public Works and Water Management bears (final) responsibility for railway inspections carried out by the Inspectorate for Transport and Water Management.<sup>189</sup>

Pursuant to the 1875 Railways Act, the Minister of Transport, Public Works and Water Management bears (final) responsibility for approving the RandstadRail Service Regulations (DRVR) drawn up by HTM and RET that, among other things, must include safety-related regulations for HTM and RET personnel.<sup>190</sup> The minister authorised the Inspectorate for Transport and Water Management to issue this approval on his or her behalf.

The Minister of Transport, Public Works and Water Management bears (final) responsibility for granting authorisation to commence operations, which is required prior to the start of services.<sup>191</sup> On-location inspection of the infrastructure to be used must take place before such authorisation can be granted. The minister authorised the Inspectorate for Transport and Water Management to grant this authorisation on his or her behalf.

The Minister of Transport, Public Works and Water Management is responsible for initiatives concerning new railway-related legislation and regulations.

#### 4.4.3 Role of the Inspectorate for Transport and Water Management as supervisor

On behalf of the Minister of Transport, Public Works and Management, the Inspectorate for Transport and Water Management is responsible for the implementation and enforcement of legislation governing, among other things, the transport of persons and goods by road, rail, water and air. Within the Inspectorate's Railways Supervisory Division, a distinction is maintained between the following four supervisory activities:

- approval and continuation
- inspections
- reporting
- consultation and expertise.

On behalf of the Minister of Transport, Public Works and Management and pursuant to the 1875 Railways Act, the Inspectorate is responsible for granting authorisation for the commencement of operations on a railway

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<sup>184</sup> Haaglanden Subproject Funding Decision of 11 December 2002, Article 2.

<sup>185</sup> Normative Document for Light Rail Safety, version 5.0 as at 25 November 2002, p. 3.

<sup>186</sup> The authorities of both regions had already reported in writing to the Inspectorate for Transport, Public Works and Water Management that they would also use the Normative Document in the formulation of basic principles for RandstadRail.

<sup>187</sup> Secondary and Tram Railways Act, Section 2, paragraph 1.

<sup>188</sup> Secondary and Tram Railways Act, section 1, paragraph 1.

<sup>189</sup> 1875 Railways Act, Section 10, paragraph 1.

<sup>190</sup> Ibid. Section 6, paragraph 1.

<sup>191</sup> Ibid. Section 7, paragraph 1.



network.<sup>192</sup> The authorisation granted with respect to RandstadRail related only to the sections of the network designated as secondary railway. For those sections, the Inspectorate was obliged to form an opinion about the safety of RandstadRail. The part of The Hague's city tram network used by RandstadRail was not designated within the context of the 1875 Railways Act. As a result, the Inspectorate did not have any legal duties and powers in relation to that part of the RandstadRail network.<sup>193</sup>

In forming its opinion about the safety of a railway network in relation to the granting of authorisation to commence operations, the Inspectorate must in any case determine whether legal regulations have been complied with. In the case of secondary railways (light rail), the Primary and Secondary Railways Service Regulations (RDHL) apply.

Authorisation to commence operations can only be granted if 'a government inspection of the railway and associated structures' ('government inspection' in this case referring to the Minister of Transport, Public Works and Water Management) has taken place.<sup>194</sup> In practice, the Inspectorate carries out this inspection on behalf of the minister.

If public safety requires the immediate cessation of services, the Inspectorate is authorised to order such a cessation.<sup>195</sup> If services have been suspended in this way, they may only be resumed with the permission of the Minister of Transport, Public Works and Water Management.<sup>196</sup> The Inspectorate is authorised to grant this permission on behalf of the minister.

Due to the funding made available to the project by the Minister of Transport, Public Works and Water Management, the Inspectorate had a duty to check the design of RandstadRail in terms of safety.<sup>197</sup>

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<sup>192</sup> Ibid. section 7.

<sup>193</sup> The Inspectorate for Transport, Public Works and Water Management and HTM agreed in the summer of 2007 that the separation would no longer be maintained and that, rather, the main focus would be on the seriousness of an accident and the extent to which such an accident had implications for the safety of the part for which authorisation to commence operations was granted (i.e. the part designated as secondary railway); in other words, whether safety-related problems on the city tram network could also occur on the secondary railway part and/or affect safety on that latter part.

<sup>194</sup> 1875 Railways Act, Section 7, paragraphs 1 and 2.

<sup>195</sup> Ibid. Section 16, paragraph 1.

<sup>196</sup> Ibid. Section 20.

<sup>197</sup> Haaglanden Subproject Funding Decision of 11 December 2002.



## 5 ANALYSIS OF DERAILMENTS AT RANDSTADRAIL

This chapter opens with an overview of RandstadRail derailments followed by brief descriptions of the main direct and underlying causes of each type of derailment. Virtually all derailments are caused by a combination of structural and situational factors, as a result of which it is often impossible to determine the precise extent to which each factor contributed to a given derailment. It is usually clear, however, which factors were of greater and lesser importance.

Following the derailments in 2006, the Haaglanden Urban District and HTM carried out their own investigations into what went wrong and took appropriate measures. This means that they had already translated part of what had been learned into practice. The Dutch Safety Board asked the Haaglanden Urban District and HTM for an overview of the measures taken as a result of the derailments. These measures are specified in Appendix S. The Ministry of Transport, Public Works and Water Management also announced measures following the derailments. These are stated in Chapter 8, which deals with the external supervision exercised.

### 5.1 OVERVIEW OF RANDSTADRAIL DERAILMENTS

As indicated in Chapter 1, the Dutch Safety Board carried out an investigation into nine RandstadRail derailments that occurred shortly after the start of operations. The Dutch Safety Board used the investigation reports of the parties involved (HTM, RET, the Haaglanden Urban District) and of the supervisor, the Inspectorate for Transport and Water Management (IVW), to analyse these derailments.<sup>198</sup> In addition, the Dutch Safety Board obtained a second opinion on this analysis from an international expert in railway technology and also inspected the derailment locations, low-floor trams and switches.

The derailments were divided into four categories based on the parts of the railway system involved. The respective locations of the derailments are given on the following map:

1. derailment on a switch (close to the Forepark stop on 29 November 2006);
2. derailment in a curve (on a viaduct close to the Ternoot stop on 29 November 2006);
3. derailments on a worn rail (on the Muzen Viaduct [*Muzenviaduct*] close to The Hague Central Station on 3 and 4 November 2006);
4. derailments at openable switches (on The Hague city tram network on 24 November 2006 and 24 and 26 January, 25 May and 20 July 2007).<sup>199</sup>

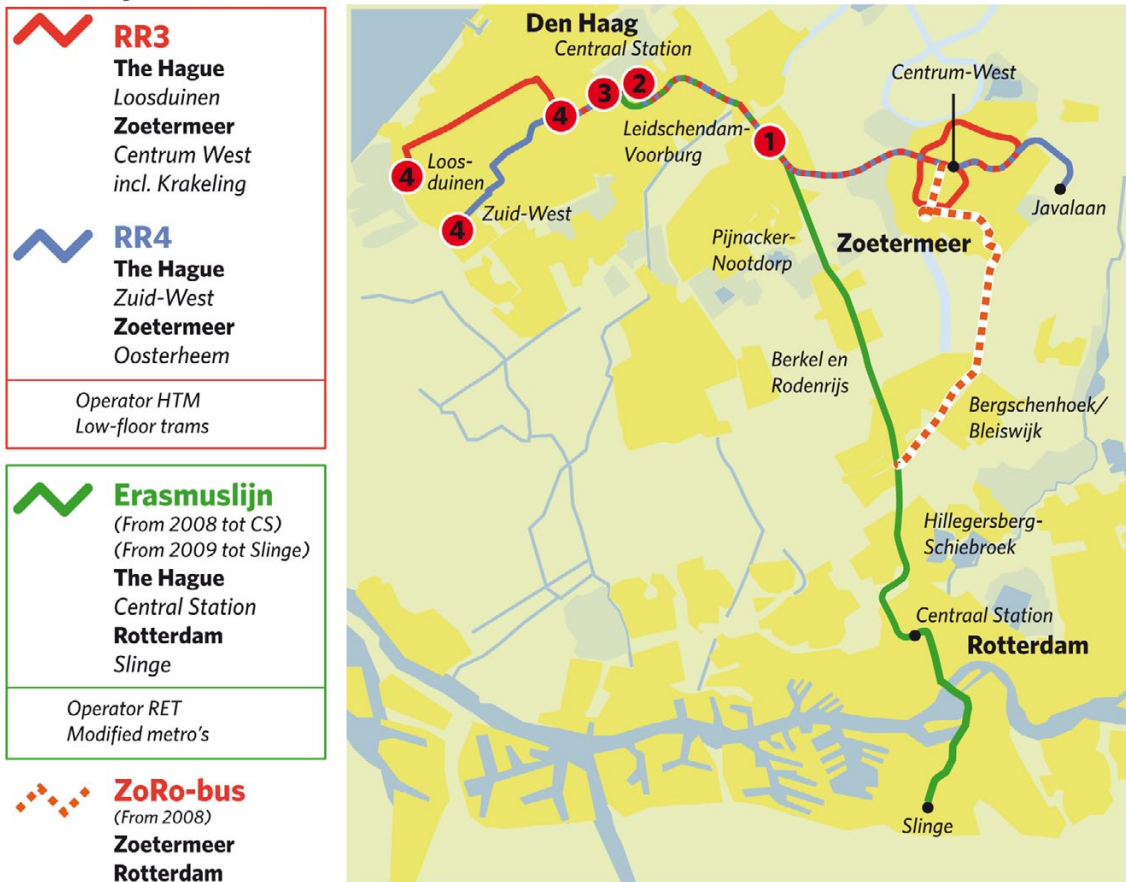
All derailments occurred in the jurisdiction of the Haaglanden Urban District and, with the exception of the Forepark derailment, on The Hague city tram network.

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<sup>198</sup> The Inspectorate for Transport, Public Works and Water Management only investigated the Forepark derailment because all of the other derailments occurred on the RandstadRail city tram network (which fell outside the scope of the supervision exercised by the Inspectorate; see Chapter 8, 'Supervision').

<sup>199</sup> Openable switches feature a spring mechanism in the switch machine which makes them openable by railway vehicles (travelling in a direction other than the set direction) without resulting in damage. Once the railway vehicle has passed, an openable switch returns to its original position.

## Railway sections



©Dutch Safety Board - RandstadRail / Railway sections

Figure 8 – Locations of investigated RandstadRail derailments

### 5.2 DERAILMENT ON A SWITCH AT FOREPARK

The following is a summarised description of the analysis. Appendix I contains a more comprehensive description of the relevant facts and direct and underlying causes of the derailment in question.

#### *Relevant facts*

A switch is a special construction that enables a railborne vehicle to switch from one track to another.<sup>200</sup> During the evening peak hour of 29 November 2006, a RandstadRail vehicle belonging to RET and carrying 120 passengers derailed at switch 846 close to the Forepark stop (between Leidschendam-Voorburg and the Zoetermeer/Rotterdam junction). This accident resulted in injury to 17 of the passengers. Partly as a result of this derailment, HTM and RET ceased operations and IVW formally suspended passenger services on part of the RandstadRail network (The Hague Central Station-Zoetermeer/Nootdorp) until further notice. In addition, IVW and HTM/RET launched an investigation into the derailments.

<sup>200</sup> See Appendix J for a description of switches and how they work, and for definitions of 'opening' and 'openable'.



### *Situation*

The derailment at Forepark occurred on a RandstadRail section where all rails and switches had been replaced between June and September 2006 (the conversion period). These replacements were carried out by the RandstadRail Project Bureau (PoRR) of the municipality of The Hague on the instructions of the Haaglanden Urban District. HTM and RET were involved in this replacement work as consultants by virtue of their future roles as infrastructure managers. The advice they provided was not binding, for that matter, as is evidenced by the doubts they expressed about the choice of switch machines (see the 'Other findings' section further below in this chapter). Although the derailed vehicle belonged to RET, the Forepark railway section was used by both HTM and RET vehicles. HTM was the prospective infrastructure manager of the section but, at the time of the derailment, management had not yet been transferred to it from the municipality of The Hague (PoRR). ProRail had been the infrastructure manager prior to the conversion period.

### *Direct cause*

The direct cause of the 29 November 2006 derailment was that a RandstadRail vehicle belonging to RET (specially modified metro) passed a defective switch (switch 846). A route over the switch in question had been set for the vehicle prior to the incident. No signal was received from the safety system that the switch machine was broken.

### *Underlying causes*

The switch machine had broken shortly before on 29 November 2006 when it was passed by another RandstadRail vehicle belonging to RET (specially modified metro) while the switch was not in the correct position. The passage of this vehicle broke the rods connecting the blade with the switch machine. This event did not, however, generate a report in the safety system.

The switch machine was able to break without generating a report in the safety system as a result of damage it had already sustained most probably in the building phase (June-August 2006). To augment the accident investigations carried out by IVW<sup>201</sup> and HTM/RET,<sup>202</sup> the Dutch Safety Board performed a further analysis into the cause and consequences of this damage and into the ways it should have been prevented.

The investigation carried out by DeltaRail on the instructions of IVW revealed that the damage sustained by the switch machine resulted in the failure of the mechanism which enabled a switch that was in the wrong position to move in the direction of travel of a railway vehicle (the mechanism in question was stuck). Inevitably, this functional failure would ultimately cause the rods connecting the switch machine and switch blade to break if and when the switch was passed by a railway vehi-

<sup>201</sup> Inspectorate for Transport, Public Works and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

<sup>202</sup> HTM/RET, 2007. Ontsporing metro RandstadRail – onderzoeksrapportage naar de procesmatige aspecten van de ontsporing van voertuig 5262 op wissel 846 te Leidschendam – Depot op 29 november 2006. O.W846.R.1.

cle travelling in a direction other than the one for which the switch was set.<sup>203</sup> The switches had not (always) been connected to the safety system during the building phase, which meant that they had had to be manually operated during that period. Manual operation meant that if a driver of a construction vehicle wished to pass a switch travelling in a direction for which the switch was not set, he or she first had to observe that this was indeed the case and subsequently leave his or her vehicle to set the switch in the correct position.

The municipality of The Hague had put a procedure in place for the manual operation and securing of switches (part of the basic documentation on switches):<sup>204</sup>

'With the exception of switches with movable points, all switches on RandstadRail sections subject to the RandstadRail Service Regulations (DRVR) are openable.<sup>205</sup> These switches are not, however, comparable with the openable switches of The Hague's city tram network. A RandstadRail switch may sustain damage that is not reported in the safety system when thrown open by a vehicle movement. The passage of a subsequent vehicle at high speed may result in derailment. For this reason, a RandstadRail switch must be checked after it has been thrown open by a vehicle movement. In contrast, regular openable switches do not sustain damage when thrown open.'

In practice, this procedure was not always adhered to, as not all drivers set switches to the correct positions before passing them. Following the derailments, investigation by HTM and the RandstadRail Project Bureau (PoRR) of the municipality of The Hague revealed that more switches had been damaged during the building phase. Although the switches in question had not been damaged in the same way as the one on which the derailment occurred, damage was extensive and varied in nature, and was subsequently repaired.

There were indications during the conversion phase that switches were not always being passed in the direction for which they were set, also referred to as being 'thrown open' (by vehicle movement), and that they sustained damage as a result. Opening by vehicle movement was reported in a number of cases, after which the switch supplier inspected the switches in question and, if necessary, carried out repairs. In response to these reports, the municipality of The Hague (PoRR) sent an e-mail to the contractors (and copies to, among others, the switch supplier and HTM) communicating the fact that damage to switches had been observed.<sup>206</sup> In this e-mail, the municipality of The Hague again referred to the aforementioned procedure for the manual operation of switches. Not all opening movements were reported, however. An external inspection of switch 846 carried out on 7 August 2007 concluded on the basis of the damage pattern observed that it had been thrown open by vehicle movement. In spite of these indications, inspection of the switches prior to commencement of operations, the so-called Site Acceptance Tests, remained limited to external checks and functional tests. This kind of procedure is indeed adequate for putting a new switch or one whose functioning has been continuously monitored by a safety system into operation. In the case of RandstadRail, however, the functioning of the switches was an unknown factor, as they had not been connected to the safety system during the conversion phase. Until the contrary had been proven, the parties involved should therefore have assumed that the switches might have been damaged during that phase. More in-depth inspections of the switches to ascertain damage, involving internal checks of the switches according to procedures prescribed in the applicable documentation, would therefore have been the proper course of action.

The division of responsibility between the municipality of The Hague (PoRR) and the contractors building the switches and other RandstadRail parts may have been a factor in the failure to detect the damage on time. Contrary to common practice, the municipality of The Hague rather than the railway contractors performing the work was responsible for the quality of the switches upon completion. This was the case because the switches had been made available by means of a management delivery by the municipality of The Hague and therefore did not form part of the invitation to tender issued to the contractors.

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<sup>203</sup> Although the broken distance bolts complied with the applicable specifications, the safety margin was limited. This point is comprehensively addressed in the investigation report of the Inspectorate for Transport, Public Works and Water Management.

<sup>204</sup> Memorandum on the Manual Operation and Securing of Switches (Notitie Handmatig bedienen en klemmen van wissels), version 0.7, 18 September 2006. The memorandum forms part of the basic documentation on switches (file containing technical descriptions and other documents relating to RandstadRail switches).

<sup>205</sup> A properly openable switch is one that can be thrown open by a vehicle movement and sustain very little or no damage as a result. In addition, the opening movement must generate a report in the safety system.

<sup>206</sup> The e-mail also indicated that the municipality of The Hague (PoRR) was unaware whether there were other contractors in addition to the railway contractors in the address list that were making use of the switches with certain types of vehicles, such as lorry-mounted cranes. The municipality of The Hague therefore requested that the message also be forwarded to the contractors they were unaware of and that the procedure referred to in the e-mail be declared binding.

### *Other findings*

In addition, the following issues were observed. While they have no direct relation to the derailment, these issues are nevertheless relevant to safety and illustrative of RandstadRail safety management.

- For a number of reasons, and based on management perspectives, future infrastructure managers RET and HTM had doubts about the type of switch chosen by the municipality of The Hague (PoRR). RET and HTM only had an advisory role, however, not a decisive vote in the choice of switch. That choice was made by the municipality of The Hague (PoRR). The municipality did indeed extract additional guarantees and undertakings from the switch supplier in response to the objections, but doubts remained on the part of the future infrastructure managers.
- The type of switch machine selected had hardly been used in the Netherlands before. The only time it had been previously been used, namely on the Amstelveen Line (Amstelveenlijn), a railway vehicle derailed on a switch shortly after the machine had been put into operation, though for reasons other than those applicable to the Forepark incident. The design of the switches was altered after this derailment. In September 2005, the municipality of The Hague (PoRR) instructed the switch supplier to survey switch-related experiences at GVB, the public transport operator involved. This survey apparently indicated that problems were under control at that time and that the switches were functioning satisfactorily.<sup>207</sup>
- The switch machines had EBA certification.<sup>208</sup> This certification was not valid, however, because modifications had been introduced relative to the model certified by the EBA. Furthermore, the certification and modifications did not relate to the strength of the distance bolts between switches and switch machines.
- There was no statement of conformity, i.e. documentary evidence of safe interaction between the switches and the safety system, at the time operations were started. The ISA engaged by the Haaglanden Urban District saw this as a small risk and no reason to stop the trial operation and launch of operations. As there was no statement of conformity, however, this opinion was based on assumptions.

## 5.3 DERAILMENT IN A CURVE AT TERNOOT

The following is a summarised description of the analysis. Appendix L contains a more comprehensive description of the relevant facts and direct and underlying causes of the derailment in question.

### *Relevant facts*

On 29 November 2006, approximately half an hour before the Forepark derailment, a RandstadRail vehicle belonging to HTM derailed just after a curve on a viaduct (approximately six metres high) between The Hague Central Station and the Ternoot stop. This derailment occurred when the vehicle started moving from a stationary position and did not result in any injuries. HTM investigated the derailment.<sup>209</sup>

<sup>207</sup> During the Dutch Safety Board's investigation, the municipality of The Hague originally stated that it had not had a survey carried out at GVB. Following a question put by the Dutch Safety Board based on the inspection procedure, the municipality of The Hague made further information available which indicated that a survey had indeed been conducted. HTM stated during the inspection procedure that it had not been aware of this information and had been informed by representatives of GVB about the GVB derailment after the Forepark derailment (in the spring of 2007).

<sup>208</sup> The Eisenbahn-Bundesamt (EBA) is the German railway safety supervisor charged with, among other things, approving vehicles, infrastructure and transporters.

<sup>209</sup> HTM, Onderzoeksrapportage naar de ontsporing van voertuig 4021 nabij station Ternoot op 29 november 2006. 3 January 2007.





Figure 10 – The derailed vehicle at Ternoot

#### *Situation*

On the viaduct between The Hague Central Station and the Ternoot stop, RandstadRail vehicles use unmodified city tram railways. Shortly before the Ternoot stop, the RandstadRail route branches off towards a new viaduct that passes through Beatrixkwartier (the so-called Netkous) in the direction of The Hague Laan van NOI station. The derailment occurred on a city tram railway. Infrastructural modifications that can affect travelling speeds at the derailment site had, however, been made in the area as part of the RandstadRail project. These modifications were a switch branching off towards Beatrixkwartier (maximum speed of 25 km/h) and a signal. The infrastructure manager of the particular section is HTM, as was already the case before the start of RandstadRail operations. Furthermore, the section is used by RandstadRail vehicles purchased and operated by HTM and city trams.

#### *Direct cause*

The viaduct close to Ternoot was built 30 years ago and the railway layout did not meet the pre-conditions applied by the vehicle manufacturer. A high degree of superelevation occurs in the curve within a relatively short distance. This superelevation partially overcomes the centrifugal force, thus reducing the risk of derailment and making it possible for vehicles to travel through the curve at high speeds (70 km/h). At lower speeds, however, there is a risk of derailment in the transition from superelevation back to level railway.<sup>210</sup> Some vehicles had to travel slowly in the curve at Ternoot due to the railway branch heading towards the new Beatrix Viaduct (Beatrixviaduct) and the presence of a signal that might require vehicles to stop if necessary.<sup>211</sup> The risk of derailment in the curve at Ternoot in combination with dryness and rail wear ultimately resulted in the derailment of the RandstadRail vehicle in question, though it could just as easily have been a subsequent vehicle travelling through the curve at low speed.

#### *Underlying causes*

New rolling stock is often operated in full or in part on existing infrastructure. It is therefore common for the infrastructure manager to make the characteristics of the infrastructure and the requirements associated with it known. In addition, a railway undertaking must demonstrate that the vehicles it operates are suitable for use on the infrastructure in question. If operational problems are identified, there are in principle four options:

- selection of a different type of vehicle
- modification of the vehicle
- modification of the infrastructure
- a combination of the two preceding options.

The option ultimately chosen depends in part on its financial consequences.

Generic requirements aimed at making RandstadRail infrastructure suitable for the new Rands-

<sup>210</sup> For further explanation, see Appendix L, 'Analysis of the Ternoot Derailment'.

<sup>211</sup> A maximum speed of 25 km/h applies on the switch and RandstadRail branch in the direction of the Beatrix Viaduct.

tadRail vehicles were set out in the Schedule of Requirements by the Haaglanden Urban District. HTM exercised an advisory role in this regard and was supervised in its purchase of vehicles by an advisory committee specially set up for the purpose by the Haaglanden Urban District. The vehicle manufacturer submitted more specific preconditions to HTM in January 2006. These specified the requirements the infrastructure had to meet, because the values used in the Schedule of Requirements were not sufficiently accurate. A thorough analysis of the differences between these two sets of requirements would have shown that the precondition applied by the vehicle manufacturer in relation to the transition spiral, i.e. the transition from level rails to a given degree of superelevation, was more stringent than the one that had been used in the RandstadRail Schedule of Requirements.<sup>212</sup>

The railway layout in the curve at Ternoot did not meet those preconditions.<sup>213</sup> When the first trial runs were being carried out with the new RandstadRail vehicles in the spring of 2006, HTM had the vehicle manufacturer carry out calculations, as part of a separate report, of the situation at Ternoot based on design drawings made available by HTM Infra. The vehicle manufacturer concluded on the basis of these calculations that wheel flange climbing would occur in the curve. This meant that the wheel flanges would bear the load as the wheels' running surfaces lost contact with the rail head but that a vehicle would not derail if certain basic assumptions as used in the calculations were adhered to.<sup>214</sup> There would be maintenance problems in the form of wear to the vehicle, however. In order to retain the guarantee on the vehicles, the vehicle manufacturer recommended to HTM that vehicles travel through the curve at a minimum speed of 50 km/h and that the layout of the curve be altered to meet the specifications within six to eight months.<sup>215</sup>

HTM adopted the vehicle manufacturer's conclusion that there was no risk of derailment without being aware of the following:

- RandstadRail vehicles belonging to HTM are usually unable to reach a minimum speed of 50 km/h in the curve at Ternoot, as, due to a switch for the RandstadRail branch in the direction of Beatrixlaan (the normal RandstadRail route towards Zoetermeer), there is a signal after the curve that requires vehicles to stop if necessary. In addition, vehicles may only travel at a maximum speed of 25 km/h on the initial, curving part of that branch. The purpose of the recommended minimum speed was to limit wear to the vehicle, which would be more pronounced at lower speeds. However, the risk of derailment was greater at lower speeds. That risk was underestimated;
- the actual railway layout in terms of twist and superelevation was less favourable than the situation depicted in the design drawings on which the calculations were based. In addition, the rails were worn. In its report about the situation at Ternoot, the vehicle manufacturer had made clear that it was the operator's responsibility to make sure that the actual railway layout did not deviate by more than 10 mm from the values used for the calculations.

#### 5.4 DERAILMENTS NEAR THE HAGUE CENTRAL STATION

The following is a summarised description of the analysis. Appendix O contains a more comprehensive description of the relevant facts and direct and underlying causes of the derailments in question.

##### *Relevant facts*

On 3 and 4 November 2006, RandstadRail vehicles belonging to HTM derailed in a curve on the Muzen Viaduct, both at exactly the same location. In addition, an HTM city tram had derailed at the same location on 12 August 2006 (RandstadRail vehicles were not yet using the railway section at the time). These derailments did not result in any injuries and were investigated by HTM.<sup>216</sup>

<sup>212</sup> The RandstadRail Schedule of Requirements specify a maximum twist of 20 mm per 6 m stretch of railway but does not impose a limit on the degree of superelevation. In its calculations, the vehicle manufacturer assumed a maximum superelevation of 75 mm.

<sup>213</sup> The Haaglanden Urban District stated that it had not been aware of this fact because the railway infrastructure at that location was managed by HTM.

<sup>214</sup> In accordance with standard EN 14363, the vehicle manufacture maintained that wheel flange climbing up to 5 mm is not classified as derailment. Within the railway sector, however, loss of contact between the running surface of a wheel and the rail head is a phenomenon that is never acceptable, even when the wheel flange guarantees that the vehicle will not derail.

<sup>215</sup> When making these recommendations, the vehicle manufacturer indicated that certain guarantees relating to the vehicles would lapse if the recommendations were not implemented.

<sup>216</sup> HTM, Ontsporingen Centraal station 3072 (12 augustus 2006), 4024 (3 november 2006), 4002 (4 november 2006), 2007

HTM, *Analyse ontsporingen Railbedrijf – recente ontsporingen met de GTL8 en de RegioCitadis*. 25 July 2007





Figure 11 – The derailed vehicles near The Hague Central Station on 3 and 4 November 2006

#### *Situation*

RandstadRail vehicles make use of the existing city tram network on the viaduct between the tram platform of The Hague Central Station and the centre of The Hague (the Muzen Viaduct). The rails of this section were replaced as part of the RandstadRail project. The RandstadRail Project Bureau (PoRR) of the municipality of The Hague selected replacement rails of a different quality than was usual at HTM. The section is used by RandstadRail vehicles and city trams belonging to HTM. HTM was the manager of the infrastructure in question.

#### *Direct cause*

Because the rail heads involved were extremely rough and had been worn to a slant, wheel flange climbing occurred to such a degree that the vehicles derailed.

#### *Underlying causes*

The rails on the viaduct near The Hague Central Station were replaced in April 2006 prior to the start of RandstadRail operations. Investigation following the derailments revealed that the rails had worn within an unusually short period by HTM standards. Within the time interval between prescribed periodic inspections, the rails had worn to a condition below the safety standard and had in addition become extremely rough. Post-derailment investigations carried out by HTM and external experts<sup>217</sup> revealed that the accelerated rate of wear had primarily been caused by city trams with slanted bogies that also used the rails. In addition, the rails used had an incorrect hardness and were as hard as the wheels of the vehicles using them (both RandstadRail vehicles and the HTM city trams).<sup>218</sup> This equal hardness caused greater and rougher wear of the rails.

Until the derailments in question, HTM's management organisation had been unaware of the combination of factors involved. After the derailment in August 2006, HTM concluded that the cause had been the extremely rough and slanted wear of the rails, and subsequently carried out the necessary repairs and applied lubrication. Following the derailment on 3 November 2006, HTM originally thought that the vehicle had derailed after a rail brake had broken off. Shortly after clearance had been given to resume rail traffic, another derailment occurred, again involving a RandstadRail vehicle belonging to HTM. It was then clear to HTM that the derailment had again been caused by the extremely rough and slanted wear of the rails. HTM used the investigation carried out after the derailments to build up its knowledge and subsequently took measures in the curve near The Hague Central Station (lubrication) and in The Hague's city tram network in its entirety (welding work was carried out at locations where similar wear had also occurred). In addition, the bogies of the city trams were checked and corrected where necessary, and the wheels were replaced or reprofiled.

<sup>217</sup> Stork FDO BV, Onderzoek naar de oorzaak van het overmatig slijten van tramspoor (in opdracht van HTM). Amsterdam, February 2007.

<sup>218</sup> HTM usually uses softer rails in combination with harder wheels. In order to save on maintenance costs, a harder type of rail was used in the belief that the rate of wear would be slower. HTM did not realise that equal hardness with vehicle wheels would lead to accelerated and rougher wear in curves. Insofar as it has been possible to ascertain, the first derailment caused by this particular set of factors occurred on 1 August 2003 in the curve near the Pasgeld stop of tram line 1. At the time, HTM had difficulty explaining the derailment and stated that it had only been able to acquire the necessary insight after the RandstadRail derailments near The Hague Central Station in 2006 and the associated investigations.

## 5.5 DERAILMENTS ON OPENABLE SWITCHES IN THE HAGUE CITY TRAM NETWORK

The following is a summarised description of the analysis. Appendix P contains a more comprehensive description of the relevant facts and direct and underlying causes of the derailments in question.

### *Relevant facts*

On 24 November 2006 and 24 and 26 January, 25 May and 20 July 2007, RandstadRail vehicles belonging to HTM derailed on openable switches in The Hague city tram network.<sup>219</sup> The derailment of 24 November 2006 took place on Monstersestraat, while those of 24 and 26 January 2007 took place at Arnold Spoelplein and those of 25 May and 20 July 2007 occurred on Meppelweg. These derailments did not result in any personal injuries.



Figure 12- Vehicle approaching an openable switch

### *Situation*

The derailments on the openable switches took place in The Hague city tram network. The sections in question are only used by HTM vehicles belonging to HTM and HTM is also the infrastructure manager.

Openable switches were not originally used in the city tram network and were introduced at turning points as part of the RandstadRail project. The city trams, which can only travel in one direction, use so-called turning loops to travel their respective routes in the opposite direction. The new RandstadRail vehicles, however, are capable of travelling in both directions. There was therefore no need to lay turning loops at turning locations. RandstadRail vehicles would instead be able to travel their respective routes in the opposite direction after reaching the turning point and switching to the appropriate railway by means of an openable switch.

The Meppelweg turning point was meant to have been equipped with eclectically operated switches. Because these were not ready on time, however, HTM Infra opted to use openable switches temporarily. An openable switch is pushed by a railway vehicle into the desired position and, once the vehicle has passed, returns to its original position. At the Arnold Spoelplein, practical considerations prompted HTM Infra to use openable switches as a permanent solution.

### *Direct cause*

The new RandstadRail vehicles have doors on both sides and can travel in both directions. A turning loop is therefore not required at the end point to enable the vehicle to subsequently travel in the opposite direction. Use can instead be made of a tail track, a turning section with openable switches. The RandstadRail tram drivers had not realised that their respective vehicles had not

<sup>219</sup> Openable switches feature a spring mechanism in the switch machine which makes them openable by railway vehicles (travelling in a direction other than the set direction) without resulting in damage. Once the railway vehicle has passed, an openable switch returns to its original position. See Appendix J for a more comprehensive explanation.

fully passed the switches in question. The switches therefore returned to their original positions underneath the vehicles and the vehicles consequently derailed when they started travelling in the opposite direction.

#### *Underlying causes*

The decision was made to use openable switches for turning purposes at end points. This type of switch was a recent introduction to The Hague city tram network and drivers were not yet familiar with it. Although HTM had provided instructions and a training programme on how openable switches were to be used (make sure that the vehicle in its entirety has passed them and only then turn), there were no clear markings that a driver could use to establish that it was safe to execute the turning manoeuvre. Markings of this kind were introduced after the derailments.

The risk associated with turning at end points had not yet been addressed in the safety analysis of the Haaglanden Urban District, which specified the risks present in the city tram network. This was because the solutions to be applied were not yet known at the time the analysis was being carried out. Once it became known that openable switches would be used, however, the safety analysis was not adjusted accordingly.

## 5.6 FROM DERAILMENTS TO SAFETY MANAGEMENT

This section establishes a link between the causes of the derailments described in this chapter in terms of risks and RandstadRail safety management. The safety management aspects involved (i.e., the relationship between the safety management conducted and control of a specific risk) are given for each derailment.

### *5.6.1 Derailment on a switch near Forepark*

The derailment on the switch near Forepark occurred because the switch in question had been passed by construction vehicles travelling in a direction other than the one for which it was set during the conversion phase of the RandstadRail project (June-August 2006) and had been damaged as a result. As the switch was not (always) connected to the safety system during that phase, it was not always able to prevent or detect the passage of vehicles travelling in a direction other than the one for which switches were set.

The risk of damage to switches was not adequately managed during the building phase. As is evidenced by the excerpt taken from the Memorandum on the Manual Operation and Securing of Switches (see section 5.2 above), the municipality of The Hague (PoRR) was aware of the fact that switches could be damaged by incorrect use.<sup>220</sup> The parties involved failed to recognise to a sufficient degree, however, that this risk could manifest itself already in the building phase, i.e. even before the operational phase. Inspections of the switches carried out prior to the launch of operations therefore remained limited to external checks and functional tests. This kind of inspection is only adequate for switches that have not yet been used or have only been used in a properly controlled way. Due to the uncontrolled use of switches during the building phase, more comprehensive inspections also involving internal checks would have been the proper course of action. The damage that would have been observed should then have been repaired accordingly.

The derailment at the Forepark switch could occur due to the following shortcomings in safety management:

- insufficient insight on the part of the Haaglanden Urban District and municipality of The Hague (PoRR) into risks concerning the risk of damage to switches during the building phase and a consequent failure to base safety policy on such insight;
- insufficient implementation and enforcement: due to a failure to fully appreciate the risk of damage during the building phase on the part of the municipality of The Hague (PoRR), subsequent inspection was insufficiently thorough and appropriate follow-up action was not taken;
- insufficient tightening of the safety policy by the Haaglanden Urban District and municipality of The Hague (PoRR) following indications of damage in the building phase;<sup>221</sup>
- insufficient verification by the railway undertakings, HTM and RET, with respect to the sub-

<sup>220</sup> During the inspection period, the Haaglanden Urban District indicated an awareness that switch points could be damaged when switches were thrown open by vehicle movements and stated that the procedure in place was aimed at preventing such damage. The switch machines were not to be damaged when switches were opened by vehicle movements. The Dutch Safety Board considers this distinction as being of little importance, given that the switches as a whole were not openable.

<sup>221</sup> During the inspection period, the Haaglanden Urban District stated that it was not aware of indications of damage during the building phase.

stantiation put forward by the Haaglanden Urban District in support of its assertion that the infrastructure was safe.

### 5.6.2 *Derailment in the curve at Ternoot*

To a significant extent, the derailment in the curve at Ternoot was the result of city tram infrastructure that did not meet the requirements of HTM's new RandstadRail vehicles.

The risk of derailment was in itself recognised. The vehicle manufacturer was obliged to demonstrate by means of derailment-related calculations that the vehicles would not derail when using infrastructure built according to specifications provided by HTM and the Haaglanden Urban District. The Haaglanden Urban District had checks carried out to ensure that the layout of the new and converted RandstadRail infrastructure was actually as described.

No such checks were carried out, however, with respect to the unconverted city tram infrastructure. The Haaglanden Urban District simply assumed that it met RandstadRail specifications. In its capacity as advisor and vehicle purchaser, HTM informed the Haaglanden Urban District of the infrastructure-based specifications for RandstadRail. HTM did not, however, check whether The Hague city tram network met these requirements. In addition, HTM failed to undertake a thorough consideration of the vehicle-based requirements in relation to the infrastructure indicated by the vehicle manufacturer. Even a quick analysis would have revealed that one of the vehicle manufacturer's specific requirements was extremely critical, and failure to meet it resulted in a derailment risk.<sup>222</sup>

After the vehicle manufacturer had completed derailment-related calculations in the summer of 2006, HTM failed to ascertain whether the actual layout of the infrastructure matched the basic values used in the calculations. In addition, the fact that the minimum speed of 50 km/h recommended by the vehicle manufacturer could not be reached for practical reasons (a maximum speed of 25 km/h applied on the branch in the direction of the Beatrix Viaduct and there was also a signal in the curve) was not taken into account.<sup>223</sup> In addition, HTM ultimately made the decision that the curve at Ternoot was safe, whereas the Haaglanden Urban District was responsible for RandstadRail safety.

The derailment in the curve at Ternoot could occur due to the following shortcomings in safety management:

- insufficient insight on the part of the Haaglanden Urban District and HTM into risks concerning the characteristics of the new low-floor trams and a consequent failure to base safety policy on such insight;
- insufficient implementation and enforcement of safety policy concerning verification of whether the layout of the unconverted city tram infrastructure matched the basic values used by the vehicle manufacturer and agreements in this regard between the Haaglanden Urban District and HTM.

### 5.6.3 *Derailments near The Hague Central Station*

The derailments on the viaduct near The Hague occurred because the rails at the location were extremely rough and worn. This wear had been caused primarily by city trams with slanted bogies. In addition, the hardness of the wheels of both the city trams and RandstadRail vehicles was the same as the hardness of the rails. Prior to the derailments, HTM was not aware of either factor and therefore did not intensify regular inspections to monitor the condition of the rails more closely.

The derailments near The Hague Central Station could occur due to the following shortcomings in safety management:

- insufficient insight on the part of HTM into the wear-related effect of using wheels and rails of the same hardness and a consequent failure to base safety policy on such insight;
- accident investigation following the derailment of a city tram did not lead to a timely recognition of the accelerated rate of rail wear.<sup>224</sup>

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<sup>222</sup> This specific requirement concerned superelevation. See Appendix M for an explanation of superelevation and twist and Appendix M, 'Analysis of the Ternoot Derailment', for an explanation of the derailment-related calculations.

<sup>223</sup> When making this recommendation, the vehicle manufacturer indicated that certain guarantees relating to the vehicles would lapse if the recommendation was not implemented.

<sup>224</sup> As indicated in section 5.3, insofar as is known, the first derailment caused by the same wear-related problem occurred in August 2003. Additional investigation following the RandstadRail derailments enabled HTM to identify the cause of the incidents.

#### 5.6.4 *Derailments on openable switches*

The derailments on openable switches in The Hague city tram network occurred because the drivers were not always able to use the switches safely; they were not always able to determine how far they had to continue with their respective vehicles to prevent derailment. HTM placed appropriate signs at all locations after several derailments on openable switches.

The derailments on the openable switches could occur due to the following shortcomings in safety management:

- insufficient insight on the part of the Haaglanden Urban District and HTM concerning the specific risks of using openable switches in tail tracks and a consequent failure to base safety policy on such insight;
- insufficient investigation following the first derailment and a consequent failure on the part of HTM to use the findings of that investigation to tighten safety policy by adopting both a more proactive (during the trial operation) and reactive (after the accidents) stance with respect to checking whether drivers could use the openable switches safely.



## 6 ANALYSIS OF RANDSTADRAIL SAFETY MANAGEMENT

The structure and organisation of activities relating to safety management play a crucial role in the demonstrable control and continuous improvement of safety. This applies to all organisations that are directly or less directly involved in activities that entail potential hazards to residents and citizens of the Netherlands.

The derailments that occurred shortly after the launch of RandstadRail operations prompted the Dutch Safety Board to analyse RandstadRail safety management. The analysis, which is set out in this chapter, concerns the safety management conducted by all of the parties involved in RandstadRail in the Haaglanden area, namely HTM, the municipality of The Hague and the Haaglanden Urban District. The analysis focuses on the design, realisation and completion (including testing and trial operation) phases as well as on the management and operation of the RandstadRail project.<sup>225</sup>

The assessment of RandstadRail safety management focuses on both the plans on which it was based and its conduct. This is because the way in which the safety plans were implemented determined whether the safety management being conducted was actually functioning as a means of ensuring RandstadRail safety. Where implementation-related shortcomings were observed, the safety plans were subjected to close examination in terms of the specific aspects involved.

In assessing the planning and implementation of RandstadRail safety management, the Dutch Safety Board used its own assessment framework (see section 3.3. and Appendix F). This assessment framework comprises the following five focal areas:

- the use of insight into risks as the foundation for safety policy
- implementation and enforcement of safety policy
- demonstrable and realistic safety policy
- refinement and tightening of safety policy
- management control, involvement and communication.

Following a description of the RandstadRail safety management plans, the manner in which safety management was conducted is detailed on the basis of the assessment criteria used by the Dutch Safety Board. Where relevant, this chapter considers a derailment and the preceding sequence of events associated with it to illustrate how safety management was conducted in practice.

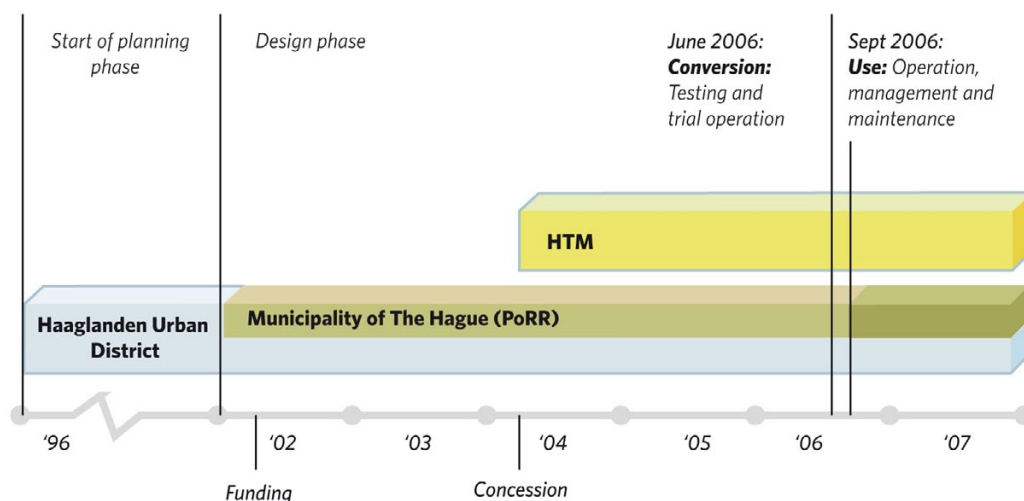
The respective roles of the parties involved evolved over time – that is, from the point at which funding was made available to the start of passenger services – in terms of their scope and nature. Distinctive roles do not, however, mean that responsibility for safety is divided or indeed that it should be: each party bears individual responsibility for safety within the parameters of its respective role. In addition, passing the buck to other parties involved is not conducive to safety.

At the start of the RandstadRail project, the Haaglanden Urban District and Rotterdam City Region were responsible in their capacity as principals for the safety of RandstadRail, each for the part of the project within its jurisdiction and, jointly, for the project as a whole. In addition, the Haaglanden Urban District also expressly retained responsibility for RandstadRail safety in the Haaglanden area in the agreement concluded with the municipality of The Hague. As various project phases were completed, more responsibility was placed with HTM, the railway undertaking and manager. The granting of the concession for operations to HTM was a key marking point in this regard. From that point on, HTM was bound by the Operational Safety Plan (OSP), which formed an integral part of the concession. HTM was not given any other responsibilities during the project's building phase. The following figure gives the timeline for the parties involved.<sup>226</sup>

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<sup>225</sup> Appendix C.2 contains a schematic representation of the RandstadRail project's lifecycle.

<sup>226</sup> It must be noted in this regard that the municipality of The Hague (RandstadRail Project Bureau) remained involved in the operational phase because responsibility for the safety of the switches had not yet been transferred at the time.



©Dutch Safety Board - RandstadRail / Timeline of the parties involved

Figure 13 – Timeline for the parties involved in RandstadRail

The following table specifies the respective roles of the parties for each derailment.

Derailment	Legal regime	New or existing infrastructure	Transporter	Manager
Forepark switch	Secondary railway (IVW supervision)	New railway and switch (PoRR)	RET (derailed) and HTM	RandstadRail Project Bureau
Ternoot curve	City tram network (no supervision)	(Partly) existing railway, new switch and signal (PoRR)	HTM	HTM
Worn rails near The Hague Central Station	City tram network (no supervision)	(Partly) existing railway, new and harder rails (PoRR)	HTM	HTM
Openable switch in city tram network	City tram network (no supervision)	(Partly) existing railway, new openable switches (HTM Infra)	HTM	HTM

Table 1 – The parties involved and their roles during the derailments

The above table shows that eight of the nine derailments occurred on parts of the city tram network that had already been in existence and of which HTM was already railway undertaking and infrastructure manager. This chapter therefore addresses the safety management conducted by HTM before proceeding to an analysis of the safety management conducted by the municipality of The Hague (RandstadRail Project Bureau), which was relevant to the Forepark derailment. This derailment occurred on a newly laid switch that had been damaged during the building phase, and the municipality of The Hague (RandstadRail Project Bureau) had at the time been responsible for the switches.

As RandstadRail principal, the Haaglanden Urban District was responsible for RandstadRail safety management as a whole. In this connection, HTM and the municipality of The Hague (PoRR), among others, functioned as suppliers of RandstadRail parts. The present chapter therefore concludes with an analysis of the safety management conducted by the Haaglanden Urban District.

## 6.1 SAFETY MANAGEMENT OF HTM

Pursuant to the Rail Concession, HTM was responsible for the transport of passengers on and the management and maintenance of RandstadRail infrastructure.<sup>227</sup> HTM was obliged in this regard to adhere to the OSP prepared by the Haaglanden Urban District and Rotterdam City Region.<sup>228</sup> In addition, HTM was, among other things, an advisor and purchaser of rolling stock. Section 4.3 details

<sup>227</sup> Rail Concession 2006-2016.

<sup>228</sup> RandstadRail Operational Safety Plan, version 1.0, draft of 27 May 2005.



the duties and obligations arising from HTM's roles. The following sections describe the way in which HTM prepared for passenger services and the operational management of railway infrastructure to ensure safety. With regard to the former, the specific focus is on the preparations made, testing and trial operation and HTM's decision to commence passenger services.

#### *6.1.1 Use of insight into risks as the foundation for safety policy*

##### *Safety cases*

The Haaglanden Urban District formulated a safety policy for RandstadRail as a whole (see section 6.3). Within this context, HTM, as the future railway undertaking, prepared safety cases with a view to the operational phase.<sup>229</sup> These safety cases contain an inventory and analysis of risks and the measures put in place to manage them. Because it was not responsible for the work, HTM was not obliged to prepare safety cases with respect to the construction of infrastructure. As a future RandstadRail infrastructure manager, however, HTM did prepare an infrastructure management safety case. On 1 September 2006, four of the five cases to be prepared by HTM were ready, namely infrastructure maintenance, rolling stock maintenance, central traffic control and operations. Although the rolling stock safety case was not completely ready, it was complete enough for the ISA to issue a statement of no objection with respect to the use of the new vehicles.

Prior to the launch of RandstadRail operations, the ISA discussed each safety case with HTM management, prepared Safety Notices and forwarded these to the Haaglanden Urban District. The Haaglanden Urban District subsequently sent copies to HTM. The ISA concluded the discussions with a statement that HTM could begin the trial operation.

At the start of operations, HTM management reviewed the status of the safety cases that had been prepared by HTM. These had all been drawn up and elaborated, though ranged in status from draft to definitive. The draft safety cases were reasonably complete but not definitive due to the absence of, for example, test results. HTM management was not aware at the time that it decided to launch RandstadRail operations that the majority of safety cases to be prepared by the other parties involved (including the Haaglanden Urban District and RandstadRail Project Bureau) were not yet ready, some of them still being at an early stage of preparation.<sup>230</sup> This was especially true of the infrastructure safety cases.

By omitting to monitor the infrastructure safety cases, HTM deprived itself of an instrument to form an accurate impression of the safety management conducted by the parties responsible for ensuring that the infrastructure was safe. Insight into this safety management was relevant to HTM, given that HTM would be responsible for the safety of passengers and personnel and that operational safety depends in part on infrastructural safety. HTM could therefore encounter infrastructure-related risks in the operational phase that arose during the design and realisation phases. HTM was aware of the political pressure to commence RandstadRail operations as quickly as possible. In addition, it would have been practical for HTM to monitor the safety management conducted in relation to the infrastructure because it would be the future infrastructure manager and, within that context, management of the infrastructure was due to be transferred to it by the municipality of The Hague (PoRR) via the Haaglanden Urban District.

#### *6.1.2 Demonstrable and realistic safety policy*

##### *Safety management system*

HTM did not have a safety management system when RandstadRail operations were launched at the end of October 2006.

Prior to the start of operations, HTM management opted to meet legislative and regulatory requirements as well as those of the principal (Haaglanden Urban District). There is no legal obligation to put a safety management system in place for secondary railways and tram and other public transport systems. In 2003 HTM did, for that matter, state that it would put a safety management system in place.<sup>231</sup> The legislature made safety management systems mandatory for primary railway networks from 1 January 2005. The Haaglanden Urban District therefore made the use of a

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<sup>229</sup> A safety case is a cumulative file which describes how safety was and is ensured in the design, building and operational phases. See section 6.3.1 for a description of the context in which these safety cases were prepared. Appendix E contains background information concerning the use of safety cases to assess safety.

<sup>230</sup> Section 6.3 contains a closer analysis of the safety management as planned and conducted by the Haaglanden Urban District, including among other things considerations of the status of the safety cases.

<sup>231</sup> This was in response to the relevant recommendation in the De "vrije" trambaan report of the Transportation Safety Board (2003). See section 8.2 on supervision and individual responsibility.

safety management system by HTM one of the conditions for the concessions.<sup>232</sup> In response to this requirement, HTM decided to put a safety management system in place for all HTM rail transport, i.e. also for The Hague city tram network rather than just for The Hague section of the Randstad-Rail network.

Within the context of preparing for passenger services, the Haaglanden Urban District required HTM to prepare safety cases for five activities.<sup>233</sup> The work involved in preparing these safety cases meant that HTM was unable to simultaneously put a safety management system in place for operations and the management of infrastructure. With the approval of the Haaglanden Urban District and IVW, HTM decided to prepare the five safety cases before putting a safety management system in place for operations. HTM laid down this agreement in the operations safety case. The approval of this safety case meant that the Haaglanden Urban District, the ISA and IVW were aware of the agreement.

HTM started setting up a safety management system in November 2006. This system was not ready prior to the launch of RandstadRail operations.

### *6.1.3 Implementation and enforcement of safety policy*

#### *RandstadRail organisation within HTM*

The RandstadRail project passed from the development phase to the implementation and operational phase in 2004. It became clear in that year that the Haaglanden Urban District would outsource the operation, management and maintenance of RandstadRail to HTM. At that point, HTM's director of operations became responsible for the RandstadRail project. Prior to that time it had been a development project. The director of operations set up a project bureau and appointed a RandstadRail project manager, whose duty was to coordinate the activities HTM had to carry out in preparation for RandstadRail operations. In addition, the project manager acted as HTM's representative in, among other things, administrative consultations about RandstadRail (PMT). In broader organisational terms, the project bureau supported HTM's implementing departments, assisting the rolling stock department, for example, in the latter's purchase of RandstadRail vehicles. In addition, HTM management appointed a rail safety coordinator in 2005 to coordinate preparation of the safety cases and safety management system.

HTM was eager to operate RandstadRail, among other things because RandstadRail services would replace tram lines 3 and 6. HTM viewed the other roles associated with RandstadRail (the purchase of rolling stock, future infrastructure manager, contractor, consultant and supervisor of the design and construction of infrastructure; see Chapter 4) as preconditions for the operation of RandstadRail.

#### *Training of personnel*

HTM had to deal with the issue of training approximately 200 new tram drivers in a very short time (summer of 2006). This was the case because, among other things, RandstadRail was being built on existing lines and disruption of passenger services had to be kept to a minimum. In addition, HTM wanted to deploy the drivers in actual services immediately after the completion of training.

HTM resolved the training issue by commissioning the development of a simulator at an early stage which could be used to practice trips on large parts of what would become the future RandstadRail network. Ordered in 2004, this simulator was completed in the spring of 2006 and has remained in daily use up to the present time. 85 to 90% of training hours were completed in the simulator, the remaining 10 to 15% on the actual railway network.

HTM assessed the training level of personnel, both drivers and traffic controllers, by means of an examination. All drivers involved in testing and the trial operation (see next section) had successfully completed this examination.

#### *Testing and trial operation*

HTM contributed to the trial operation by making vehicles and personnel available to the municipality of The Hague (PoRR) and Haaglanden Urban District. These parties also tested the functionality of components (such as switches, railways and infrastructural safety features). HTM carried out its own tests, for example, to ensure that the gaps between platforms and vehicles were sufficient throughout the network to enable the proper passage of vehicles and that power was being prop-

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<sup>232</sup> One of the conditions is adherence to the Operational Safety Plan, which requires the presence of a safety management system.

<sup>233</sup> A safety case is a cumulative file which describes how safety was and is ensured in the design, building and operational phases. See section 6.3.1 for a description of the context in which these safety cases were prepared. Appendix E contains background information concerning the use of safety cases to assess safety.

erly supplied to the vehicles. HTM did not play a role in the testing of areas which lay outside its scope of responsibility. This was the case, for example, with respect to the testing of infrastructural safety features.

Once the tests had been completed, clearance was given to begin the trial operation, the purpose of which was to train HTM and RET personnel to conduct operations safely. HTM carried out trial runs for two weeks, three days of which were based on the timetable and during which no problems were encountered. The Haaglanden Urban District then gave the green light for regular operations to begin and HTM commenced passenger services. Following the derailments and the suspension of operations, HTM conducted additional trial operations for a period of five months.

#### 6.1.4 Management control, involvement and communication

##### *Approval of infrastructure and authorisation to commence operations*

HTM was not involved in approving components of the new infrastructure for operations. This approval process was completed by the municipality of The Hague (PoRR) and Haaglanden Urban District. In addition, HTM was not aware of the testing programme and the criteria used to determine whether the technical installations were safe to use. A meeting that was attended by all the parties involved took place prior to the start of operations. The Haaglanden Urban District gave the go-ahead for operations at that meeting.

IVW issued an authorisation to commence operations to the Haaglanden Urban District. This authorisation was first sent by e-mail. HTM received a signed copy of the decision a week later.

##### *HTM's decision to commence passenger services*

At the beginning of the modification, testing and trial operation period, HTM informed the Haaglanden Urban District in writing that its decision to commence passenger services would be based first and foremost on the safety of passengers and personnel.<sup>234</sup> At the end of the period referred to, HTM inspected the infrastructure, using existing standards (HTM Infra Railway Regulations) and formulating introducing additional ones relating to the infrastructure from the perspective of vehicle operation. Based on this inspection, HTM agreed to the start of operations.

HTM management were informed on 27 October 2006 of the Haaglanden Urban District's decision, which had been reached in consultation with HTM, to commence RandstadRail line 4 passenger services on 29 October 2006. In terms of rail safety, this decision on the part of HTM was based on the following considerations:

- an HTM safety case had been completed to a sufficient degree for all subsystems;
- IVW's Railways Supervisory Division had approved commencement of operations;
- the ISA would prepare a statement of no objection and forward this statement to IVW before 29 October;
- the safety management teams of the Haaglanden Urban District and Rotterdam City Region had approved operations and would confirm this approval in writing;
- HTM had carried out tests and obtained results adequate for passenger transport in all areas within its scope of responsibility, in particular with regard to:
  - the training of drivers and the completion by most of them of the examination;
  - the training of central traffic controllers and the completion by all of them of the relevant examination;
  - a sufficient number of vehicles;
  - the guarantee of radio communication between vehicles and central traffic control;
  - the intensive testing of the organisation for a period of two days through the operation of 15 RandstadRail vehicles on the first day and 20 on the second;
  - the operation of line 4 according to its timetable and service route from Monsters-estraat to Javalaan;
  - the scheduled simulation of an emergency on 28 November 2006 to test the emergency response organisation.

HTM commenced RandstadRail line 4 passenger services on the basis of the abovementioned considerations. The authorities likewise approved the start of Erasmus Line services. At the time at which it launched operations, HTM had no reason to believe nor any information that suggested that the infrastructure was not safe. HTM adhered in this respect to the view of the principal and

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<sup>234</sup> During the inspection procedure, HTM made a letter of 7 June 2006 available to the Dutch Safety Board which had been sent to the Haaglanden Urban District and in which HTM stated that it would apply the safety of passengers and personnel as the basic principle. The letter does not link any safety criteria or objectives for testing and trial operation to this basic principle. It does, however, specify a number of minimum facilities such as safe stops, visibility-based travel at an adjusted speed of 70 km/h and local safety features at railway convergence points.

concession grantor, the Haaglanden Urban District, and did not independently verify whether RandstadRail was indeed sufficiently safe for operations. The Dutch Safety Board is referring in this case to the safety of the transport system as a whole, including therefore its infrastructure.

#### *Transfer of infrastructure management to HTM*

The previous subsection addressed the way in which HTM had to confirm that its affairs as a railway undertaking were all in order and that it could commence operations. In addition, within the context of operational management HTM was expected to carry out on behalf of the Haaglanden Urban District, HTM was expected to ascertain whether the completed parts of the (railway) infrastructure could be accepted for management. According to the Rail Concession, management and maintenance of RandstadRail (railway) infrastructure by HTM began on 1 January 2006.<sup>235</sup> The former Hofplein Line was originally excepted.<sup>236</sup> Management in Haaglanden jurisdiction was transferred to HTM by a decision adopted by the Haaglanden Urban District's General Committee on 13 December 2006.<sup>237</sup>

The launch of railway operations also meant that management of parts of the (railway) infrastructure had to be transferred to HTM from the municipality of The Hague (PoRR) via the Haaglanden Urban District. HTM would then be responsible for the management of the railways, switches, overhead power cables and cabling in general.

At the start of operations, only day-to-day management had been transferred to HTM. It was agreed that the municipality of The Hague (PoRR) would remain responsible for the completion of remaining points and also retain responsibility for the power supply and associated installations. The transfer of responsibility for these installations would take place at a later date. In addition, the municipality of The Hague (PoRR) remained responsible for the safety of the switches. This responsibility would be transferred as soon as additional information concerning the verification of the switches was available at HTM.<sup>238</sup>

When day-to-day management was transferred from the municipality of The Hague (PoRR) to HTM, HTM requested completion documents. HTM inquired into the switches, in particular into their condition, and asked for an overview of remaining points. HTM received these documents after repeating its requests a number of times. The foregoing occurred during the period of purchases preceding authorisation to commence operations in the autumn of 2006. HTM initially refused to accept management of the switches because the associated administration was not yet in order. The documents involved were not available prior to the start of operations by HTM. After finally receiving these documents in April 2007, HTM concluded that they contained no essential points of concern.<sup>239</sup>

HTM launched operations in spite of the above because it never once had the impression that the infrastructure was not safe. Management had not been transferred yet because the associated files were not yet available for transfer. In addition, the maintenance regime for the switches was still under discussion. The same was true with regard to the overhead power cables, where an incorrect type of connection was a factor. None of these issues concerned safety in the specific sense of rail safety (collisions, derailments and so on). HTM did not have the impression that there was a heightened level of risk. There were quality-related problems and some of the files still had to be properly completed.

As at the middle of November 2008, responsibility for management and maintenance has still not been transferred in full to HTM. A weekly Integral Progress Meeting is held within HTM, however, which is followed by a meeting with the Haaglanden Urban District. This meeting focuses on operations and all HTM departments take part. HTM Infra is still working on the transfer of the construction files. As at the middle of November 2008, management of the switches has still not been taken over.

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<sup>235</sup> This did not apply to railway sections formerly used by Dutch Railways (Zoetermeer City Line and Hofplein Line). Management of those sections, were used by Dutch Railways until 3 June 2006, was transferred to the Haaglanden Urban District on 16 June 2006.

<sup>236</sup> From the railway convergence signals near Leidschenveen.

<sup>237</sup> Management in Rotterdam City Region jurisdiction is conducted by RET. Arrangements are in place between HTM and RET concerning the maintenance of RET-specific systems in The Hague jurisdiction.

<sup>238</sup> Letter of 5 October 2006 from the RandstadRail Project Bureau to the Haaglanden Urban District and HTM.

<sup>239</sup> During the inspection procedure, the municipality of The Hague (PoRR) stated that it had made the documents available to HTM on 6 October 2006. This matter concerned a difference of opinion as to the documents that were required by the prospective manager for the transfer of management responsibility. See also the explanation given in Appendix A concerning this point.

### 6.1.5 Refinement and tightening of safety policy

#### *HTM decision-making following the first derailments*

Following a derailment, HTM always conducts an investigation to determine its causes, also if these are not related to the technology used. All components relevant to a derailment are carefully assessed and authorised or re-authorised. Operations are resumed once all components have received authorisation. HTM investigates all derailments. These are discussed in a derailment committee comprising HTM managers. The criteria used to decide whether operations should remain suspended or may be resumed are determined by the composition and expertise of the committee. A fixed method is still being developed.<sup>240</sup>

With reference to the derailments near The Hague Central Station and Ternoort, HTM should have monitored wear of the rails more closely and intervened earlier in response to previous derailments involving city trams. Rail wear was not a problem specific to RandstadRail: The Hague Central Station incidents could just as easily have involved city trams and the type of wear detected had occurred throughout the city tram network. Measurements were probably carried out extensively. The results obtained, however, did not lead to any action. In this connection, there is a new construction value and a rejection value and, in between these two, a value at which a warning must be issued. This did not happen. This working method was included in HTM's quality management system after the derailments near The Hague Central Station.

HTM did not proactively analyse the cause of the rail wear. A considerable period of time therefore elapsed before HTM engaged an expert to investigate the matter. In retrospect, this investigation should have taken place sooner. When it purchased trams 30 years ago, HTM fitted them with bogies that were 20 years old at the time, as these were still fit for service. However, it had been known since the 1950s that these bogies become slanted. Rather than resolving the problem, the rails were adjusted to counter the effects of that slanting. After the derailments, HTM concluded that the bogies should have been replaced and could not explain why this conclusion had not been reached earlier. HTM did, however, overhaul the bogies between 2004 and 2006. It did not realise when doing so that replacing the axles of the bogies could cause a different wear pattern. The reason for this lack of awareness can no longer be traced.

## 6.2 SAFETY MANAGEMENT OF THE MUNICIPALITY OF THE HAGUE (RANDSTADRAIL PROJECT BUREAU)

As stated earlier, the municipality of The Hague set up a temporary RandstadRail Project Bureau (PoRR) specifically for the design and construction of RandstadRail. In organisational terms, this bureau is part of the City Management Department of the municipality of The Hague. The municipality of The Hague's associated duties and obligations are detailed in section 4.2. The present section addresses the way in which the municipality of The Hague ensured safety during realisation of the infrastructure, particularly with regard to the switches.

### 6.2.1 Safety management system

The municipality of The Hague (PoRR) did not have its own safety management system, as described in the Dutch Safety Board's assessment framework (see Appendix F). For the safety system used during the design and construction of RandstadRail infrastructure, the municipality referred to the safety plans prepared by the principal, the Haaglanden Urban District (see section 6.3). These plans did not require contractors to have their own safety management system, and there is also no legal obligation to have a safety management system in place during the construction phase of a railway project.

The Haaglanden Urban District did, however, instruct the municipality of The Hague (PoRR) to prepare two safety cases, one for the safety system and the other for the power supply. The municipality of The Hague did not have to prepare a safety case for the part of the infrastructure, including the switches, that it would build. Providing evidence of this infrastructure's safety was the responsibility of the Haaglanden Urban District (see section 6.3).

The municipality of The Hague implemented the RandstadRail project in Haaglanden jurisdiction for its own account and risk. The Hague's municipal council and executive supervised project implementation and received periodic progress reports. These progress reports focused mainly on man-

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<sup>240</sup> HTM stated that it would in future use a different working method. The director of operations has since become chairman of the derailment committee (the previous chairman was the manager of HTM Infra). In the event of a complex derailment, an HTM employee proceeds to the location of the derailment and, in consultation with the Rail, Infra and Rolling Stock departments and the technical advisor, determines whether operations can continue or should be suspended.



agement of the planning, finances and image, however, and did not address quality, which among other things included safety.

### 6.2.2 Trial operation and transfer

Prior to the start of operations, the municipality of The Hague (PoRR) and Haaglanden Urban District tested the railway system by means of a trial operation.

As described above, day-to-day management of the infrastructure was then largely transferred from the municipality of The Hague (PoRR) to HTM via the Haaglanden Urban District at the start of RandstadRail operations.

As has already been stated, the municipality of The Hague (PoRR) retained responsibility for the safety of the switches, including the Forepark switch on which a RandstadRail vehicle derailed. These switches were part of a management delivery. This means that management, in this case the municipality of The Hague, was responsible for the design, production and inspection of the switches. The contractor was responsible vis-à-vis the management for the proper transport, placement and use of the switches. The municipality of The Hague (PoRR) then placed the infrastructure at the disposal of the Haaglanden Urban District and was therefore responsible for ensuring that the contractors had placed and used the switches correctly.

Prior to the completion of the infrastructure, there had been indications that the switches had been passed in a direction other than the one for which they were set during the building phase and had sustained damage as a result. These indications did not lead to a tightening of inspections prior to the use of the switches in regular operations. If the municipality of The Hague (PoRR) had had an integral and systematic safety policy in place during the building phase, the risk of damage to switches through their improper use by construction vehicles would probably have been detected in time.

## 6.3 SAFETY MANAGEMENT OF THE HAAGLANDEN URBAN DISTRICT

### 6.3.1 RandstadRail safety management plans

The Normative Document for Light Rail Safety was prepared by the Ministry of Transport, Public Works and Water Management as an aid which decision makers in light rail projects can use to formulate and test their safety philosophy.<sup>241</sup> Among other things, it contains a description of the processes to be followed. In the Dutch Safety Board’s opinion, the Normative Document constitutes a solid foundation for a safety policy that accords with the Board’s assessment framework. However, the way in which safety policy is implemented ultimately determines the degree to which safety is managed and ensured.

The Haaglanden Urban District and Rotterdam City Region used the Normative Document to jointly prepare the following safety plans:

- Integral Safety Plan
- Operational Safety Plan
- Safety Management Plan.

As shown in the following figure, these safety plans concerned specific RandstadRail phases and operated at different levels.

RandstadRail development and realisation phase	Operation, management and maintenance
<b>Integral Safety Plan (ISP)</b> and Schedule of Requirements	<b>Operational Safety Plan (OSP)</b>
Operation of ISP: <b>Safety Management Plan (SMP)</b>	

Figure 14 – Areas of application of RandstadRail safety plans<sup>242</sup>

The scope, summarised content and area of application of each plan are given below. The section concludes with IVW’s opinion of the safety plans.

<sup>241</sup> See description in Chapter 3 and the summary of the Normative Document in Appendix C.

<sup>242</sup> RandstadRail Integral Safety Plan, version 4.1, definitive from 18 May 2006, p. 1.



### *RandstadRail Integral Safety Plan*

The RandstadRail Integral Safety Plan (ISP) was prepared in 2003 and sets out a vision concerning RandstadRail safety.<sup>243</sup> The ISP applied to the development and realisation phase of the RandstadRail transport system. Projected operations (timetables and passenger numbers) constituted key preconditions for the plan. Moreover, the ISP applied and applies to the RandstadRail transport system as a whole, including new and existing infrastructure, rolling stock, traffic control, process execution and management, and safety and telecommunications throughout the RandstadRail network. The plan was adopted by the RandstadRail Administrative Consultation Committee (BoRR) in November 2003.

The ISP was jointly prepared by the Haaglanden Urban District and Rotterdam City Region, and was largely based on the Normative Document in terms of its structure. The purpose of the ISP was to create a framework for the following:

- to formulate answers to safety-related questions relevant to the RandstadRail transport system;
- to substantiate internal safety-related decisions;
- to manage the design and operation of the transport system in terms of safety.

Implementation of this plan was and is aimed at ensuring the safety of RandstadRail operations. Among other things, the ISP sets out a safety philosophy, is based on a risk approach, specifies safety standards, and defined the organisation of safety management for the design and building phases as well as the roles, duties and responsibilities associated with this management.

In addition, the ISP details how RandstadRail safety is ensured. This safety is demonstrated and fostered by means of safety reports that, among other things, include risk analyses which had to be studied and elaborated in each phase and result in a safety case.<sup>244</sup> A safety case is a cumulative file that specifies how safety was and is ensured in the design, building and operational phases, and concerns the transport system as a whole and the subsystems used within it.

### *RandstadRail Operational Safety Plan*

The Haaglanden Urban District and Rotterdam City Region also adopted a RandstadRail Operational Safety Plan (OSP).<sup>245</sup> As its name suggests, this plan concerns safety in the operational phase and focuses on the management of both the railway infrastructure and the transport of passengers. As concession grantors, the Haaglanden Urban District and Rotterdam City Region obliged the concession holders for RandstadRail transport and railway infrastructure management, HTM and RET, to adhere to the OSP in the Rail Concession 2006-2016.

The OSP defines the (safety) frameworks within which railway undertakings and railway infrastructure managers HTM and RET must operate. Furthermore, the OSP sets out the safety-related organisation, duties and responsibilities of the parties involved in operations and management and maintenance.

As with the ISP, the OSP applied and applies to the RandstadRail transport system as a whole, including new and existing infrastructure, rolling stock, traffic control, process execution and management, and safety and telecommunications throughout the RandstadRail network.

Among other things, the OSP contains the safety philosophy and safety objectives, provisions concerning the lifecycle and risk management, a description of roles, duties and responsibilities, provisions concerning quality management at system level, and requirements relating to the railway undertaking, traffic control, infrastructure managers and the safety management system.

### *RandstadRail Safety Management Plan*

The Safety Management Plan (SMP) is an operational elaboration of the Integral Safety Plan (a working plan) and was prepared by the Safety Managers of the Haaglanden Urban District and Rotterdam City Region.<sup>246</sup> Among other things, the SMP describes current and future safety management activities, phases, verification, validation and authorisation to commence operations, the RandstadRail safety case, deployment of Independent Safety Assessors (ISAs), coordination with IVW's Railways Supervisory Division and the planning.

An important part of the SMP is the division of the RandstadRail safety case into constituent safety cases for each subsystem (infrastructure, rolling stock, operations, management and maintenance) and associated duties (author, party with final responsibility and ISA). The plan provides for a total

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<sup>243</sup> Ibid.

<sup>244</sup> Appendix E contains background information relating to the assessment of safety by means of safety cases.

<sup>245</sup> RandstadRail Operational Safety Plan, version 1.0, draft of 27 May 2005.

<sup>246</sup> RandstadRail Management Plan, version 1.1, definitive from 21 May 2006.

of approximately 20 safety cases. An overview of these safety cases, including respective authors and parties bearing final responsibility, is included in Appendix Q. Those responsible for completion of these constituent safety cases in the Haaglanden region were:

- HTM: rolling stock, operations, management and maintenance and traffic control;
- The municipality of The Hague (PoRR): safety and power supply;
- Haaglanden Urban District: other safety cases concerning railway infrastructure not prepared by the municipality of The Hague (PoRR), including, among others, the one concerning switches and the city tram network.

In addition, the Haaglanden Urban District was responsible for the integral safety case, which set out safety management for the RandstadRail system as a whole.

#### *Checks of plans by IVW*

The ISP and OSP were approved by IVW. IVW's director and chief inspector wrote the following about the ISP:

'Following a reading of the document, I confirm that all essential aspects concerning safety have been addressed. I furthermore note that the matter of safety has been given due consideration within RandstadRail through the use of the Normative Document for Light Rail Safety as a framework. I also confirm that proper efforts have been undertaken to conduct and foster sound safety management within the complex of parties and powers in which RandstadRail operates. I therefore approve the safety philosophy described and method of implementation outlined in the document.'<sup>247</sup>

The chief inspector of IVW's Railways Supervisory Division wrote the following about the OSP:

'Following a reading of the document, I confirm that it provides an accurate impression of the manner in which RandstadRail intends to ensure safety in the operational phase. I furthermore confirm on the basis of the document that the various focal areas of operations are properly addressed by the safety philosophy. Pursuant to the ISP, it must be noted in this regard that the policy described entails obligations both within a party's individual set of responsibilities and between the parties. A properly functioning safety management system is crucial to the implementation of all elements of the OSP.'<sup>248</sup>

#### *6.3.2 Use of insight into risks as the foundation for safety policy*

Proper safety management must be based on insight into risks.

The RandstadRail risk analysis is described in the ISP. To carry out this risk analysis, the Haaglanden Urban District and Rotterdam City Region used the accident types described in the User Instructions, which were prepared as a complement to the Normative Document for Light Rail Safety and explain criteria, background and practical applications.<sup>249</sup> For purposes of orientation, these User Instructions describe a number of accident types and provide a non-exhaustive list of possible causes and specific light rail characteristics relevant to the accident risk in question. A distinction is maintained in the User Instructions between the following types of accident:

- collisions
- accidents on crossing points
- accidents involving passengers at a station or stop
- derailments
- accidents involving other road traffic
- collisions with a person, animal, object and cases of suicide
- accidents in tunnels
- collisions with personnel
- other aspects (electrocution, fires, falls, explosions, falls from a moving vehicle).

The derailments category is of relevance to the RandstadRail incidents being addressed in the present report. The risk analysis for this type of accident consisted of three parts: section 1,<sup>250</sup> sec-

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<sup>247</sup> Inspectorate for Transport, Public Works and Water Management letter to the Haaglanden Urban District of 26 January 2004 regarding the RandstadRail Integral Safety Plan.

<sup>248</sup> Inspectorate for Transport, Public Works and Water Management letter to the Haaglanden Urban District of 22 December 2005 regarding the RandstadRail Operational Safety Plan.

<sup>249</sup> User Instructions for Light Rail Safety, version 5.0, 25 November 2002.

<sup>250</sup> Hofplein Line: Melanchtonweg-Leidschenveen, Zoetermeer City Line: Leidschenveen-Centrum West, Krakeling and Oosterheemtak. Shared railway section: Leidschenveen-The Hague Laan van NOI-The Hague Central Station (railway 11/12).

tion 2<sup>251</sup> and the ground-level sections. Furthermore, the Haaglanden Urban District maintained a number of basic assumptions in this regard, of which the following were of relevance to the derailments that occurred:

- The switches should be used by vehicles for which they were designed: no additional derailment risk through the use of this switch type.<sup>252</sup>
- RandstadRail uses two types of vehicles: low-floor and high-floor vehicles.<sup>253</sup> Wheel geometry and rails should be the same as those used in conventional rail traffic (system description).<sup>254</sup>
- The basic assumption applied to ground-level sections (The Hague city tram network) was based on tram lines 3 and 6, which would travel the same route as RandstadRail on The Hague city tram network. In addition, it was assumed that only technology known in the city tram network would be used.

The Schedule of Requirements, agreements with the municipality of The Hague (PoRR) or HTM and the safety cases all failed to demonstrate that the requirements implied by these basic assumptions had been met. The switches, for example, were used by non-RandstadRail vehicles, namely construction vehicles engaged in work commissioned by the municipality of The Hague. In addition, by using ground-level sections as the frame of reference, the Haaglanden Urban District implicitly assumed that they already met the requirements set out in RandstadRail Schedule of Requirements without actually confirming that this was indeed the case and ensuring that it would remain the case by, for example, concluding written agreements with HTM in that regard.

In addition, the risk analysis had a number of lacunae, in particular with respect to risks that could not be assessed at the time the analysis was performed due to the absence of sufficiently specific information. The risk analysis for the city tram network, for example, noted that a proper risk assessment of tail tracks, or turning points, was as yet not possible because the matter still had to be settled. The decision was ultimately taken to use openable switches at these turning points. The documents made available by the Haaglanden Urban District indicate that this modification was not incorporated into the risk analysis. Openable switches had not been used before, or only to a very limited extent, within the city tram network. The basic assumption that only known technology would be used was therefore also inaccurate.

It is no longer possible to determine the extent to which risks were managed by appropriate adjustments to the Schedule of Requirements. The Haaglanden Urban District carried out a safety assessment and compared the quantified risks with predetermined target values. If the risks exceeded the target values, measures were generated to manage them. Among other things, this process led to proposals by the safety managers of the Haaglanden Urban District and Rotterdam City Region to adjust the Schedule of Requirements (Schedule of Requirements change proposals). The Schedule of Requirements was managed by the Haaglanden Urban District. In the starting period the changes were communicated by e-mail and processed. It is no longer possible to retroactively identify all the changes made to the Schedule of Requirements.

The municipality of The Hague, railway undertakings and suppliers of system parts then started preparing safety cases. As described in the SMP, safety cases must substantiate that the stipulations set out in the Schedule of Requirements have been met and thereby demonstrate the safe functioning of RandstadRail. As not all Schedule of Requirements change proposals could be traced, it was not possible to determine how the Haaglanden Urban District established that all risks identified by the risk analyses had been sufficiently covered and properly accounted for in the constituent safety cases.

In addition, the Haaglanden Urban District and municipality of The Hague (PoRR) did not set the safety objectives and criteria that the testing and trial operation had to meet in order to substantiate the safety of RandstadRail as a whole in advance.<sup>255</sup> Safety objectives for the testing and trial operation carried out were not established in writing in advance, no risk analysis appears to have been performed and no evidence, written or otherwise, was provided to show that the objectives had been achieved. A so-called robustness objective<sup>256</sup> was, however, formulated during the trial

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<sup>251</sup> The Hague Central Station tram platform via Beatrixlaan stop to The Hague Laan van NOI stop and the tram tunnel.

<sup>252</sup> RandstadRail Safety Analysis, Risk Analysis of Section 1 Derailment, Utrecht, 23 January 2006, p. 13.

<sup>253</sup> Ibid. p. 4.

<sup>254</sup> RandstadRail Safety Analysis, Risk Analysis of Section 2 Derailment, Utrecht, 1 February 2006, p. 8.

<sup>255</sup> Safety tests were carried out at subsystem level.

<sup>256</sup> The Trial Operation Plan of Action (16 October 2006; first version 6 October 2006) prepared by the Haaglanden Urban District contains a robustness objective: a maximum of three Category 1 malfunctions may occur with a joint duration of 30 minutes at most and no Category 2 malfunctions may occur for a period of 35 hours at peak-hour load.

operation and IVW specified criteria for the testing and trial operation in a letter to the Haaglanden Urban District a few days before issuing authorisation to commence operations.<sup>257</sup>

**Example: risk of damage not recognised during building phase**

The risk of damage to the switches during the building phase (June-August 2006) was not recognised in the risk analyses. Due to the large scale of the RandstadRail modification project, the railway into which the new switches had been incorporated was used intensively by construction vehicles. There were indications throughout the modification period that the switches were not always being used and secured in the correct manner. The Site Acceptance Test (SAT) revealed, for example, that the point of switch 846, on which the derailment took place, was damaged.

This SAT discovery did not lead to subsequent inspections of this and the other switches to ascertain whether damage had occurred. Inspections of switches during the SAT were limited to functional tests (to ascertain whether a switch responded correctly to an instruction received from the safety system). At that time, the control bolt in the switch was almost certainly already damaged, as a result of which the switch was unable to move. A Klammer Test in combination with one to ascertain whether both control bolts could move would probably have revealed the problem.<sup>258</sup> These tests did not form part of the SAT procedure and were not performed. The Klammer Test is described in the basic documentation on switches, which specifies a number of tests to identify technical problems with switches.

The note concerning damage made on the SAT form could have prompted the performance of such tests, all the more so because of the stipulation in the basic documentation that all RandstadRail switches had to be checked after being opened to ascertain whether damage had occurred and the fact that the switches were manually operated during the building work, as a result of which the passage of vehicles in a direction other than the one for which the switches were set could not be prevented and/or detected by the safety system.

*See Appendix I, 'Analysis of Derailment on Switch 846 near Forepark Stop' (section 1.5)*

### 6.3.3 Demonstrable and realistic safety policy

The Dutch Safety Board expects a realistic and practically applicable safety policy, including its associated basic principles, to be put in place to prevent and manage undesirable events. As stated earlier, the Haaglanden Urban District did so by preparing the Integral Safety Plan (ISP) and Operational Safety Plan (OSP), which were both adopted at management level. In addition, safety managers detailed how the ISP would be implemented in practice in the Safety Management Plan (SMP).

The Dutch Safety Board believes that the ISP and OSP are broadly in line with its definition of safety policy. An important part of such plans is the documenting of safety management in safety cases, in the present matter the cumulative safety file of RandstadRail. In itself, however, a plan does not guarantee safety. Plans must be sufficiently elaborated and applied in practice. In this regard, there were shortcomings in the implementation of safety management (see sections 6.3.4 and 6.3.5). In addition, the Dutch Safety Board discovered a number of weaknesses in the plans that contributed to the shortcomings in implementation.

The OSP set out requirements relating to the safety management system to be conducted by the future infrastructure manager and railway undertaking.<sup>259</sup> The ISP, on the other hand, did not specify requirements concerning the way in which safety management was to be conducted by the parties involved in RandstadRail in the earlier design and realisation phases. The RandstadRail Project Bureau of the municipality of The Hague, for example, that was responsible for the design and realisation of RandstadRail infrastructure, did not have a demonstrable safety policy. By omitting to specify requirements in relation to the safety management conducted by the parties in the design and realisation phases, the Haaglanden Urban District gave the impression that it considered a safety management system relevant only in the operational phase. However, although the RandstadRail derailments occurred during the operational phase, their underlying causes were

<sup>257</sup> Following the reading of the draft report, the Inspectorate for Transport, Public Works and Water Management responded to this passage by forwarding a letter to the Dutch Safety Board which specified criteria for RandstadRail testing and trial operation. As this letter was dated 24 October 2006 (a few days before the start of operations), the Dutch Safety Board does not see it as constituting objectives and criteria set in advance. In addition, these criteria were formulated by the external supervisor, not the parties directly involved.

<sup>258</sup> The Klammer Test (described on p. 34 of the switch machine manual of 25 April 2006) is used to check the position of the bolt and thereby determine whether any damage has occurred.

<sup>259</sup> Operational Safety Plan, draft, 27 May 2005, Chapter 8.

rooted essentially in the design and realisation phases and in the transition between these phases. The derailments therefore show that all parties involved must work according to a realistic safety policy for the entire lifecycle of a project.

### **Example: testing and trial operation**

#### *Safety policy*

Testing and trial operation serve several purposes. In addition to ensuring safety, testing and trial operation are also aimed at acquiring an impression of a system's reliability and operational integrity prior to its launch.

There are no generic standards and guidelines for testing and trial operation. In terms of safety, therefore, RandstadRail's safety policy should have guided the testing and trial operation carried out. In other words, risk analyses should have been used to establish criteria and objectives in advance. In addition, the testing and trial operation should have been carried out for long enough to empirically substantiate to a sufficient degree that the safety of the system as a whole was ensured. For a combined system like RandstadRail, a couple of weeks of testing and trial operation were insufficient. A sound approach entails making targeted risk estimates. Given that safety cases were used within the RandstadRail project to deal with risks, it would have been logical to prepare a safety case for the modification and testing and trial operation phases as well; a case which specified all risks and associated criteria so that each phase could be completed successfully. The documents received by the Dutch Safety Board concerning the organisation of the modification and testing trial operation period do not indicate the application of a safety philosophy to establish criteria and objectives for the testing and trial operation carried out.<sup>260</sup>

#### *Realistic period*

Due to the wish to resume passenger services on the Zoetermeer City Line and Hofplein Line as quickly as possible, a relatively short period had been planned in the RandstadRail project for testing and trial operation. Based on experience with other railway projects, this period was not realistic. Had more time been allocated to testing and trial operation, the risks that led to the derailments might have been detected on time. RandstadRail operations ultimately began later than planned. In addition, these operations were suspended following the derailments of 29 November 2006 until September/October 2007 – for almost a year, in other words. This suspension can be seen as an extension of the originally planned testing and trial operation.

As stated above, there are no standards or guidelines to specify a minimum period for modification, testing and trial operation, as this period depends on the nature and scale of a project. Given this consideration, the Dutch Safety Board provides a description based on the estimate of an expert judgement of a realistic period for modification, testing and trial operation as applicable to the RandstadRail project. Had this period been adhered to, the risks that led to the derailments might have been detected on time.

Work is usually planned for a project like RandstadRail. The planning process includes determining the work that can be performed simultaneously and the work that must be carried out sequentially. In addition, a plan must incorporate reserve time based on a risk estimate that takes the complexity of the project into account. During RandstadRail realisation, platforms had to be modified, the layout of the rails adjusted and so on following the laying of new railway track on the Zoetermeer City Line (the railway track of this line must be closer to the platforms because RandstadRail vehicles are smaller than NS ones). A planned period of two months (excluding the laying of new railway track) and three months (including the laying of new railway track) would have been realistic for RandstadRail modification work.

Systems must be tested after construction. Each system must first be tested individually (switches, signal lights, supply of information to traffic controllers etc) and subsequently tested in terms of their interaction (functioning of switch in accordance with traffic control input, safety indication by signal when crossing point is closed or switch is in the correct position etc). The testing of safety features in a variety of situations also forms part of this process. In addition, test results must meet clearly formulated criteria. In this connection, the testing programme must specify the parts to be tested and, if necessary, the sequence in which tests must be carried out and the approval criterion for each individual test. In the case of a testing sequence, a subsequent test may only be carried out after a preceding one has been successfully completed. For the testing of systems in a project like RandstadRail, one month would be required in the most favourable case and two months in the case of setbacks.

Trial runs may be carried out once all systems have been tested. At this stage, vehicles travel railway routes to determine whether all signals, switches, crossing points, stop indicators, broadcasting system and so on

<sup>260</sup> The Trial Operation Plan of Action (16 October 2006; first version 6 October 2006) only contained a robustness objective: a maximum of three Category 1 malfunctions may occur with a joint duration of 30 minutes at most and no Category 2 malfunctions may occur for a period of 35 hours at peak-hour load. The relevance of this objective to safety is that passengers leave the vehicle and walk along or on the railway in cases of extended standstill.



are functioning as they should. All possible scenarios must be tested, such as travelling on a railway in the wrong direction, setting incorrect routes, opening switches, emergency braking manoeuvres and so on. All safety risks identified, previously or otherwise, must be addressed in these trial runs. As with the system tests, criteria that can be tested concerning, for example, the number of malfunctions, the duration of a malfunction and the occurrence or non-occurrence of a certain type of malfunction must likewise be established in advance.

Trial operation can commence if the number of malfunctions remains below a level agreed in advance. This stage involves completion of the timetable in its entirety without passengers. This is done to determine whether the timetable has been properly prepared in terms of, for example, the likelihood of problems arising when lines branch off or converge and the ability of drivers to keep to it. All drivers must in addition be given the opportunity to make a sufficient number of trips prior to the start of operations. It goes without saying that the trial operation period depends on the complexity of the new line(s), the timetable and the degree of novelty. In addition to acquiring insight into whether the railway undertaking has allowed a sufficient number of personnel to obtain the necessary experience, a certain punctuality percentage is often applied as a criterion to establish the success of the trial operation. A period of one month is usual but a period of two to three months is recommended to ensure a reliable product. An objective (a certain reliability or punctuality percentage, for example) is normally formulated to ensure that a reliable product is in place at the start of operations.

#### 6.3.4 Implementation and enforcement of safety policy

A working method must be defined in terms of, among other things, concrete objectives and plans, including the preventative and repressive measures arising from them, for the implementation and enforcement of safety policy and the management of identified risks. To that end, it is important to have a transparent, unequivocal and universally accessible division of duties, responsibilities and powers on the shop floor for the implementation and enforcement of safety plans and measures.<sup>261</sup> This requires a clear specification of the personnel and expertise required for the performance of the various duties and active, central coordination of safety-related activities.

In addition, the Executive Committee of the Haaglanden Urban District must exercise internal supervision on RandstadRail safety policy. Internal supervision makes it possible to periodically determine whether the system is functioning as a means to ensure the safety of activities. The object of internal supervision is to ascertain whether a process has been completed in accordance with the applicable safety plans and whether a system meets legal safety requirements. The matter in this respect concerns forming an objective and substantiated opinion about the implementation of the safety policy and safety plans and about the preventative measures themselves.

The Integral Safety Plan (ISP) is weak in terms of defining the implementation of safety policy or, in other words, the way in which internal supervision is to be exercised and compliance with agreements enforced. It does not define the way supervision aimed at ensuring that the implementing parties involved actually work as described is exercised. The Safety Management Plan (SMP), which is an operational translation of the ISP, does not incorporate this safeguard either. Although the safety plans specify concrete objectives, they do not describe the preventative and repressive measures arising from them.

Safety plans must set out a transparent, unequivocal and universally accessible division of safety-related duties and responsibilities on the shop floor. A problem at the Haaglanden Urban District was that the safety manager bore final responsibility for ensuring safety and therefore also for the preparation of the constituent safety cases concerning the infrastructure. As a result, the safety manager bore *de facto* responsibility for demonstrating that the infrastructure was safe instead of being free to check whether the project (RandstadRail Project Bureau) had ensured that this was the case (risk level 'As Low As Reasonably Practicable', or ALARP). Responsibility for demonstrating the safety of the infrastructure should not have been placed with the safety managers but with the implementing organisation, namely with the director of the RandstadRail Project Bureau of the municipality of The Hague. By way of comparison, responsibility for ensuring safety at HTM was placed with the implementing organisation: the line managers involved bore final responsibility for completion of the constituent safety cases and HTM's rail safety coordinator exercised an advisory role in this regard.

In addition, a clear division of powers was not included in the plans. The powers required by the safety manager to exercise his responsibility for safety were not specified, for example. With the exception of operational duties and responsibilities, the duties, responsibilities and powers of the

<sup>261</sup> A duty is that which a party is obliged to carry out vis-à-vis a principal.

A power is that which a party is entitled to do in terms of decision-making and coercion relative to other parties.

Responsibility is accounting for the exercise of duties and responsibilities.



administration, the decision-makers who bore final responsibility for RandstadRail safety, were also not defined.

### **Inadequately defined responsibilities and powers**

'Ensuring RandstadRail safety is a responsibility of the principals Rotterdam City Region and Haaglanden Urban District. Both appointed a safety manager to give this responsibility concrete form. The safety managers shall bear joint responsibility for ensuring safety, collecting safety cases and preparing the final (top-level) safety case throughout the design and building phases.'<sup>262</sup>

'The decision-makers of the RandstadRail project are the principals Rotterdam City Region and Haaglanden Urban District. No operational safety-related duties or responsibilities are attached to the role of decision-maker.'<sup>263</sup>

The safety managers approved parts of RandstadRail in spite of the fact that their powers had not been defined. In other words, they attributed a certain operative interpretation to their powers without those powers having been defined.

In practice, implementation of the safety policy proceeded on a course different from the one set out in the ISP. This point was already made in the operational translation of the ISP, the SMP.

'Due to tight planning with regard to the start of operations, it is not possible to fully document the verification/validation of the first phase. In close consultation with the ISA, a process is being put in place to ensure that a complete representation is available at the start of preliminary operations on 3 September 2006 for use by the ISA and IVW to form an opinion and issue a permit, respectively, and to ensure that all necessary documentation is available at any given time. Design and verification/validation plans must in any case be available in advance. The safety case for the start of operations must be completed as soon as possible after 3 September.'<sup>264</sup>

The SMP was not formally adopted in an official or administrative meeting. It is, rather, an internal working plan for RandstadRail safety management. The issue as to whether official and administrative responsibilities accorded with this deviation from the working method set out in the formally adopted ISP was therefore not documented. An analysis of the safety cases revealed that, in addition to the omission to document verification and validation, a significant number of the safety cases were not in order with respect to content at the time of the derailments. Some of the constituent safety cases were still limited to a table of contents with explanation in which essential information was lacking. Appendix R provides an overview of the stages at which the various constituent safety cases were at the time of the derailments. Of note in this regard is the fact that the railway constituent safety case (as a whole and the switches section) and ground-level lines constituent safety case, both of which were relevant to the RandstadRail derailments, had not yet been completed and lacked key information.

The decision to leave safety cases incomplete – or, in the words of the parties involved, proceed 'on the fly' – meant that proof confirming the safety of RandstadRail was lacking to a significant degree at the start of operations. Given that this course of action deviated from the officially adopted basic principles as formulated in the ISP, the decision to effect such a deviation should, in the view of the Dutch Safety Board, have been made the subject of explicit scrutiny at the highest administrative level. This did not happen, however (see section 6.3.6).

The Haaglanden Urban District's acceptance of the fact that HTM did not have a safety management system in place at the start of operations constituted another deviation from the ISP (see section 6.1.2). The Haaglanden Urban District had, for that matter, already undertaken in 2001 to set up a safety management system together with the railway undertakings.<sup>265</sup>

In addition, the way in which the Haaglanden Urban District would substantiate its decision to approve RandstadRail operations was not defined following the jettisoning of the instrument previously agreed and adopted for the purpose (documentation in safety cases completed by suppliers to the transport system). Reports of the official RandstadRail consultative body (PMT) indicate that

<sup>262</sup> RandstadRail Integral Safety Plan, version 4.1, definitive from 18 May 2006, p. 25.

<sup>263</sup> Ibid. p. 20.

<sup>264</sup> RandstadRail Safety Management Plan, version 1.1, definitive from 22 May 2006.

<sup>265</sup> This was in response to the relevant recommendation in the Veiligheidsrisico's van de Nederlandse stadstram report of the Transportation Safety Board (2000). See section 8.2 on supervision and individual responsibility.

experts of the parties involved were frequently consulted in the last phase – at the end even on a daily basis – and that the decision to approve operations was reached in that manner. Given that neither this decision nor the criteria used to make it were recorded, the Dutch Safety Board concludes that in the final period prior to the launch of RandstadRail operations, an informal working method was used to conduct safety management.

### **Approval and transfer**

The Haaglanden Urban District had defined a procedure for the transfer of infrastructure management from the municipality of The Hague (PoRR) to HTM (see Appendix T). In that connection, the Haaglanden Urban District asked HTM as the future manager to perform a number of activities on its behalf. This left intact, however, the Haaglanden Urban District's individual responsibility as a principal and its responsibility in the interests of safety to make a properly substantiated decision to approve RandstadRail passenger services.

The administration of the Haaglanden Urban District did not sufficiently supervise implementation of the safety policy.

No safety-related responsibilities had been placed with the administration of the Haaglanden Urban District, only ones concerning time and money. In addition, the subject of safety was not a structural and regular agenda item in administrative meetings of the Haaglanden Urban District. Most safety-related issues were addressed and decided upon by the PMT. The Dutch Safety Board notes in this connection that while issues relevant to safety were discussed on a number of occasions by the PMT, reports of the administrative meetings do not indicate that these issues were also discussed at the highest administrative level. The concerns expressed by the PMT in July 2006 concerning the tight planning of the modification, testing and trial operation phases, for example, were not reflected in the administrative meeting reports of the Haaglanden Urban District during the period referred to:<sup>266</sup>

'Time is running out. More manpower or money is no longer an option. In the coming period, tests will be combined and time will be tighter than it already was. All of the parties involved have promised their cooperation *à outrance* but there is no longer a margin. If something unforeseen occurs, 3 September will no longer be feasible. Progress has been discussed with the safety inspectors and they have confirmed that we are still on course, but it remains to be seen how long the current pace will remain responsible. Risks can no longer be glossed over.'

The lack of supervision by the administration of the Haaglanden Urban District is further evidenced by the way in which certain comments made by the ISAs engaged by the Haaglanden Urban District and Rotterdam City Region were handled. The ISA was charged with assessing whether the safety of the RandstadRail transport system was sufficiently guaranteed. To do so, the ISA had to assess, among other things, the integral safety case prepared by the Haaglanden Urban District and Rotterdam City Region, which had to provide evidence that safety requirements relating to the interaction of infrastructure and rolling stock had been met. In forming an opinion, the ISA also had to include safety cases that had already been assessed by other ISAs, the focus in this regard being on scope and integration aspects.<sup>267</sup>

The ISA expressed warnings about the conduct of RandstadRail safety management in its assessment reports (prepared a year and half a year, respectively, before the start of modification work).

### **ISA warnings**

In the first assessment report concerning the specifying phase of RandstadRail, the ISA's overall conclusion was that project activities and deliverables up to that time gave sufficient grounds to believe that a safe system would ultimately be completed.<sup>268</sup> Nevertheless, a number of recommendations were made that had to be implemented. These recommendations were based on, among others, the following findings:

- Work is performed too implicitly.
- Due to ongoing changes in the project, a number of plans, descriptions and risk analyses are no longer current.
- There is a lack of clarity about the safety cases (purpose, content, and format) and the way proper evidence must be obtained.

The ISA's conclusion in the assessment report on the second phase, the design of RandstadRail,

<sup>266</sup> Excerpt from the report of the PMT meeting held on 11 July 2006.

<sup>267</sup> ISA RandstadRail Offer, part of ISA assignment, TARA/04/0006, 23 June 2004, point 3.6.

<sup>268</sup> ISA Phase I RandstadRail Assessment Report, May 2005, definitive status.

reveals doubts about the system's safety.<sup>269</sup> This conclusion was based on, among other things, the following findings:

- Work is still performed too implicitly. Verification and professional activities are carried out without advance planning, without clear definitions of the assignments, without checklists and without recording. In addition, follow-up action to remarks made is not formally monitored.
- Little action is taken with respect to the demonstrable achievement of safety levels or full performance of agreements relating to safety requirements. This seems to be caused in part by a lack of clarity about the purpose, structure and minimally required content of the safety cases.
- Completion of the required safety cases is behind schedule. Rapid corrective action must be taken in this regard to prevent an approval risk due to the absence of proper safety cases at the start of operations.
- In addition, an approval risk might arise due to the inadequate recording of verification and validation activities, the carrying out of professional reviews in an unstructured way and the failure to sufficiently adhere to a structured design and development process, which in turn means that the proper functioning of interfaces and interaction between system components are insufficiently guaranteed. Successful system integration is therefore less likely and last-minute repairs may be necessary.
- The modification, testing and trial operation phase is time-critical, which means that more substantial proof of proper process monitoring and safety management in relation to the design must be provided.<sup>270</sup>

These warnings were discussed in the PMT in January 2006. The reports of the RandstadRail Administrative Consultation Committee (BORR) dating from the same period indicate that the Haaglanden administration had not been informed about these warnings. The Dutch Safety Board therefore concludes that responsibility for safety, which should have rested at the highest decision-making levels, was instead absorbed lower down in the official hierarchy. This situation was caused in part by the fact that the ISA did not report to decision-makers at the highest level but, rather, to RandstadRail safety management staff, whose activities it had been engaged to assess. Given the latter consideration, the Dutch Safety Board would have expected the ISA to report to decision-makers at the highest level.

In the course of 2006, the PMT decided in consultation with the ISA and IVW that verification and validation would not have to be documented in the safety cases prior to the start of RandstadRail operations. As a consequence, the ISA had to base its opinion on safety on other sources, such as assessment, status of remaining points, observations and provisional safety cases. These provisional safety cases likewise lacked verification and validation results as well as other essential information.

In August, September and October 2006, three interviews were conducted by the ISA with representatives of the municipality of The Hague (PoRR) for the purpose of reviewing the verification and validation activities for railways and switches. These activities were recorded in the *Overzicht verificatie, validatie en vrijgave memorandum*.<sup>271</sup> The memorandum listed numerous remaining points, such as the absence of an HTM clearance profile survey report and railway geometry approval. The Dutch Safety Board is of the opinion that the other evidence available at that time, such as the status of the railways and switches safety cases, which lacked essential information, constituted insufficient grounds for a statement of no objection. It is of course possible that the ISA was persuaded during the discussions with the parties involved.

The *Restpunten ISA verklaring indienststelling Lijn 4 memorandum* explained why the ISA had no objection to the start of operations and specified what still had to be done.<sup>272</sup> The document contained numerous remaining points, some which were relevant to safety in the sense that, in the opinion of the ISA, they had to be resolved prior to the launch of operations. The Dutch Safety Board takes the view that, in such cases, one is dealing not with 'remaining points'<sup>273</sup> but with 'blocking findings'.<sup>274</sup> The Dutch Safety Board would therefore have expected the ISA to have withheld a statement of no objection until it had made certain that the points in question had been

<sup>269</sup> ISA Phase II RandstadRail Assessment Report, January 2006, definitive status.

<sup>270</sup> Phase in which modification, testing and trial operation were planned (3 June-3 September 2006).

<sup>271</sup> The document applies to the area of Monstersstraat via the tram tunnel, tram platform and Beatrixlaan to The Hague Laan van NOI, The Hague Central Station to Javalaan (connecting with Oosterheem Line and Hofplein Line), excluding the Krakeling.

<sup>272</sup> Version of 27 October 2006.

<sup>273</sup> A finding concerning something that is not yet complete but that does not constitute a major risk, for example the absence of a signature on a document that has already been approved.

<sup>274</sup> Findings that constitute a major safety risk that must first be resolved before operations may proceed.

resolved. A number of excerpts from the memorandum referred to are provided below to provide examples of matters that the Dutch Safety Board believes should not have been classified as remaining points:<sup>275</sup>

#### Train safety

Train safety was tested in the usual manner. There is a document sets out preconditions for the execution of the trial operation and that will remain valid until further notice. The [railways] safety case has not been inspected yet. This is according to plan but attestation with possible restrictions that the installation is sufficiently safe for passenger transport is expected from the ISA and the RAMS<sup>276</sup> manager of RandstadRail section I. This attestation has not been received yet. The ISA's statement is based on verbal information provided by the SAT<sup>277</sup> testers and on the ISA's own observations during SATs and safety tests.

The visibility of signals is not good. An observation has been written on this matter. Requirement: the visibility of the signals at Oosterheem, Javalaan and Willem Dreeslaan stations is so poor that action must be taken as soon as possible. The applicable procedural measures must be adhered to. The visibility of all other signals and signs must be checked.

The temporary safety installations at Seghwaert and Centrum West must receive integral safety certification before being put into operation.

The functioning but crossed out signals on the Beatrix Viaduct must be covered prior to the start of operations.

#### Rolling stock

Rapid braking capability via TDK1 information in the case of an incorrect switch position was not implemented in the low-floor vehicles. No clear answer about the risks involved in passing a switch in an incorrect position is as yet available and, in the opinion of the ISA, the probability of this occurring is too high.

#### Remaining points:

The ISA believes that the information provided by the infrastructure for the safety of switches 815 and 860 must also be used in low-floor vehicles for rapid braking or an emergency report. Ready before the end of December 2006.'

### 6.3.5 Refinement and tightening of safety policy

Safety policy must undergo continuous refinement and tightening through proactive action (periodic and whenever a change is made to the basic assumptions) in the form of, among other things, inspections and audits and reactive action (in response to incidents and accidents).

The Haaglanden Urban District did not sufficiently incorporate the changes that were continuously occurring during the project into its safety policy (see section 7.2 for a further consideration of these changes). The derailment on the switch near Forepark demonstrates that a change (the modification of the Zoetermeer City Line) can lead to risks (switches damaged by construction vehicles).

As the derailments on the openable switches near The Hague Central Station make clear, it is also important for other parties involved, such as railway undertaking and manager HTM, to continuously refine and tighten safety policy. In both cases, further derailments occurred before the cause became known (rail wear) or HTM took adequate measures (openable switches). The safety management of HTM and the municipality of The Hague was described in the previous sections.

### 6.3.6 Management control, involvement and communication

Safety must ultimately be discussed at the highest level so that administrative decision-makers can strike an explicit balance between safety and other factors (cost control, time pressure etc). The joint project bodies of the Haaglanden Urban District and Rotterdam City Region did not function in this way on administrative (steering group) and management (joint management board) levels.<sup>278</sup> In internal terms, Haaglanden Urban District management must ensure clear and realistic expectations with respect to levels of safety aspired to and a climate of continuous improvement. In external terms, the working method and assessment procedure on the basis of unequivocal agreements

<sup>275</sup> Version 0.2 of 19 October 2006.

<sup>276</sup> RAMS stands for Reliability, Availability, Maintainability and Safety.

<sup>277</sup> SAT stands for Site Acceptance Test.

<sup>278</sup> See section 7.4 on organisational structure.

must be clearly communicated. This also applies to expectations at the highest administrative level of the Haaglanden Urban District.

The RandstadRail safety plans were unable to function sufficiently as controlling instruments for the management conducted by the parties involved. As already stated in section 6.3.4, the responsibilities and powers of management staff and administrative decision-makers were not defined. The safety plans also did not specify decision moments at which safety was to be assessed and a clear and properly substantiated go/no-go decision made with respect to the subsequent phase. The lifecycle comprises 14 steps.<sup>279</sup> Steps 1 to 6 are referred to as the design phase, which is followed by Steps 7 to 10 of the realisation phase and, finally, the operational phase. No controlling mechanism in the form of decision moments at the transition points of the 14 steps or between the three phases (design, realisation, operation) was put in place. The Dutch Safety Board would have expected the administrative decision-makers of the Haaglanden Urban District to use these steps to define decision moments as part of the internal supervision they exercised on RandstadRail safety policy.

A decision moment had been specified for the transition from the realisation to operational phase, namely the decision to approve RandstadRail infrastructure for operations. In accordance with the Normative Document, the first step of this decision moment involved acceptance of the system's safety by the principal, in this case the Haaglanden Urban District, and the subsequent transfer of responsibility for the system to the principal for the operational phase by means of an internal approval process. Of note with respect to this decision moment is that the Haaglanden Urban District did not formulate its responsibility for the decision in concrete terms within its own organisation: its own role in and criteria used for system acceptance are not specified in the ISP. The decision was placed with the ISA and IVW, the supervisor. In this connection, the ISA opted to conduct three interviews with project managers due to a lack of transparency and documentation on activities.

#### **Responsibility placed with IVW**

'They [the safety managers] shall submit the safety cases, including the assessment of the ISA, and OSP to the supervisor and ask the supervisor to grant an operating permit. RandstadRail operations may commence, possibly subject to restrictions, if the permit providers grant the required permits on the basis of the documents submitted.'<sup>280</sup>

In their capacity as principals, the respective administrations of the Haaglanden Urban District and Rotterdam City Region are responsible for RandstadRail safety. Following the completion of RandstadRail infrastructure, the principal had to determine whether it could accept it in terms of safety and approve its use for operations. A precondition in this respect was a sufficient guarantee of RandstadRail safety. Given this responsibility, the Dutch Safety Board would therefore have expected the launch of operations to be based on an explicit administrative decision that was itself substantiated by criteria and safety documentation. The documents received by the Dutch Safety Board, however, show no evidence of such an administrative decision having been explicitly made or substantiated.

Interviews conducted with and reports of the administrative and official consultative bodies reveal that the Haaglanden Urban District's decision to approve RandstadRail infrastructure for operations was made during a daily meeting at official level between representatives of the Haaglanden Urban District, Rotterdam City Region, municipality of The Hague, HTM, RET and other parties involved. In addition, the earlier issue of a statement of no objection and granting of authorisation to commence operations in the RandstadRail's outer area by, respectively, the ISA and IVW also played a role.<sup>281, 282, 283</sup> The ISA's statement included a list of remaining points of relevance to safety that had to be resolved before RandstadRail services could begin. The ISA did not see this as a reason, however, to withhold a statement of no objection.

It must furthermore be noted that the assessments of the ISA and IVW had a particular scope, namely the process adhered to (ISA) and the part of RandstadRail designated as secondary railway (IVW). In addition, the ISA and IVW were external parties who formed their opinions on the basis of a selection of information. The parties that should have maintained the keenest oversight on RandstadRail safety as a whole were the Haaglanden Urban District and Rotterdam City Region.

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<sup>279</sup> RandstadRail Integral Safety Plan, version 4.1, definitive from 18 May 2006, p. 12.

<sup>280</sup> Ibid. p. 18.

<sup>281</sup> ISA statement concerning the commencement of Hofplein Line shuttle services, 8 September 2006.

<sup>282</sup> ISA statement concerning the commencement of line 4 Monstersestraat-Javalaan services, 27 October 2006.

<sup>283</sup> ISA statement concerning the commencement of Nootdorp-The Hague Central Station (lower section) services, 10 November 2006.





## 7 ANALYSIS OF RANDSTADRAIL CONTEXT

The previous chapter provided an analysis of RandstadRail management which focused on the derailments. That chapter answered the question as to why the safety management conducted failed to prevent the derailments. In addition, the ways in which the parties involved could have acted differently were set out for each derailment.

This chapter places the findings within their broader context. To enhance what can be learned from the derailments, the Dutch Safety Board sought explanations to the findings. Why did the parties involved in RandstadRail act as they did? Answering this question is important because future initiators of light rail projects may encounter similar circumstances that could influence the safety of their light rail system.

### 7.1 TIME PRESSURE DURING THE REALISATION OF RANDSTADRAIL

As explained in Chapter 2, RandstadRail was not an entirely new public transport system but, rather, was introduced alongside existing tram, bus and heavy rail public transport systems. It is a public transport system that uses parts of other systems that were already in existence, namely:

- the Zoetermeer City Line section;
- the Rotterdam Hofplein Line section;
- part of the city tram network in The Hague; and
- after 2009, part of the metro network in Rotterdam.

These existing sections could not simply accommodate the new HTM vehicles and modified RET vehicles: various parts had to be replaced or newly constructed (see section 2.2). Services on the existing Hofplein Line and Zoetermeer City Line were temporarily suspended. NS ceased operations on these two lines on 3 June 2006. Management responsibility of the previous infrastructure manager ended on 16 June 2006. In the intervening period, this infrastructure manager had to take various measures to disconnect the Zoetermeer City Line and Hofplein Line from the national railway infrastructure. After 16 June 2006, the municipality of The Hague could independently commence work on the Zoetermeer City Line and Hofplein Line, i.e. without the involvement of the previous infrastructure manager.

The intention was to use the 2006 summer holiday period to carry out the necessary conversion work. Transport services would resume in September. After all, around 140,000 passengers who used these lines on week days had to use replacement transport during the conversion period. Political pressure was therefore exerted, among others by the municipality of The Hague, to keep the suspension of regular services as short as possible:

'The Zoetermeer City Line and Hofplein Line must be modified to enable RandstadRail operations. This means that platforms must be lowered, railways must be connected, safety features must be modified and so on. To that end, a conversion period was and is taken into account. No rail traffic will be possible on these lines during the conversion period. Given the large number of passengers that use these lines, especially the Zoetermeer City Line, this suspension of rail traffic will entail considerable logistical consequences and, above all, inconvenience to customers. The original plan was therefore to have the conversion work carried out in the 2006 summer holiday period; in other words, in the six-week period during which passenger numbers are lower than usual. Completing the conversion work would be possible in that time. It has since come to our attention that the estimate of the time required for completion is increasing. It appears that NS will cease operations on 3 June instead of 1 July or thereabouts and there is talk of having to expect trial operation to start at the beginning of November(!) 2006, whereas testing had been scheduled for completion during the summer holiday period. It now appears that the conversion period will span six months rather than six weeks. The consequences for passengers will then be enormous and the probability that this will have a negative effect on customer numbers for the new railway undertaking, HTM, is high. The Municipal Executive's reply is that RandstadRail services between Oosterheem and The Hague Central Station and on the Hofplein Line between The Hague Central Station and Hofplein will begin on 3 September 2006. Services on the Zoetermeer City Line will be suspended from 3 June to 3 September 2006 and replacement transport provided. Agreements have been concluded with HTM and RET by virtue of which they will be responsible, as from 3 September 2006, for the Zoetermeer City Line and Hofplein Line, respectively.<sup>284</sup>

<sup>284</sup> Reply of the Municipal Executive to a written question of a councillor of The Hague, 6 December 2005 (summary from search of administrative documents at [www.denhaag.nl](http://www.denhaag.nl)).

This explains why the Haaglanden Urban District and municipality of The Hague made efforts to complete the RandstadRail project as quickly as possible, and why the administrative meetings focused mainly on planning.

Interviews conducted revealed that the administration of the Haaglanden Urban District deliberately increased pressure with respect to the completion of RandstadRail. It communicated the date on which RandstadRail operations would start to outside parties.<sup>285</sup> This had both internal and external consequences. The deadline communicated to external parties generated, consciously or otherwise, internal pressure to do everything possible to achieve that deadline. The deadline was seen by the implementing parties more as a hard requirement than a basic point of departure. That was also the aim of the Haaglanden Urban District's administration, which did not realise that this explicit deadline had ramifications for the conduct of safety management. The deadline contributed to the decision made at lower levels of the administration, for example, to not complete the working method that had been agreed in advance with respect to the safety cases prior to the launch of RandstadRail operations. The time allocated to testing and the trial operation was also influenced by the deadline. The Dutch Safety Board notes, for that matter, that it did not find any evidence to suggest that concrete safety issues were deliberately ignored because of the deadline, nor that there was a direct relationship between the deadline and the derailments. As described in the previous chapter, there were also other causes. The Dutch Safety Board does believe, however, that the pressure generated by the deadline indirectly reduced the probability of safety-related shortcomings being detected prior to the launch of RandstadRail operations.<sup>286</sup>

Proper and timely preparation is all the more critical when great importance is attached to the rapid completion of a project. Pressure on planning in the RandstadRail project was the result of a failure to prepare the activities required for realisation on time, among other things because certain essential parts of RandstadRail were only decided upon or became known at a comparatively late stage. The following section addresses this aspect more closely.

## 7.2 NATURE OF SYSTEM AND SIZE OF RANDSTADRAIL PROJECT

The analysis of RandstadRail safety management set out in Chapter 6 makes clear that the parties involved were insufficiently aware of the size of the RandstadRail project and its nature as a combined transport system. One explanation for this is that the nature and size of RandstadRail gradually changed. In itself this was not exceptional, as such change is characteristic of large-scale infrastructural projects.

With respect to the Zoetermeer City Line, the Haaglanden Urban District originally assumed that the train would simply be replaced by a new light rail vehicle with the characteristics of a tram. There was sufficient knowledge of and experience with trams within the municipality of The Hague. That the former Hoefflein Line would be connected to the Rotterdam metro network on one side and continue to The Hague on the other was a complex but not insurmountable challenge. After all, similar projects had been carried out in other locations. In Amsterdam, for instance, GVB metro line 51 shares a number of kilometres of railway with city tram 5 on its route to Amstelveen, for example. Successful combinations have also been implemented in Kassel, Karlsruhe and other cities in Germany.

RandstadRail realisation therefore did not at first appear to be such a major and complex undertaking to the parties involved: a number of new concrete and steel structures would have to be built or modified (Ternoot branch, new Ternoot stop, Beatrixlaan with a Netkous stop, Oosterheem Line), additional stops put in place and new underpasses constructed at a number of locations.

The existing Zoetermeer City Line and Hofplein Line remained under the management of the previous infrastructure manager until 3 June 2006, and it was only from that date onwards that the Haaglanden Urban District and municipality of The Hague had access to the lines in management terms. Before that time, all activities that the Haaglanden Urban District and municipality of The Hague wished to have carried out to or in the immediate vicinity of the existing railway infrastructure had to be arranged via the then infrastructure manager. The typical railway-related activities involved were limited: most of the railway could remain as it was when the infrastructure manager transferred responsibility to its successor and the laying of new railway sections in Zoetermeer-

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<sup>285</sup> The date of opening festivities, at which pop group Kane would also appear, was already known in advance.

<sup>286</sup> During the inspection procedure, HTM made a letter of 7 June 2006 available to the Dutch Safety Board which had been sent to the Haaglanden Urban District and in which HTM stated that it would apply the safety of passengers and personnel as the basic principle. The letter does not link any safety criteria to this basic principle. It does, however, specify a number of minimums such as safe stops, visibility-based travel at an adjusted speed of 70 km/h and local safety features at railway convergence points.

Oosterheem and Beatrixlaan was not unduly complex and could easily be carried out by an experienced railway contractor.

A number of key railway engineering issues arose after the municipality of The Hague began designing the infrastructure. Firstly, it emerged that there were significant differences between the respective wheel profiles of tram and metro vehicles. A solution had to be found for this issue. Either part of The Hague city tram network would have to be modified or the switches would have to be appropriately equipped.

In addition, the decision was made during the project to install a safety system throughout a large part of RandstadRail. Instead of simple installations at a few crucial locations, which is usual for tram networks and was also the case in The Hague, the combination of speed, frequency and two transport systems required a safety system that could be used by both RET and HTM.<sup>287</sup> It gradually became clear that, in addition to having one on the shared section, a safety system would also be required on the entire section to, respectively, Rotterdam and Zoetermeer.

It also became clear at a late stage that the Haaglanden Urban District and Rotterdam City Region would themselves have to arrange a new power supply for RandstadRail. The municipality of The Hague therefore had to have substations, switch stations and feed points built.

Because the Zoetermeer rails were found in the summer of 2005 – a year before conversion work started – to be in a worse state of repair than the Haaglanden Urban District had assumed on the basis of information provided by the previous infrastructure manager, the decision was made at that time to replace a 36-km stretch of the Zoetermeer City Line railway (45,000 sleepers, the required tonnes of ballast and construction vehicles), as a result of which, among other things, the newly placed and sometimes not entirely ready (safety) switches were subject to intensive use by heavy rolling stock. Due to this change, the conversion period was extended from 6 to 13 weeks. In addition, the municipality of The Hague indicated at that time that 'the last bit of planning margin had evaporated'.

All in all, due to the increase in intensity and scale of railway engineering aspects during the project, the RandstadRail undertaking gradually evolved from a 'concrete and steel project with some railway' into a 'railway project with some concrete and steel'.

### 7.3 EXPERIENCE IN HAAGLANDEN AND THE HAGUE WITH LIGHT RAIL

Due to its nature and size, realisation of the RandstadRail project was not easy for the Haaglanden Urban District. The District had previously completed new tram lines,<sup>288</sup> but it had never before completed such a challenging project. Neither was its organisation geared towards the realisation of large public transport projects.<sup>289</sup> It was therefore logical that the Haaglanden Urban District outsourced realisation of RandstadRail infrastructure to the municipality of The Hague, which was geared towards and had previously completed major projects (including a tram tunnel under Grote Marktstraat and the Nieuw Centrum urban development project).

The municipality of The Hague's experience in railway technology was also limited, however. Unlike Rotterdam, The Hague did not have a municipal service like RET, which already had years of experience in the completion of large-scale projects behind it.<sup>290</sup> HTM's experience in railway technology related mainly to transport with city trams and only to a limited degree to light rail.<sup>291</sup> The municipality of The Hague therefore set up a temporary RandstadRail Project Bureau (PoRR), which hired in the necessary civil engineering (for the new Beatrixkwartier viaduct and other viaducts and tunnels) and railway engineering expertise. HTM was among the parties involved in the work.

At the time, practical experience with light rail systems was limited in the Netherlands. Only on the RijnGouwe Line had a pilot involving the operation of light rail vehicles on existing railway been running since 2002. During preparations for RandstadRail, the Haaglanden Urban District and HTM went on working visits to Kassel in Germany, where low-floor trams of a type similar to Randstad-

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<sup>287</sup> Until the arrival of RandstadRail, railway vehicles in The Hague were operated on the basis of visibility, with the exception of the Grote Marktstraat tram tunnel and The Hague Central Station tram platform.

<sup>288</sup> Tram lines were extended to Ypenburg (line 15) and Wateringseveld (lines 16 and 17). A tram line from Delft to Leidschenveen (line 19) is being designed and developed.

<sup>289</sup> The Haaglanden Urban District employs 111 FTEs, of which 37 FTEs are engaged in Traffic and Transport and 11 of those in Public Transport.

<sup>290</sup> RET was made an independent public limited company on 1 January 2007.

<sup>291</sup> HTM was involved in the operation of light rail vehicles on existing NS railway of the RijnGouwe Line (supply of vehicles).

Rail vehicles had been in operation since the beginning of 2006 (approximately half a year before the start of RandstadRail vehicles). These trams were only used on lines in outer areas until the autumn of 2007.

#### 7.4 ORGANISATIONAL STRUCTURE

The RandstadRail project was characterised by the involvement of several parties, some of whom fulfilled multiple roles. The key parties involved were described in Chapter 4.

The Haaglanden Urban District and Rotterdam City Region were joint principals of RandstadRail. They were also jointly accountable for the project as a whole to the Minister of Transport, Public Works and Water Management. Both parties were responsible for the completion of parts necessary to RandstadRail within their respective jurisdictions. Compromises that had implications for RandstadRail realisation were also necessary, however. The decision was made, for example, to operate both low-floor HTM trams and high-floor RET metro vehicles on the RandstadRail network. Among other things, the simultaneous operation of high and low-floor vehicles determined the design of the stops. The vehicles also had different wheel sizes, which determined the type of switch that could be used on shared sections of the network.

As explained in section 4.3, the Haaglanden Urban District and Rotterdam City Region set up a joint project bureau for RandstadRail. This comprised a steering group (administrative level), a joint management board (highest administrative level) and a Project Management Team (PMT, implementation level).<sup>292</sup> In addition, the Haaglanden Urban District and Rotterdam City Region each had their own organisations. The emphasis in the project bureau was on implementation level (PMT). Key joint activities at this level were prepared and discussed by the PMT. Issues that had to be discussed at administrative level were addressed separately in the Haaglanden Urban District and Rotterdam City Region rather than in the joint project bodies. The steering group and joint management board ceased to function as such after the start of project realisation.

The Haaglanden Urban District and Rotterdam City Region concluded working agreements with each other about the joint aspects each of them would attend to on behalf of the other. The intention was to simplify the organisational structure. In practice, however, complex situations arose. The RandstadRail Project Bureau of the municipality of The Hague, for example, was responsible for selecting switches that could be used by both HTM trams and RET metros. RET focused on the traction feed because it had years of experience with 750 V systems.

The Haaglanden Urban District also had to ensure that agreement was reached between the various municipalities covered by the RandstadRail network: The Hague, Leidschendam-Voorburg, Zoetermeer and Pijnacker-Nootdorp. Issues discussed between the municipalities involved included planning, vehicle selection and the realisation of tunnels and viaducts.

Unlike the situation in the Rotterdam City Region, where all matters concerning implementation were ultimately handled by a single party, RET, realisation of RandstadRail infrastructure in the Haaglanden Urban District was outsourced to the municipality of The Hague while HTM was placed in charge of other implementation activities. New vehicles had to be purchased, for example, though by who was initially unclear because a railway undertaking had not yet been chosen, and HTM had to make The Hague city tram network under its management suitable for use by the new RandstadRail vehicles. The Haaglanden Urban District retained responsibility for RandstadRail safety and the safety manager appointed by it worked under its auspices. A safety manager had also been appointed for the Rotterdam part of the project on the instructions of both the Rotterdam City Region and RET. Unlike the situation in the Haaglanden Urban District, however, this safety manager was deliberately made part of RET's project bureau.

The Haaglanden Urban District was therefore responsible for guiding the activities of the municipality of The Hague and HTM in an integral way and, within this context, devoting particular attention to the interaction between RandstadRail's constituent systems. A change to a RandstadRail vehicle could, after all, have safety-related implications for the infrastructure and vice versa. A key role in this respect concerned management of the integral Schedule of Requirements and safety management, duties that were therefore explicitly carried out by the Haaglanden Urban District (see section 6.3 for an assessment of the way in which the Haaglanden Urban District performed these

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<sup>292</sup> The responsibility of the Haaglanden Urban District for the integral safety of RandstadRail was not translated into the duties of the steering group as determined at the inception of the RandstadRail project. These duties all focused on progress (products), planning and financial issues. No reference is made to safety in general and railway safety in particular. The same applies to the duties of the administrative-level bodies, the joint management board and PMT.

duties). An additional complication for the Haaglanden Urban District in this connection was that HTM had several roles in the RandstadRail project. These roles meant that HTM was at times a formal other party (for instance as a railway undertaking, albeit at a late stage) and, at others, an advisor or a party involved in an informal capacity. The aim of the municipal councillor involved in basing the RandstadRail Project Bureau of the municipality of The Hague in the same building as that which accommodated HTM's head office was to foster informal contacts between the two. In addition, an informal working agreement had been concluded between safety management staff of the Haaglanden Urban District and HTM concerning assessment of the city tram infrastructure's safety (see the box below). HTM's range of formal and informal roles resulted in a lack of clarity and in implicit assumptions with regard to ensuring safety.

#### **HTM's role concerning the city tram infrastructure**

Illustrative of the Haaglanden Urban District's position relative to HTM is the previous history of the derailments that occurred on the city tram infrastructure. As future manager of a part of RandstadRail infrastructure, HTM was responsible vis-à-vis the Haaglanden Urban District and municipality of The Hague for the information that it provided or did not provide to them concerning RandstadRail. In practice, HTM independently made a number of decisions in relation to the city tram infrastructure based on the idea that it was in those cases the party primarily responsible for ensuring the proper course of affairs. HTM estimated a number of risks incorrectly and this was one of the reasons that it failed to adequately inform the Haaglanden Urban District and municipality of The Hague in a number of cases.

HTM made a number of decisions on its own concerning Ternoot without adequately informing the Haaglanden Urban District and municipality of The Hague about the background to the situation there.<sup>293</sup> HTM did not check the actual layout of the railway but worked on the basis of the design drawings. The rails were also worn, a factor that had not been expected. HTM did not realise that the consequences arising from deviations as set out in a report by the vehicle manufacturer actually constituted safety risks, and the measures that HTM took on its own initiative were unrealistic.

In addition, HTM did not recognise the modifications that were made to the city trams as risks. These modifications led to an accelerated rate of wear and roughening of the rails. HTM did not correctly estimate the risk of derailment with regard to the accidents on the switches. It was assumed that the drivers were sufficiently trained and the actual situation at openable switches, where additional marking points which could be used by drivers for purposes of orientation were required, was insufficiently taken into account.

It is worth comparing RandstadRail with other, recent light rail projects of local authorities, for example the RijnGouwe Line. This is a projected light rail connection between Gouda-Leiden-Oegstgeest and the coast at Katwijk and Noordwijk. Pilot operations have started on the Gouda-Alphen aan den Rijn section to build up experience with this new transport system. The other sections are in the design and realisation phases. With regard to pilot operations, the RijnGouwe Line is simpler than RandstadRail as a system and in terms of organisation.<sup>294</sup> There is only one principal (the Province of South Holland) instead of RandstadRail's two (Haaglanden Urban District and Rotterdam City Region). In addition, only one public transport system already in existence is being used (the existing Alphen aan den Rijn-Gouda line) while all other sections are being newly constructed (RandstadRail uses two public transport systems that were already in existence). Responsibility for the management of that public transport system was and remains with one infrastructure manager. In the case of RandstadRail, this responsibility was transferred from one manager (the then manager of the Zoetermeer City Line and Hofplein Line) via another (the municipality of The Hague) via two others (the Haaglanden Urban District and Rotterdam City Region) to two managers (HTM and RET) that manage this infrastructure in combination with the other secondary/regional railway network in both regions in an integrated way. In addition, the RijnGouwe Line is operated by one railway undertaking (NS Reizigers<sup>295</sup>), whereas RandstadRail is operated by two (HTM en RET). It must furthermore be noted that the planners of the RijnGouwe Line deliberately opted for a phased approach. Pilot operations were launched on one section (Gouda-Alphen aan den Rijn) to gain ex-

<sup>293</sup> The opinions of the parties involved as to whether the Haaglanden Urban District was aware of the situation at Ternoot are divided. HTM refers in that connection to a meeting. The Haaglanden Urban District claims that it was not aware of the situation.

<sup>294</sup> The complexity of the RijnGouwe Line will increase when the pilot is expanded to include the Alphen aan den Rijn-Leiden section. The plan is to operate light rail and heavy rail services together and at a higher frequency than is currently the case. Light rail stops will then be passed by heavy rail vehicles that in normal operations travel at a maximum speed of 130 km/h. A separation between infrastructure management and traffic control will be effected for services in the city.

<sup>295</sup> The RijnGouwe Line does have a separate manager for the rolling stock, namely HTM. The transporters manage the rolling stock in the case of RandstadRail.

perience with the system. Operations on the other sections are expected to begin in 2010 (Gouda-Oegstgeest) and 2013 (to Katwijk and Noordwijk).



## 8 ANALYSIS OF LEGAL FRAMEWORK AND SUPERVISION OF RANDSTADRAIL

This chapter contains an analysis of the legal framework and external supervision of RandstadRail. The organisations that exercised supervision during the RandstadRail project are discussed. The chapter closes with an examination of the question as to how that supervision was exercised, both in terms of process and content. Following the RandstadRail derailments, the Netherlands Organisation for Applied Scientific Research (TNO) was commissioned by the Inspectorate for Transport and Water Management (IVW) to investigate IVW's conduct with regard to its granting of authorisation to commence RandstadRail operations.<sup>296</sup> Where relevant, this chapter refers to the findings and conclusions of that investigation.

### 8.1 LEGISLATION AND REGULATIONS

Applicable railway legislation is not tailored to light rail projects such as RandstadRail in which different parties are involved for construction, management and operational purposes.<sup>297</sup> The 1875 Railways Act and Secondary and Tram Railways Act, for example, are based on the assumption that construction, management and operation are all in the hands of a single railway entrepreneur. It is not always clear, therefore, at which party the provisions of these two Acts are directed. Only the Primary and Secondary Railways Service Regulations (RDHL) were specially amended for RandstadRail in that regard.

The Normative Document for Light Rail Safety developed by the Minister of Transport, Public Works and Water Management has no foundation in law. The intention had been to make adherence to the Normative Document one of the conditions for the provision of funds to the RandstadRail project. This did not happen. The Haaglanden Urban District and Rotterdam City Region voluntarily opted to apply the Normative Document to the design and construction of RandstadRail and informed IVW of this intention in writing. It was therefore possible for the Haaglanden Urban District and Rotterdam City Region to decide that the safety cases, which had to prove that RandstadRail was sufficiently safe prior to the launch of operations, did not have to be complete before the start of services.

Because the Normative Document has no legal status, the role it should play in the decision to grant authorisation to commence operations was unclear to IVW. IVW approved the ISP and OSP without there having been a legal foundation to do so, for example. In addition, IVW allowed operations to go ahead before the safety cases were completed.

Since railway legislation only applied to a part of RandstadRail, supervision was poorly regulated. The authorisation to commence operations granted by IVW only applied to the sections subject to railway legislation. IVW (or another supervisor<sup>298</sup>) was therefore unable to exercise supervision on RandstadRail sections within The Hague city tram network. As a result, the external supervisor of RandstadRail could not assess the safety of the system as a whole.

### 8.2 SUPERVISION AND INDIVIDUAL RESPONSIBILITY

The new Railways Act came into force on 1 January 2005. It does not, however, apply to light rail systems. The Normative Document for Light Rail Safety prepared under the responsibility of the Minister of Transport, Public Works and Water Management primarily emphasises the individual responsibility of the local public transport authorities. The Normative Document sets out guidelines concerning the safety management process. The Dutch Safety Board subscribes to the importance of individual responsibility. This means that the legislature must confine itself to steering the process that ensures the safety of an organisation's activities. The supervisor must then exercise supervision (possibly on the basis of technical requirements) as an independent third party to ensure that the organisations involved, in this case the Haaglanden Urban District and Rotterdam City Region, structure and actually complete the process in accordance with this legislation. The mat-

<sup>296</sup> TNO, *Onderzoek naar de handelswijze van Inspectie VenW inzake RandstadRail*, Delft, April 2007.

<sup>297</sup> Ministry of Transport, Public Works and Water Management, *Nota Veiligheid op de rails*, November 2004 (point 4.7) and *Overzicht onderzoeken Onderzoeksraad voor Veiligheid 1996-2006*, 29 June 2007, p. 24.

<sup>298</sup> As described in section 3.1.3, the city tram network part of RandstadRail was not supervised at all, because legislation and regulations did not provide for such supervision. In theory, IVW could exercise such supervision if the legislation and regulations were appropriately amended. Alternatively, the municipality of The Hague could act as supervisor of The Hague city tram network. As stated in section 3.1.3, the Municipalities Act grants municipalities the power to establish regulations for city trams and monitor compliance with them by means of a byelaw.

ter concerns an objective and substantiated opinion about the safety policy, safety management system and preventative measures themselves. The supervisor must ascertain whether the system functions as a means to ensure the safety of activities.

The Transportation Safety Board (predecessor of the Dutch Safety Board) already made recommendations in this regard to the Minister of Transport, Public Works and Water Management and the regions involved in a report on safety risks in Dutch city tram systems published in 2000:<sup>299</sup>

It is recommended that the Minister of Transport, Public Works and Water Management make safety management systems mandatory at tram companies by means of formal regulations.

In response to this recommendation, the Minister of Transport, Public Works and Water Management stated that the Transportation Safety Board's recommendations would be reviewed during the formulation of a new Order in Council which would be prepared for the railway network being addressed at that time. This Order in Council has not as yet been prepared.<sup>300</sup>

It is recommended that the municipal councils of the Amsterdam (Amsterdam, Amstelveen), The Hague (The Hague, Voorburg, Rijswijk, Leidschendam, Delft), Rotterdam and Utrecht (Utrecht, Nieuwegein and IJsselstein) regions introduce a safety management system for tram companies in the near future and in advance of formal regulations.

In response to the same report, the Haaglanden Urban District announced that, in advance of formal regulations introduced by the Ministry of Transport, Public Works and Water Management, it would set up a safety management system together with railway undertakings in its jurisdiction and work towards making this system operational by the end of 2001.<sup>301</sup> This target was not achieved: the Haaglanden Urban District eventually obliged HTM to have a safety management system in place with the arrival of RandstadRail at the end of 2006. HTM informed the Dutch Safety Board that its safety management system became operational at the beginning of 2008.

The Transportation Safety Board directed recommendations at public transport companies in its De 'vrije' trambaan report of 2003:<sup>302</sup>

It is recommended that public transport companies adopt a proactive stance with regard to the external safety of trams. In connection with risks to personnel and passengers, risks to third parties must be:

- made explicit and public
- reduced to as low a level as reasonably possible
- monitored by means of a safety management system

In their joint response, the Haaglanden Urban District, participating municipalities and HTM agreed with this recommendation.<sup>303</sup> They stated that they did not view the matter as one concerning only HTM and they therefore intended to set up a public transport safety committee in consultation with IVW. The response did not address the safety management system for public transport companies.

In 2007<sup>304</sup> and 2008<sup>305</sup> the Minister of Transport, Public Works and Water Management informed the Lower House that a new Secondary and Special Railways Act/Decree was being prepared. According to the ministry, agreement about the content and Order in Council would be reached in the middle of 2008. The Order in Council and the necessary amendment of the Railways Act with respect to secondary and special railways would then be completed in 2009. The new regulations will also set out a safety management system.

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<sup>299</sup> Transportation Safety Board, Veiligheidsrisico's van de Nederlandse stadstram. The Hague, August 2000.

<sup>300</sup> Letter of the Minister of Transport, Public Works and Water Management to the Lower House concerning the status of railway investigations of the Transportation Safety Board, 14 August 2001.

<sup>301</sup> Letter from the Executive Committee of the Haaglanden Urban District and Municipal Executive of The Hague to the Minister of Transport, Public Works and Water Management, 20 February 2001.

<sup>302</sup> Transportation Safety Board, De 'vrije trambaan'. The Hague, September 2003.

<sup>303</sup> Letter from the Executive Committee of the Haaglanden Urban District to the Minister of Transport, Public Works and Water Management, 6 October 2004.

<sup>304</sup> 2006-2007 Parliamentary Papers, 30800 XII, No. 79, letter from the Minister of Transport, Public Works and Water Management accompanying the presentation of the Overzicht onderzoeken Raad voor Transportveiligheid/Ongevallenraad 1996-2006, 29 June 2007.

<sup>305</sup> 2007-2008 Parliamentary Papers, 29893, No. 67, letter from the Minister of Transport, Public Works and Water Management to the Lower House concerning the safety of rail transport, 25 February 2008.

### 8.3 FRAMEWORK

Railway legislation and supervision of it was undergoing change during the RandstadRail project. Government supervision, for example, was exercised in turn by the National Traffic Inspectorate (RVI), Railned B.V. on behalf of IVW, and then by IVW itself.

Based on the 1875 Railways Act, the Minister of Transport, Public Works and Water Management designated the following RandstadRail sections as 'secondary railway': The Hague Central Station-Zoetermeer and the Leidschendam-Rotterdam branch.<sup>306</sup> IVW was charged with exercising supervision on those parts of RandstadRail and grant authorisation to commence operations for them on behalf of the Minister of Transport, Public Works and Water Management. IVW was therefore not authorised to exercise supervision and approve the start of operations on RandstadRail's city tram sections.

The municipality of The Hague did not exercise its power under the Municipalities Act to establish regulations for city trams by means of a byelaw. No supervisor was therefore appointed. The Dutch Safety Board noted the lack of a specific legal framework for city trams as early as in 2000<sup>307</sup> and 2003<sup>308</sup> and alerted the Ministry of Transport, Public Works and Water Management to the matter in a recommendation. No follow-up action has as yet been taken on the recommendation (see also section 8.2).<sup>309</sup>

In forming an opinion as to whether RandstadRail was sufficiently safe to allow for operations, IVW had in any case to determine whether the legal stipulations set out in the Primary and Secondary Railways Service Regulations had been complied with.<sup>310</sup>

Prior to granting authorisation to commence operations on behalf of the Minister of Transport, Public Works and Water Management, IVW had to 'inspect the railway and associated structures'.<sup>311</sup>

In the case of RandstadRail, IVW also had a duty to form an opinion about 'what in its view should be done to ensure railway maintenance and the proper provision of services'.<sup>312</sup>

IVW is authorised to suspend services if they endanger public safety.<sup>313</sup> Once services have been suspended in this way, they may only be resumed with the permission of the Minister of Transport, Public Works and Water Management.<sup>314</sup>

The funding decision of the Minister of Transport, Public Works and Water Management stated that the design of the infrastructure had to be submitted to and checked by IVW's Railways Supervisory Division in terms of safety prior to construction.<sup>315</sup> When asked, IVW indicated that no independent meaning should be attributed to this statement, as it is simply a reference to the Railways Act with a view to granting authorisation to commence railway operations.

### 8.4 SUPERVISORS AND RANDSTADRAIL

Organisational changes occurred at the supervisor during realisation of the RandstadRail project. Railned B.V. was involved in the project from the beginning but in changing roles. Railned was originally hired by the Haaglanden Urban District as an advisor. Later on, from 1 July 2002, Railned also exercised supervision on behalf of IVW within the context of railway legislation. In a reply to a request for clarification about its role, IVW indicated in a letter of 1 September 2003 to the safety managers of the Haaglanden Urban District and Rotterdam City Region that its role *'is confined to*

<sup>306</sup> Designation of RandstadRail as secondary railway, Government Gazette, 30 May 2006, No. 103, p. 13.

<sup>307</sup> Transportation Safety Board (predecessor of the Dutch Safety Board), Veiligheidsrisico's van de Nederlandse Stadstram, The Hague, August 2000.

<sup>308</sup> Transportation Safety Board, De 'vrije trambaan': Veiligheidsstudie tramongevallen (botsveiligheid, infrastructuur en de bestuurlijke factoren), The Hague, September 2003.

<sup>309</sup> The Dutch Safety Board noted the intention of the Minister of Transport, Public Works and Water Management to modernise legislation and regulations for secondary railways (2007-2008 Parliamentary Papers, 29893, No. 67, letter from the minister to the Lower House concerning the safety of rail transport and 2006-2007 Parliamentary Papers, 30800 XII, No. 79, letter from the minister to the Lower House accompanying the presentation of the Overzicht onderzoeken Raad voor Transportveiligheid/Ongevallenraad 1996-2006).

<sup>310</sup> i.e., with respect to the parts of RandstadRail that had been designated as secondary railway.

<sup>311</sup> Railways Act, Section 7, paragraphs 1 and 2.

<sup>312</sup> Ibid. Section 13, paragraph 1.

<sup>313</sup> Ibid. Section 16, paragraph 1.

<sup>314</sup> Ibid. Section 20.

<sup>315</sup> Haaglanden Subproject Funding Decision of 11 December 2002.

*facilitating, checking, validating, providing a permit and ultimately also inspecting. This means that the advisory role is subordinate to the supervisory one.*' IVW did not provide a further description of the supervisory and advisory roles in its letter.

The parties involved indicated that they attached great importance to IVW's contributions during the design and building phase in the area of safety. It was more or less assumed that something approved by IVW was sufficiently safe. To ensure independent supervision and prevent a lack of clarity, it would in the opinion of the Dutch Safety Board have been better if IVW had ceased to play an advisory role – and had informed the parties involved accordingly – from the moment at which Randed started performing statutory supervisory duties on behalf of IVW.

## 8.5 SYSTEM-ORIENTED OR CONTENT-ORIENTED SUPERVISION

The way in which IVW arrived at its decision to grant authorisation to commence RandstadRail operations was investigated.

The report of that investigation, which TNO was commissioned by IVW to carry out, concludes the following:<sup>316</sup>

'The Inspectorate for Transport and Water Management (IVW) did not tighten the broad frameworks described in three documents (concerning supervisory principles for railways, a working method for the approval of systems and light rail safety (the Normative Document)) in the form of an internal quality system and/or project plan. IVW therefore did not take the opportunity to conclude hard agreements in writing both within its own organisation and with the parties involved and make its own operations transparent, unequivocal and reproducible. Such systems are broadly accepted internationally.'

Demonstrable records were not kept of the extent to which IVW only exercised supervision on the safety process or also checked railway engineering (content-oriented) aspects with respect to RandstadRail. The 1875 Railways Act seems to assume content-oriented supervision. During the period in which RandstadRail was being completed, the role of supervision was redefined in accordance with a broad societal wish to have a less intrusive form of government and, where possible, to have government supervision exercised as reticently as possible. A letter from the Ministry of Transport, Public Works and Water Management to the Lower House,<sup>317</sup> for example, stated among other things that supervision would be based on system or meta level.<sup>318</sup>

The Dutch Safety Board wonders, for example, about the extent to which IVW's opinion was primarily based on the safety plans and safety cases prepared by the Haaglanden Urban District and Rotterdam City Region, and about the requirements that IVW set in relation to those plans. What is clear is that the opinion of the ISA played an important part in the conclusion reached about safety. However, no requirements were set either by regulations or by IVW itself with respect to the ISA, which meant that no random checks were performed, for example, to show whether the requirements had been met. The Dutch Safety Board agrees with the conclusion of the TNO report concerning this point:<sup>319</sup>

'IVW does not have minimum requirements for the approval of the ISP, the realisation permit and the authorisation to commence operations, as a result of which it does not have an instrument to generate clarity and transparency for the parties involved.'

To the extent that IVW formed an opinion about the safety plans, the method and criteria it used to approve the ISP, which had weaknesses in certain sections, were not recorded. The plan described the duties involved, for example, but not the responsibilities and powers required to perform them. It did not, for instance, accord to safety managers the power to authorise parts of the system for use and, by implication, make an initial decision about their safety. It also did not specify the grounds on which such a decision was to be made. In addition, the ISP did not set out the way in which its implementation was to be ensured, and the decision to commence operations was placed with IVW.

The Dutch Safety Board did not find evidence that IVW conducted its own survey of risks in advance by means of a systematic risk inventory. IVW used the risks identified in the Rail Safety Policy Document to perform the risk analysis. These risks concern infrastructural defects, the passing

<sup>316</sup> TNO, Onderzoek naar de handelswijze van Inspectie VenW inzake RandstadRail, Delft, April 2007, p. 33.

<sup>317</sup> 2004-2005 Parliamentary Session, 29 515, No. 86.

<sup>318</sup> This means that supervision would focus on the working method or system of an organisation, rather than on the results or products of this working method.

<sup>319</sup> TNO, Onderzoek naar de handelswijze van Inspectie VenW inzake RandstadRail, Delft, April 2007, p. 33.

of a stop signal, rolling stock malfunctions, technical safety, accidents, incidents and near accidents and vandalism.

The switches, for example, were not identified as particularly risky because IVW believed they incorporated a proven technology.<sup>320</sup> However, there were grounds to conclude otherwise, at least with respect to RandstadRail, for the following reasons:

- The switch machines were relatively new to the Netherlands (had only been used by GVB before).
- The switches would be used by trams and metros with different wheel sizes, which meant that a railway engineering solution had to be found.
- There was no conformity statement for the switch and safety system (was issued in December 2006).
- There were problems with a similar switch in Amsterdam (problems other than those at Forepark). GVB had informed IVW about the problems.<sup>321</sup>

IVW did not establish how it would check RandstadRail safety in advance; whether it would form an independent content-related opinion or only look at the process.<sup>322</sup> In practice, the supervision exercised by IVW appears to have alternated between system-oriented and content-oriented forms. With regard to authorisation to commence operations, the 1875 Railways Act stipulates that a railway and its associated structures must have been inspected prior to the granting of such authorisation. IVW complied with this stipulation by means of – in its own words – a ‘classic inspection’; that is, assessing whether there were any visible risks.

To the extent that IVW exercised system-oriented supervision, it did so insufficiently. A number of safety cases, including the one concerning the switches, were not yet ready prior to the start of operations.<sup>323</sup> IVW trusted the opinion of the ISA in that regard. As described in section 6.3.6, the ISA statement included a list of remaining points, a few of which concerned blocking findings.<sup>324</sup> The ISA nevertheless issued a statement of no objection and IVW granted authorisation to commence RandstadRail operations.

The Dutch Safety Board’s investigation found no substantiation for IVW’s decision that there were sufficient guarantees in place and that therefore authorisation to commence operations could be granted.

## 8.6 THE MEASURES ANNOUNCED BY IVW

The follow-up action to the recommendations set out in the TNO report was formulated in a letter to the Lower House:<sup>325</sup>

‘The TNO recommendations are aimed to produce a learning effect: the improvement of the approach and working method applied by the Inspectorate in its authorisation of rail systems. The Inspectorate has since translated these recommendations into the approach adopted with respect to the resumption of RandstadRail services. The recommendations focus on transparent and clear communication and on instruments for supervision. The follow-up action to the TNO recommendations taken by the Inspectorate is detailed below.

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<sup>320</sup> Ibid. p. 28.

<sup>321</sup> GVB, Veiligheidsevaluatie verlenging Amstelveenlijn – overzicht van over het eerste half jaar van de exploitatie, Amsterdam, May 2005, p. 6 and p. 9.

<sup>322</sup> IVW has made further information available since this report was published for comments. This indicated that the parties involved could have deduced the applicable scope of IVW’s supervision from the authorisation to commence operations itself and a letter dated 24 October 2006, a few days prior to the launch of operations. The Dutch Safety Board does not view this information as having been sufficiently timely to inform the parties about the method of inspection.

<sup>323</sup> IVW was aware that the safety case was not yet complete. Following a careful consideration of all interests and consultation with the parties involved in the project, IVW nevertheless believed that there were sufficient grounds to authorise regular operations. In its response, IVW stated that there were a sufficient number of ISA statements, particularly with regard to the switches, to warrant an application for authorisation to commence operations. The Dutch Safety Board’s investigation revealed that this was not true both with regard to the switches themselves and the conformity statement concerning safe interaction between the switches and safety system (this statement was issued in December 2006).

<sup>324</sup> For example the absence of a statement that the train safety system was sufficient to warrant passenger transport, insufficiently visible signals and no rapid braking capability.

<sup>325</sup> 2006-2007 Parliamentary Papers, 23645, No. 160, Lower House, letter from the state secretary accompanying the presentation of IVW’s investigation report on the RandstadRail derailment at Forepark (Leidschendam), 30 May 2007.

### *RandstadRail*

Within the context of authorising the resumption of RandstadRail operations in due course, the TNO recommendations led to the formulation of criteria for approval by the Inspectorate of the transition from the testing phase to the trial operation. The Inspectorate is also preparing criteria for the subsequent phase, the transition from trial operation to regular services.

#### Transparent and clear communication

The following action was or will be taken in the short term:

- With regard to current system assessments, an overview of the remaining points, associated risks and further particulars of each project has been prepared. This overview is being made available to the organisations involved.
- The advisory role of the Inspectorate is being clarified and adjusted. Advice provided in the past included the formulation of safety requirements and procedures and an indication of system choices. This content is no longer appropriate to the Inspectorate's current role. The Inspectorate does, however, consider providing explanation about legal provisions, procedures and working methods to be part of its duty. This role and its implications for the various officials involved in the approval process will be described in the quality system which will itself be further refined and tightened.

In the medium term, the Inspectorate will refine and tighten the quality system to enhance the transparency, uniformity, verifiability and reproducibility of its working method.

#### Instruments for supervision

The following action will be taken in the short term:

- A greater number of specific inspections during the testing phase, trial operation and immediately after the start of a project's regular operations. Inspections to be carried out were selected on the basis of risk scenarios.
- The acquisition of greater insight into a project's specific risks by means of risk analysis.
- Having an exploratory investigation carried out into the quality assurance and scope of Independent Safety Assessors (ISAs). An ISA assesses in detail whether safety standards are met during the design and realisation phases and is appointed by the principal or principals. The opinion of the ISA is an important condition for the Inspectorate's authorisation of operations. The instruction to have this exploratory investigation carried out has been issued.
- The Inspectorate will conduct audits/interviews at current projects to determine the basis on which an ISA issues its statement. The applicable plan of action is ready.

The aim is to complete all medium-term action in the course of 2007. The aforementioned recommendations have been incorporated into the process designed to facilitate the resumption of RandstadRail operations. TNO indicates that, ideally, the Inspectorate should be accorded powers commensurate with its purpose (exercising integral supervision on the development of railway systems without a distinction between city tram and secondary railway). This aspect will be taken into account in the further development of the future regulatory framework for secondary railway (tram, metro, light rail).'



## 9 CONCLUSIONS

Several derailments occurred shortly after the start of RandstadRail operations. The direct causes of these derailments varied in nature. The Dutch Safety Board investigated why the safety management conducted by the parties involved in RandstadRail failed to prevent the derailments, and studied the factors that influenced that management. This definition of the problem was translated into the following investigative question:

*How was it possible that so many derailments occurred within such a short time after the start of RandstadRail operations?*

The answer to this investigative question starts with the organisation of RandstadRail (section 9.1) and then follows the phases which led to RandstadRail realisation in reverse chronological order:

- transport of passengers with RandstadRail (section 9.2);
- decision to approve RandstadRail passenger services (section 9.3);
- testing and trial operation (section 9.4);
- realisation of the RandstadRail project and internal supervision (section 9.5);
- legislation and regulations and external supervision (section 9.6).

Because all of the derailments occurred in the Haaglanden region, the investigation focused mainly on the parties involved in that area.

### 9.1 RESPONSIBILITY FOR SAFETY AT POLITICAL ADMINISTRATION LEVEL

#### **Conclusion 1:**

The parties involved did not include safety as a subject in its own right (alongside time and money) from the beginning, and did not embed it at a sufficiently high administrative level in steering the RandstadRail project.

#### *Explanation:*

- a. The traffic and transport portfolio holder within the Haaglanden Urban District was responsible for ensuring that RandstadRail could be used as a transport system on time. Responsibility for safety was not explicitly embedded at the level of political administration within the Haaglanden Urban District.
- b. Safety was a precondition for the RandstadRail project but hardly played a role in decision-making at the level of political administration. Great importance was attached at administrative level to launching RandstadRail operations quickly. The administration focused consistently on this aspect. The same did not apply to safety, however.
- c. The administration directed its efforts at obtaining a statement of no objection from the ISA and authorisation to commence operations from IVW without carrying out its own safety assessment. In practice, the ISA statement and IVW authorisation, together with the testing and trial operation, failed to function sufficiently as safety barriers (see relevant conclusions), something that went unnoticed at the administrative level.

### 9.2 TRANSPORT OF PASSENGERS WITH RANDSTADRAIL

#### **Conclusion 2:**

In its capacity as a railway undertaking, HTM was responsible for the safety of passengers and personnel after the start of operations but failed to exercise this responsibility to a sufficient degree.

#### *Explanation:*

- a. HTM did not have an independent opinion about the safety of RandstadRail infrastructure. HTM based its decision to launch services on its own information concerning the safety of, among other things, the new rolling stock, the transport process and management of the infrastructure. Regarding other aspects – principally the safety of the infrastructure – HTM relied on the opinion of the Haaglanden Urban District without verifying whether the Haaglanden Urban District could substantiate this opinion. The opinion of the Haaglanden Urban District was accompanied by verbal undertakings that a statement of no objection from the ISA and authorisation to commence operations from IVW would be issued. At the time that HTM decided to launch services, both documents, including an appendix listing remaining points, some of which were relevant to safety, were not in HTM's possession.
- b. The repetitive nature of the derailments on the city tram network indicates that HTM did not recognise the causes in time and was therefore unable to take the measures necessary

- c. to prevent future derailments.
- c. The concession for RandstadRail transport granted by the Haaglanden Urban District included the condition that the railway undertaking was obliged to have a safety management system in place. HTM did not have a safety management system in place at the start of operations and was therefore not in compliance with the requirements attached to the concession for RandstadRail transport by the Haaglanden Urban District in its capacity as a concession grantor. Although it was aware of the fact, the Haaglanden Urban District granted the concession to HTM nevertheless.
- d. In response to an earlier recommendation of the Transportation Safety Board (the predecessor of the Dutch Safety Board), the Haaglanden Urban District undertook to set up a safety management system together with railway undertakings in its jurisdiction and to work towards making this system operational by the end of 2001. In 2003 the Transportation Safety Board again recommended that risks to third parties together with those to passengers and personnel be controlled by means of a safety management system. In a joint response, the Haaglanden Urban District, participating municipalities and HTM indicated their agreement with this recommendation. No concrete action had as yet been taken in this respect at the time of the derailments.
- e. HTM did not form part of the RandstadRail Project Bureau (PoRR) of the municipality of The Hague, the organisation in charge of infrastructure realisation. HTM was consulted in its capacity as future railway undertaking and infrastructure manager, however. The municipality of The Hague (PoRR) could disregard the advice provided, which it did with respect to the choice of switch, for example.
- f. The RandstadRail project started in 2002. HTM's involvement became structural after April 2004. This was after the Haaglanden Urban District decided that it would grant the concession for RandstadRail transport and infrastructure management to HTM subject to approval from the Ministry of Transport, Public Works and Water Management. At that time, the specifications for RandstadRail had already been established and the municipality of The Hague (PoRR) had already reached an advanced stage in the design progress.

### 9.3 DECISION TO APPROVE RANDSTADRAIL PASSENGER SERVICES

#### **Conclusion 3:**

The Haaglanden Urban District was responsible for the decision that RandstadRail infrastructure was sufficiently safe for passenger services. This decision was made lower down the organisational hierarchy rather than at the highest administrative level. The decision-making process was not framed by safety criteria that had been set in advance. Substantiation for the decision was based on an incomplete safety file that was not shared with the railway undertaking before the infrastructure was approved for passenger services.

#### *Explanation:*

- a. The decision to approve RandstadRail infrastructure was made during a meeting between official representatives of the Haaglanden Urban District, the municipality of The Hague (PoRR) and HTM. This decision and its substantiation were not recorded in writing.
- b. The Haaglanden Urban District's administration did not formulate criteria that would have to be met prior to the approval of the infrastructure. The safety plans for RandstadRail stated only that this decision could be made after the ISA had issued a statement of no objection and IVW had granted authorisation to commence operations.

#### **Conclusion 4:**

The ISA was appointed by the Haaglanden Urban District to assess whether the safety of the RandstadRail transport system was sufficiently guaranteed. The ISA issued a statement of no objection with respect to the launch of RandstadRail operations while the system's safety had not been shown to be sufficiently guaranteed.

#### *Explanation:*

- a. On the instructions of the Haaglanden Urban District, the ISA assessed whether RandstadRail had been shown to be sufficiently safe and issued a statement of no objection. The ISA did not report to the highest administrative level but, rather, to the safety manager of the Haaglanden Urban District, who personally prepared part of the documentation evidencing safety (see also Conclusion 5 under f).
- b. The ISA attached a list of remaining points to the statement of no objection, some of which concerned blocking findings. The ISA nevertheless issued a statement of no objection for RandstadRail.
- c. The opinion of the ISA should have been based on, among other things, the safety file. This safety file was incomplete, however: it lacked the results of the testing and trial operation

as well as other essential information, especially concerning the infrastructure. The safety cases for railways – which also concerned the switches – and ground-level lines contained numerous blank chapters, for example. The ISA did not substantiate why there was nevertheless no objection to approving the infrastructure for operations.

- d. During the project, the ISA indicated in its interim reports that the parties involved were not devoting sufficient attention to safety assurance. These observations were not discussed by the Haaglanden Urban District's administration.
- e. The scope of an ISA's opinion is limited to the question as to whether the established safety requirements have been met. An ISA does not address whether those requirements actually result in a safe system.
- f. An ISA has no formal authority. In the Netherlands, an ISA's work is not subject to any requirements. An ISA is not accredited and the quality of its work is not checked. The only party that assesses an ISA's work and determines the assignment is the principal, which is also responsible for the object of the ISA's assessment.

#### 9.4 TESTING AND TRIAL OPERATION

##### **Conclusion 5:**

The RandstadRail Project Bureau (PoRR) of the municipality of The Hague was responsible for the testing and trial operation of the infrastructure, while HTM was responsible for the testing and trial operation of the transport process. The testing and trial operations carried out by these parties were insufficient, which meant that operations started while safety was not ensured.

##### *Explanation:*

- a. A relatively short period had been planned for RandstadRail testing and trial operation (including two weeks for trial operation, of which three days of uninterrupted trial runs based on the timetable), due to the desire to commence regular operations as soon as possible. Based on experience with other railway projects, this brief period was not realistic.
- b. The testing and trial operation were not based on a safety-related plan of action that set out objectives and safety criteria. Consequently, no safety case was drawn up to show that such criteria had been met.
- c. No safety case was prepared for the testing and trial operation.

#### 9.5 REALISATION OF THE RANDSTADRAIL PROJECT AND INTERNAL SUPERVISION

##### **Conclusion 6:**

The Haaglanden Urban District and municipality of The Hague (PoRR) were responsible for realisation of RandstadRail infrastructure. These parties did not ensure that the infrastructure was sufficiently safe before the start of passenger services and failed to properly exercise their responsibility in that respect.

##### *Explanation:*

- a. The intention to work on the basis of safety cases was not consistently adhered to and performed in full by the Haaglanden Urban District and municipality of The Hague (PoRR). Safety cases for the infrastructure were not completed prior to the start of regular operations, for example, and no safety case was prepared for the testing and trial operation. In addition, the internal supervision exercised by the Haaglanden Urban District on the implementation of safety policy was inadequate. The foregoing resulted in insufficient insight into the actual level of safety achieved.
- b. Adherence to an explicit deadline at the highest administrative level generated time-related pressure. This pressure of time was caused by the social importance of the RandstadRail project, in part because passenger services on the busy Zoetermeer City Line and Rotterdam Hofplein Line had to be suspended while RandstadRail conversion work was being carried out.
- c. The agreements concluded at administrative and management levels within the context of RandstadRail project organisation concerned monitoring progress in terms of time and money, not safety.
- d. Safety was neither a structural nor periodic agenda item in RandstadRail administrative meetings.
- e. No decision moments which the administration could use to determine the status of RandstadRail in terms of safety had been agreed.
- f. The administration placed responsibility for ensuring RandstadRail safety at official level with the safety managers it had appointed. These safety managers had to demonstrate that the infrastructure was safe rather than assess whether the project had ensured that

it was sufficiently safe. Responsibility for demonstrating that the infrastructure was safe should not have been placed with the safety managers but, rather, with the implementing organisation, and more specifically with the director of the RandstadRail Project Bureau of the municipality of The Hague.

- g. The ISA had to assess the infrastructure. This ISA reported to the safety managers, however, not to administrators at the highest level.
- h. The administration only established requirements in relation to the safety management of the future railway undertakings and managers. No requirements were set concerning the safety management of the RandstadRail Project Bureau, the organisation that designed and built the infrastructure.

## 9.6 LEGISLATION AND REGULATIONS AND EXTERNAL SUPERVISION

### **Conclusion 7:**

The Ministry of Transport, Public Works and Water Management left legislation and regulations in place that were not appropriate to the actual situation of projects like RandstadRail. In addition, the ministry did not keep to its own decision to make compliance with the Normative Document a binding condition of the funding provided.

#### *Explanation:*

- a. Prevailing legislation did not provide a suitable framework for the safety policy conducted by the parties involved in RandstadRail. Current railway legislation is not tailored to innovative light rail projects like RandstadRail, where different parties are involved in construction, management and transport. The 1875 Railways Act and Secondary and Tram Railways Act are still based on the assumption, for example, that construction, management and transport are in the hands of a single party, namely the railway entrepreneur.
- b. The Normative Document for Light Rail Safety specifies safety requirements for light rail systems like RandstadRail. The document states that the Ministry of Transport, Public Works and Water Management will make it binding for projects that receive funding from the national government. Nevertheless, the ministry did not make the Normative Document a binding part of the funding it made available to RandstadRail. The initiators, the Haaglanden Urban District and Rotterdam City Region, voluntarily opted to use it as the foundation of RandstadRail safety management, however.

### **Conclusion 8:**

IVW granted authorisation to commence operations on a system, namely RandstadRail, that was not safe.

#### *Explanation:*

- a. IVW granted authorisation to commence operations. With the exception of a reference to the ISA's statement of no objection, it did not substantiate the grounds on which this authorisation was granted, however. IVW did not explain why it agreed to incomplete safety cases, particularly with respect to the infrastructure.
- b. IVW omitted to establish a frame of reference for supervision. Use of the Normative Document for Light Rail Safety had not been made a binding part of the funding made available to RandstadRail by the Ministry of Transport, Public Works and Water Management. As a result, the parties involved were free to decide whether they would adhere to the Normative Document or not and the extent to which it should play a role in the supervision exercised by IVW remained unclear. Both regions nevertheless voluntarily opted to apply the Normative Document to RandstadRail and informed IVW of this intention in writing. IVW did not, however, incorporate the Normative Document into a frame of reference for supervision.
- c. IVW approved the RandstadRail Integral Safety Plan without having applied demonstrable assessment criteria, even though the plan did not clearly define safety-related duties, powers and responsibilities and did not specify decision moments.

## 10 LESSONS AND RECOMMENDATIONS

The present report, like previous ones of the Dutch Safety Board, illustrates the need for parties involved to be clear about their own safety-related responsibilities. The same applies to their expectations and obligations with respect to other parties. This must result in harmonised processes of internal and external control with which parties ensure the safety of their respective contributions to the end product both internally and with respect to each other. This does not mean that responsibilities should be divided: division can lead to lacunas, a lack of clarity and even a shirking of responsibility.

Due to the virtual absence of legislation and regulations appropriate to projects like RandstadRail, external government supervision cannot play a meaningful role as a safety net. Local authorities that act as principals for such projects must therefore fully appreciate that the buck well and truly stops with them and must accordingly exercise the internal supervision necessary to ensure the project's safety. The other parties involved, such as the railway undertaking, must likewise recognise this fact. In addition, the railway undertaking must remain aware of its special responsibility for the safety of passengers and personnel and must obtain the resources required to fulfil this responsibility.

In addition to making recommendations to the parties involved in RandstadRail, the Dutch Safety Board has opted to formulate a number of lessons relevant to parties involved in future projects.

These parties are, among others:

- railway undertakings (HTM, RET and future railway undertakings through their respective sectoral organisations Mobis, the sectoral association for the group and/or mass transit of passengers by road or rail, and FMN, the Federation of Dutch Transport Companies);
- initiators and (delegated) principals (Haaglanden Urban District, Rotterdam City Region, municipalities of The Hague and Rotterdam and, for future projects, the chairmen of other city regions and umbrella organisations, the Interprovincial Consultative Association IPO, the Association of Netherlands Municipalities VNG and SKVV, the collaborative arrangement for traffic and transport put in place by the authorities of seven city regions);
- the Ministry of Transport, Public Works and Water Management as policymaker, provider of funds and supervisor.

Pursuant to their responsibility for the safety of passengers and personnel, railway undertakings must among other things verify that safety is ensured both in their own organisations and in their relationships with suppliers of the transport systems they operate.

Initiators and (delegated) principals must ensure that:

- a. responsibility is explicitly embedded at the political level of administration;
- b. periodic reporting takes place at the political level of administration with respect to safety management and the functioning of safety nets like a testing and trial operation and the findings of an ISA and an internal and/or external supervisor.

Parties involved in future projects must:

- a. establish their individual responsibility for safety and the extent to which they are dependent on other parties in the network to fulfil this responsibility in advance;
- b. conclude clear agreements with these parties about their mutual expectations to enable each to fulfil its individual responsibility;
- c. adhere to these agreements for the duration of the project in order to ensure safety.

Due to the absence of formal legal powers for all parts of the project, the role played by external supervision as exercised by IVW – also taking into account the associated limitations – was unclear. To an important extent, safety in the RandstadRail project depended on internal supervision. This concerned the Haaglanden Urban District and ultimately the railway undertaking itself, HTM. That supervision was also unable to function as a safety net, mainly because factors other than safety, such as time pressure, were allowed to dominate.

The authorisation to commence operations granted by IVW generated confusion. The authorisation gave the other parties the impression that the project as a whole had been assessed and approved. In formal terms, it only applied to the parts within the scope of IVW's supervision, i.e. the parts outside The Hague. The criteria applied by IVW in its supervision were also not clear. The Ministry of Transport, Public Works and Water Management prepared the Normative Document for Light Rail Safety in 2002 to establish a set of basic principles for the safety of light rail systems. In the opinion of the Dutch Safety Board, the Normative Document constitutes a good foundation

for ensuring safety but it was not made binding and ultimately not used to a sufficient degree.

As the last link in the chain, the railway undertaking must carry out its own assessment of the safety barriers and adhere to the agreements concluded. A legal foundation will have to be provided for government supervision aimed at ensuring that this is the case.

### **Recommendations**

The recommendation to the Ministry of Transport, Public Works and Water Management is to:

- a. ensure that regional railway projects like RandstadRail are made subject to the Railways Act (augment Section 94);

Explanation: The matter primarily concerns linking legislation to the desired allocation of responsibilities and redefining the role of the Minister of Transport, Public Works and Water Management in that regard.

- b. introduce the Normative Document for Light Rail Safety as a legally binding instrument to ensure safety.

Explanation: The matter concerns establishing which sections relevant to ensuring safety in projects like RandstadRail must in any case be applied.

Administrative authorities to which a recommendation is addressed must state their position with regard to compliance with this recommendation to the relevant Minister within six months of the date of publication of this report. Non-administrative authorities or individuals to whom a recommendation is addressed must state their position with regard to compliance with the recommendation to the relevant Minister within one year. A copy of this response should be submitted simultaneously to the chairman of the Dutch Safety Board and the Minister of the Interior and Kingdom Relations.

Once the response period has elapsed, the responses to the report that have been received by the Dutch Safety Board will be published on its website at [www.onderzoeksraad.nl](http://www.onderzoeksraad.nl). If no responses have been received, this will be reported on the aforementioned website.



# APPENDICES TO THE REPORT DERAILMENTS AT RANDSTADRAIL

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## **A. JUSTIFICATION FOR THE INVESTIGATION**

### **Reason**

RandstadRail is a new public transport system and comprises a light rail connection between The Hague, Rotterdam and Zoetermeer.<sup>1</sup> The realisation of RandstadRail was a major project that involved the construction of new infrastructure, the modification of existing infrastructure, the purchase of railway vehicles and the setting up of a transport and management organisation.

Within a month of the start of RandstadRail passenger services, five derailments occurred in the Haaglanden region. After the derailment at the Forepark stop on 29 November 2006, in which 17 passengers were injured, the railway undertakings ceased operations and the Inspectorate for Transport and Water Management (IVW) formally suspended services on The Hague part of RandstadRail by withdrawing the required authorisation.<sup>2</sup> A further four derailments occurred after services were resumed on parts of the RandstadRail network. The suspension of operations lasted for almost a year; services were resumed on parts of the network at the beginning of 2007 and on all parts in October 2007.

The Dutch Safety Board carried out an investigation into the RandstadRail derailments. The following nine derailments were investigated:

1. on 29 November 2006, a RandstadRail vehicle belonging to RET derailed on a switch near the Forepark stop in Leidschenveen;
2. also on 29 November 2006, a RandstadRail vehicle belonging to HTM derailed in a curve near the Ternoort stop close to The Hague Central Station;
3. on 3 and 4 November 2006, a RandstadRail vehicle belonging to HTM derailed on the Muzen Viaduct close to The Hague Central Station;
4. on 24 November 2006, 24 and 26 January 2007, 25 May 2007 and 20 July 2007 RandstadRail vehicles belonging to HTM derailed on openable switches in the city tram network.

### **Purpose**

The purpose of the Dutch Safety Board's investigation was to identify lessons from the derailments in question for the benefit of future, similar projects. The investigation's exploratory phase revealed the project's technical, administrative and organisational complexity as well as the pressure it was under. Further investigation therefore focused on, among other things, the extent to which these circumstances played a role in the derailments.

### **Investigation questions**

The primary investigation was:

*How was it possible that so many derailments occurred within such a short time after the start of RandstadRail operations?*

The investigation's secondary questions were:

1. What actually happened during the RandstadRail derailments? How could the vehicles have gone off the rails and what were the underlying causes?
2. How was safety management structured, planned and conducted during the design, realisation and operational phases? Was there a connection between the safety management conducted and the derailments and, if so, what was the nature of this connection?
3. What factors influenced the safety management conducted in relation to RandstadRail?
4. How was external supervision concerning RandstadRail safety exercised by the Inspectorate for Transport and Water Management?

### **Scope and delineation**

The Dutch Safety Board's investigation focused on the RandstadRail derailments that may have been structural in nature. These were divided into four categories based on the parts of the railway system that played a role in the derailments:

1. the derailment on the switch at the Forepark stop on 29 November 2006 (interface between vehicle, switch and safety);
2. the 'spontaneous' derailment in the curve close to the Ternoort stop on 29 November 2006 (interface between vehicle and infrastructure, particularly railway layout);
3. the derailments on the Muzen Viaduct close to The Hague Central Station on 3 and 4 November 2006 (interface between vehicle and infrastructure, particularly rail wear);

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<sup>1</sup> Chapter 2 contains background information about RandstadRail as a transport system and project, including phases and RandstadRail timeline.

<sup>2</sup> RET services continued on the Rotterdam Hofplein-Nootdorp section.

4. the derailments on the openable switches on The Hague city tram network on 24 November 2006, 24 and 26 January 2007, 25 May and 20 July 2007 (interface between driver, vehicle and infrastructure).<sup>3</sup>

The investigation focused on the following aspects:

- the derailments: facts and immediate causes of each case. In its investigation, the Dutch Safety Board used the results of the investigations carried out by IVW, HTM and RET into the derailments;
- roles, duties and responsibilities of the parties involved based on legislation and regulations, agreements and standards/guidelines;
- safety management: the derailments served as points of departure for an analysis of RandstadRail safety management;
- the circumstances in which the parties involved in RandstadRail operated and the influence these had on safety management;
- the external supervision exercised on RandstadRail.

Because all of the derailments occurred in Haaglanden jurisdiction, the focus of the investigation was on the parties involved in this area. A number of issues were not taken into consideration. This applies, for example, to the assistance provided after the derailments and the potential, indirect consequences of the suspension of RandstadRail passenger services for the safety of passengers.

In addition, the analysis focused mainly on the period preceding the start of RandstadRail operations. It was during this period that RandstadRail requirements were formulated, the design was prepared, safety analyses were performed and the conversion work and, finally, the testing and trial operation were carried out (see Appendix C for a specification of project phases).

In investigating the Forepark derailment, the Dutch Safety Board also did not consider the respective roles of HTM's and RET's traffic controllers and RET's metro drivers, as these were already comprehensively addressed in IVW's investigation<sup>4</sup> and the associated report already sets out learning points.<sup>5</sup>

#### Sources of information

- accident investigations of IVW, HTM and RET
- TNO investigation into the role of IVW in RandstadRail
- Delft University of Technology investigation into the role of the Haaglanden Urban District in RandstadRail
- technical documentation of the vehicles and switches
- safety plans, safety cases and associated documents
- results of the testing and trial operation
- legislation and regulations, standards and guidelines
- administrative agreements
- reports of meetings of steering groups, committees and working groups in the period 2002-2006

#### Methods of investigation

- approximately 50 interviews with representatives of the parties involved (including Haaglanden Urban District, municipality of The Hague [PoRR], HTM, Rotterdam City Region, RET, Independent Safety Assessor, vehicle manufacturer, supplier of switches, supplier of safety components, the Ministry of Transport, Public Works and Water Management and IVW)
- analysis of documents (documents were requested as substantiation for statements made during interviews, in advance of interviews and, depending on what had been made available, explained during interviews)
- inspection of damage to switch machines in the DeltaRail laboratory
- a guided tour of HTM's vehicle workshop
- an inspection of derailment locations with explanation by railway experts
- a working visit to RijnGouwe Line (reflection)

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<sup>3</sup> An openable switch has a spring mechanism in the switch machine that makes it possible for it to be opened by a vehicle movement without being damaged. An openable switch returns to its original position after the railway vehicle has passed.

<sup>4</sup> Inspectorate for Transport and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

<sup>5</sup> These learning points led to the introduction of improvement measures. See Appendix S for the measures taken by the Haaglanden Urban District and HTM partly as a result of the Forepark derailment.

## Analysis techniques

- timeline analysis
- TRIPOD
- analysis of actors

## Second opinion

The analyses of the derailments and safety management were assessed by subject area experts external to the Dutch Safety Board, namely a professor in railway engineering of international standing and an expert on safety management in the heavy chemicals industry.

## Falsification

The Dutch Safety Board subjected the findings of each constituent investigation to a critical examination. This so-called falsification procedure meant that the investigation's results were checked in terms of their solidity by internal and external experts.

## Composition of the project team

R.H.C. Rumping	Project leader
M. Baart	Secretary rapporteur
M. Konijn	Investigator
W. Walta	Investigator
K.N.R. Verhoeve	Analyst
T.M.H. van der Velden	Investigator

A number of experts were hired in to support the Dutch Safety Board's team with respect to the following areas: synthesis of accident investigations (TNO), railway engineering and safety management (DeltaRail), legal aspects (Noppe Management Consultancy) and administrative and organisational aspects (COT).

## Completion time

The investigation started in 30 January 2007 upon approval of the Plan of Action. The provisional findings, conclusions and recommendations were discussed with the supervisory committee on 3 May 2007 and presented to the Dutch Safety Board on 27 June 2007. A draft report was discussed in the Board after the engagement of experts in the areas of safety policy and engineering for counter expertise and verification on 30 October 2007, 15 January 2008 and 20 May 2008. The parties involved could respond in writing to the draft report between 20 June 2008 to 18 July 2008. After the responses had been processed, the final report was approved by the Board on 23 September 2008, with the exception of the considerations, conclusions and recommendations, which were adjusted and approved in the following weeks.

## Inspection

In accordance with the relevant provisions of the Dutch Safety Board Act, the draft final report, not including the considerations and recommendations, was submitted for assessment in terms of factual accuracy and inaccuracy to the following parties involved:

- Haaglanden Urban District and Rotterdam City Region
- HTM and RET
- Independent Safety Assessor
- suppliers of the switches, railway safety system and the new vehicles
- Ministry of Transport, Public Works and Water Management and IVW

No reference is made to organisations that, or persons who, did not respond to the draft report or did not provide content-related commentary, or whose responses were adopted in full.

## Responses to inspection

### 1.1 Reason

*Not all derailments in light rail and tram systems endanger passenger safety, certainly not when they occur at low speeds. This is evidenced by the historically low number of victims at HTM.*

It is true that the probability of injury to passengers in the case of derailments on openable switches is nil. The Dutch Safety Board nevertheless decided to include those derailments in its investigation because the same underlying factors could lead to other, potentially more serious incidents. As for the other derailments, these could have resulted in victims among passengers. This certainly applies to the derailments that occurred on sections outside the city, where speeds can reach 80 km/h. Although the probability of injury in a derailment in the city is indeed lower, the Dutch Safety Board does not believe that this risk can be excluded. In addition, the Dutch Safety Board would emphasise that the matter is not only a technical one but also one of public opinion. While it may

be true that the derailment of a tram in a city usually does not result in injury, the probability of a train derailment resulting in victims is considerably higher. A light rail vehicle, both in terms of technical characteristics and public opinion, is closer to a light train than a city tram.

*The assumption that the problems at RandstadRail can be typified by the term 'derailments' is incorrect. In rail transport, it is common for problems to manifest themselves in the form of derailments. This does not mean, however, that the underlying problems have been sufficiently defined or even analysed, or that everything can be attributed to the pressure on and duration of the conversion phase and testing and trial operation.*

The derailments constituted the reason for the Dutch Safety Board's investigation. The Board did, however, investigate the safety management and context of the project as a whole and in doing so also analysed the underlying problems. The scope in that respect was limited to the issues that played a role in the derailments.

### **1.3 Scope and method of the investigation**

*Transporter RET also operates in Haaglanden jurisdiction. This railway undertaking was involved in the Forepark derailment. The role of RET does not seem to have been investigated by the Dutch Safety Board, however.*

The Dutch Safety Board focused primarily on the infrastructure (damaged switches) as the cause of the Forepark derailment. The factors relating to RET that led to this specific derailment (transport process and traffic control) are referred to briefly in the Dutch Safety Board's report and were already addressed more fully in IVW's report.

### **3.3 Assessment framework for safety management**

*How relevant is the Dutch Safety Board's own assessment framework alongside legislation, government policy and the instructions of the concession grantor?*

The Dutch Safety Board uses its own assessment framework in all its investigations to determine the extent to which the parties involved organised and exercised their individual responsibility for safety. Every organisation must manage the risks associated with its own activities. In that respect, legislation and regulations can be seen as minimum requirements that the parties involved must meet. In addition, the Haaglanden Urban District had undertaken to introduce a safety management system for HTM trams in response to earlier reports of the Transportation Safety Board.

#### **4.3.2 Role as infrastructure manager**

*'In its capacity as infrastructure manager, HTM was responsible vis-à-vis the Haaglanden Urban District and municipality of The Hague for the information that it provided or did not provide to both concerning RandstadRail.' HTM cannot be held responsible for information that was not provided.*

The Dutch Safety Board believes that a party can be held responsible for information that is not provided. In general, a party cannot of course be held responsible for such information, as the matter depends on the applicable context. HTM had an advisory role within the context of RandstadRail and would become the infrastructure manager and railway undertaking. Against that background, the non-provision of information – in the present case concerning the suitability of the city tram network for the new vehicles in relation to the Ternoot derailment – can in the opinion of the Dutch Safety Board be seen as an omission. The text of the draft report states 'in its capacity'. The reference is to HTM's future role as an infrastructure manager of RandstadRail.

## 5.2 Derailment on the switch at Forepark (and Appendix I, 'Analysis of Forepark Derailment')

*'Until the contrary had been proven, the parties involved should have assumed that the switches could be damaged during conversion work.' Reference is subsequently made to a more in-depth inspection of the switch. Does it by definition have to be assumed that, when switches are put in place, they are broken by the vehicles of contractor personnel? Opening a switch intended for placement as part of the light signal safety system or a clasped switch is never allowed. Contractor personnel, normally engaged on a large scale by ProRail, should be aware of this, since the same rules apply at that organisation.*

Damage can always occur during construction activities. A switch can also be opened unintentionally. When a switch is used before it is connected to the safety system, incorrect use may not be detected and the parties involved are dependent on reports from the contractors. It is therefore important to check for damage during testing and prior to the launch of regular operations. In the case of RandstadRail, moreover, there were indications that the switches had been damaged during the building phase.

*It is asserted that a switch is made openable to ensure that a report is generated when it is opened. This is not the case. The report generated is an incidental benefit of an openable switch.*

The opening of a switch by a railway vehicle must always be detected in an area that has been made safe. The actual position of a switch may otherwise be different than the one indicated in the safety system, with all the risks that would entail for a subsequent train.

*The control bolt was certainly not damaged. A Klammer Test or a test of the bolt covers (section 8.3.7 of the handbook) does not check the position of the control bolt. The Dutch Safety Board's comment concerning stuck control bolts is factually inaccurate. Both control bolts functioned properly until the day of the derailment. The Klammer Test would not have added anything in this regard. Inspections were always carried out in the presence of the supplier's technicians, who were there to assist and provide further training to the technicians appointed by HTM. The supplier's technicians are expected to perform all relevant actions in accordance with the handbook.*

The DeltaRail investigation commissioned by IVW revealed that the damage was already present. As far as the Dutch Safety Board is aware, the municipality of The Hague has up to the present time never disputed that conclusion. The Dutch Safety Board's investigation revealed that the SAT inspection would not have been able to detect the damage but that a Klammer Test would. The municipality of The Hague, for that matter, noted correctly elsewhere that it was not the control bolt that was damaged. The matter concerned, rather, the inability of the sliding part to move due to a damaged locking arm (Klammer).

## 5.3 Derailment in the curve at Ternoot

*In the fifth paragraph, the vehicle manufacturer's conclusion is worded as follows. Flange climbing would occur in the curve and the wheel would lose contact with the rail but the vehicle would not derail if the basic assumptions used for the calculation were adhered to. We wish to state the following with regard to 'lose contact with the rail'. This phrase suggests that the vertical wheel load would reach the value of zero. The vehicle manufacturer calculated the ratio between vertical and horizontal wheel loads and determined that the risk was greatest at low speeds because an unfavourable ratio between horizontal and vertical wheel load occurs precisely at those speeds. The vehicle manufacturer's report does not state that the vertical wheel load could reach a value of zero.*

In the fifth paragraph, the Dutch Safety Board states that the risk of derailment was related to speeds lower than 50 km/h. The strength of this assertion is not warranted by the vehicle manufacturer's letter. Speed is indeed a factor but it was not established as a hard requirement at the time. The vehicle manufacturer only recommended a certain speed.

In the sixth paragraph, the report refers to the switch at Ternoot for the branch of another route where a maximum speed of 25 km/h applies. This was not a problem, as a driver only needs to break shortly before the signal to adjust the vehicle's speed from 50 to 25 km/h, by which time the curve has long since been passed. The comment about the signal is correct. Note however that it is located in the curve, not after it (Signal SC09).

It is true that the vehicle manufacturer does not set a **requirement** but, rather, makes a **recommendation**. Flange climbing is referred to, however. This means that the **wheel flange** bears the load and the wheel's **running surface** loses contact with the rail head. In such a situation, the vertical wheel load is  $Q = 0$ . The risk is considered greater at lower speeds. The comment in relation to the sixth paragraph confirms that a vehicle can come to a stop in the curve, namely if the signal is unsafe.

### 5.6.1 Derailment on a switch near Forepark

*In the opinion of a respondent, insufficient – in fact, no – attention is devoted to an important link in the safety chain, namely the supplier. Perhaps reference should be made to two links, namely*



*the supplier and the body that certifies the supplier's products. Complex projects like RandstadRail involve the use of various technical subsystems. In the present case, one of those systems – the switch machines that formed part of the switches – made at least a significant contribution to the problem. The switches exhibited design or manufacturing errors and the supplier omitted to perform the Klammer Test, a test described as essential in the draft report, during the acceptance procedure. The draft report nevertheless devotes virtually no attention to the roles of the supplier and certifying body in question.*

The Dutch Safety Board disagrees with the above assertion. The broken switch machine and derailment that occurred as a result were caused by a damaged and consequently blocked switch. As stated in the report, the Dutch Safety Board focused on the cause of the damage, which meant that a switch machine blocked during an opening movement and was therefore subjected to much greater forces than those for which it was designed. The control bolts between the switch machine and blades broke as a result. The broken control bolts met specifications but the safety margin was limited. This point is comprehensively addressed in IVW's report (in its own report, the Dutch Safety Board will include a specific reference to IVW's report). Under 'Other findings', the Dutch Safety Board states in its report that the EBA certification was not valid because modifications had been made. These modifications, however, are demonstrably unrelated to the derailment.

*The question being asked is the extent to which the municipality of The Hague – itself one of the links in the safety chain – should have carried out a substitute investigation into the way in which the role of the supplier possibly required adjustment. As a customer of a supplier that apparently worked with inadequate certificates of the authorities of the European country of origin, the municipality is being asked how it can ensure in future projects and deliveries that the supplier of goods, too, has met and is meeting its safety-related obligations in full.*

The Dutch Safety Board's investigation revealed that the municipality of The Hague deliberately opted to purchase the switches by means of a management delivery. As a principal, the municipality itself therefore also became responsible for monitoring the quality – including the safety – of the switches after delivery, both in relation to contractors (temporary use of switches during the building phase) and the supplier (supply of testing conditions and support during testing). In the opinion of the Dutch Safety Board, the municipality of The Hague's reference to what it considers inadequate certificates is inappropriate in this case. Firstly, the modifications made to the switches used in RandstadRail relative to the design specified in the certificates bore no relationship to the part of the switch that played a part in the derailment. Secondly, the Dutch Safety Board drew its conclusion about EBA certification on the information provided by the municipality of The Hague (that had originated from the suppliers). The municipality of The Hague could therefore have arrived at this conclusion itself at the time at which, as a principal, it assessed whether it had received what it had ordered. The municipality of The Hague had engaged a number of switch experts for this purpose.

*The draft report assumes that the municipality of The Hague (PoRR) had a responsibility as a customer to guard against design and manufacturing errors of a certified delivery. The organisation and exercise of this responsibility by PoRR was based to a large extent on the trust placed in the certifying body. In hindsight, we believe that the switch system – as well as all the other switch systems delivered – had two shortcomings, namely an insufficiently strong connection – due to bolts that were too weak – between the blades and switch machine, and solidification that de facto blocked the operation of the opening mechanism. Both issues were therefore resolved, the first on the instructions of PoRR and the second spontaneously by the supplier.*

As stated in reply to the previous responses, the 'design and manufacturing errors' referred to by the municipality of The Hague did not cause the Forepark derailment. The Dutch Safety Board therefore did not state anywhere in its draft report that PoRR had a responsibility to guard against design and manufacturing errors. The Dutch Safety Board would, however, have expected PoRR to monitor the use of the switches during the building phase. A certificate only relates to the design of the switch machine and cannot prevent damage. The other issues referred to by the municipality of The Hague (replacements) were not investigated by the Dutch Safety Board. These did not emerge during the brief trial operation prior to the derailments but during the subsequent suspension of services, which lasted for almost a year.

*The supplier of the switches also supplied the switch machines. It would therefore have been reasonable to assume that certification of the various switch components was based on their proper interaction such that there would be no interface problems between the constituent parts. The matter would appear to raise at least two issues. Firstly, the supplier worked with different types of switches that were nevertheless given the same type number, as a result of which certification and the switch systems possibly no longer matched and the validity of the certificates may have been compromised. Certification was also limited to the switch on the one hand and switch machi-*

*ne on the other, as a result of which the connection between the two, the bolts discussed earlier, remained uncertified.*

With regard to this point, the Dutch Safety Board refers to the reply it gave to the response of the municipality of The Hague in the paragraph concerning the Forepark derailment. A certificate only relates to the design of the switch machine and cannot prevent damage.

*Before the switches delivered had been ordered, a non-openable switch machine produced by another supplier was specified that met the requirements arising from all risk analyses, also in terms of breaking strengths. Legislation governing the tendering process, however, stipulates that an invitation may not be limited to one, specific supplier. PoRR was therefore legally obliged to recognise the potential eligibility of similar products. The invitation to tender was issued on a Europe-wide basis. According to the switch supplier to whom the order was awarded, its tender met the specification requirements and included the incidental benefit of openable switches.*

The normal procedure is for the principal to establish requirements in its invitation to tender, also in the case of European tenders. It is possible to set technical specifications and even to state a make and type in that regard. The tenderer is free to offer an alternative as long as it is at least equal. The tenderer must prove that this is the case to the satisfaction of the party inviting the tender. If in this case the supplier claimed that its switch machine was equal, it was PoRR's responsibility to satisfy itself that this claim was justified and subsequently accept the argument. PoRR should otherwise have rejected the argument. In this case, the switch supplier did indeed offer the requested Vialis switch machine but also presented an alternative of its own. PoRR ultimately agreed to the alternative.

*HTM also dropped its initial objections to the type delivered. This is not mentioned in the report.*

The Dutch Safety Board described the course of events concerning the advice provided by future railway undertakings HTM and RET in Appendix I under the heading 'Involvement of future infrastructure manager'. Based on the e-mail correspondence between HTM, RET and the switch expert of PoRR, the Dutch Safety Board deduced that HTM had objections to the choice of switch machine proposed by the supplier: '*The ... switch machine for RR use and installation from the first quarter of 2006 is currently not an acceptable alternative.*' The main argument was that it was not proven technology. HTM only considered it an acceptable alternative if a long trial period of six to nine months would be completed, but there was no time for that. If the new product was opted for nevertheless, HTM would only find the situation acceptable if the supplier carried out maintenance at its own expense for the first three to five years and if the switch machines were replaced by common switch machines in the event of an excessive malfunction rate. PoRR responded to HTM's counterarguments by securing additional guarantees from the supplier. HTM thereupon dropped its objections. RET claimed to have continued objecting to PoRR's choice. The Dutch Safety Board received e-mail correspondence as evidence in this connection. HTM and RET never stated that they agreed with the choice of switch machine.

*It is factually incorrect that no survey was carried out into the problems at GVB. HTM carried out a survey at GVB on behalf of PoRR. This revealed that there had been problems with the electrical control. In addition, after the problems at GVB had become known, at the request of PoRR the switch supplier sent an e-mail containing a GVB statement about the problems at GVB. The statement expresses GVB's satisfaction and specifies the reason for the problems, which stemmed from the electrical interface. However, control at GVB is effected by 136V direct current rather than 380V alternating current. The comparison with the interface and the problems stemming from it is therefore inappropriate for RandstadRail.*

This does not accord with the information the Dutch Safety Board received from the parties involved during its investigation. The finding in the draft report is based on the following substantiation. To the Dutch Safety Board's question as to whether the references of the switch supplier had been checked, PoRR's switch expert stated in May 2007 that PoRR had checked references from DeutscheBahn, Kassel and Essen and that HTM had submitted queries in Berlin and Nuremberg. The switch expert did not report that the reference in Amsterdam had been checked. The switches at GVB did not feature in the market survey of switch machines conducted by HTM and RET prior to the invitation to tender. During the provisional publication period HTM, in relation to the same finding, reiterated that it had not been aware of the problems at GVB prior to the derailments because HTM had not asked about them and GVB had not reported them.

The Dutch Safety Board therefore asked the municipality of The Hague to substantiate its response. The municipality subsequently forwarded an e-mail message of the switch supplier containing the GVB statement. The claim that HTM submitted queries to GVB was not

substantiated. This consideration and the fact that HTM itself stated that it had not been aware of the application at GVB means that the Dutch Safety Board will not amend that point in its report.

*The question being asked is to what extent a railway undertaking can be expected to check the work of the infrastructure manager. Compare in this regard the situation in which NS Reizigers does not check the work of ProRail.*

It is precisely the wish of the Dutch Safety Board to indicate that the railway undertaking must verify – that is, must satisfy itself – that the infrastructure as delivered by the infrastructure manager is safe. The railway undertaking is, after all, responsible for the safety of passengers and personnel. In the opinion of the Dutch Safety Board, the extent to which the railway undertaking must verify the safety of the infrastructure is context-dependent. This point is further elaborated in the considerations section. That section also sets out the operative link between NS Reizigers and ProRail as formulated in the report published in December 2007 concerning the third derailment at Amsterdam Central Station.

### **5.6.2 Derailment at Ternoot**

*The Dutch Safety Board asserts that the derailment at Ternoot was caused by shortcomings in safety management. According to a respondent, this assertion is not supported by the facts. The respondent argues that the situation was again calculated and consultation took place with the Haaglanden Urban District, the ISA of the vehicle, the ISA of the system as a whole and various HTM departments. On that basis, management was advised to commence operations and modify the curve in the longer term. This decision would probably have remained the same if HTM had had a safety management system in place at the time.*

Whether the decision would have been different if HTM had had a safety management system in place cannot be verified, but this is not the point that the Dutch Safety Board wishes to make. The Dutch Safety Board's focus was on whether its principles pertaining to safety – certainly those applicable to individual responsibility for safety – were applied in practice and whether such application could have prevented the derailments. The shortcomings presented by the Dutch Safety Board in substantiation of that point were not disproved during the provisional publication period. These shortcomings were the following:

- that the Haaglanden Urban District and HTM were insufficiently aware in advance of the potential risks associated with the introduction of low-floor vehicles
- and that these parties subsequently failed to verify whether the existing infrastructure met the basic assumptions on which the design was based. Calculations of derailment risk were based on design-related basic assumptions, but the parties involved omitted to check whether the Ternoot curve actually accorded with these assumptions in practice; investigation following the derailments revealed that the situation 'in practice' was less favourable relative to the basic assumptions applied by the vehicle supplier in its calculation.

### **5.6.4 Derailments on openable switches**

*Again, the Dutch Safety Board asserts that the derailments could occur due to shortcomings in safety management. The respondent points out that drivers had received written instructions about openable switches in the form of a message on operations. The first derailment constituted no reason to believe that more would follow. It is therefore incorrect to conclude that a safety management system could have prevented the derailments.*

As stated above, the Dutch Safety Board looks into the way in which the principles formulated for safety management – a party's individual responsibility for safety – were applied in practice and whether this could have prevented the derailments. As stated in the report, the Dutch Safety Board's investigation revealed that drivers could not always properly see how far they had to continue on an openable switch to prevent a derailment. This could have been discovered during investigation of the first derailment, for example by interviewing the driver and reconstructing the circumstances of the incident. The matter could then have prompted HTM to place markings and signs around the openable switches in addition to providing instructions to drivers – which in fact was ultimately done.

### **6.1.1 Insight into risks as the foundation of safety policy**

*The Dutch Safety Board asserts that 'By not monitoring the status of the infrastructure safety cases, HTM deprived itself of an instrument to form an accurate impression of the way the parties responsible for doing so ensured the safety of the infrastructure.' Would HTM have been authorised to or indeed capable of monitoring the status of the infrastructure safety cases? If not, which conditions would have to be met or, as the case may be, agreements concluded to enable such monitoring in the future?*

HTM touches on an important point here which the Dutch Safety Board addresses more comprehensively in the considerations. It is true that HTM did not have the authorisation required for such monitoring. In the applicable context, however, HTM was the intended manager and was involved in the testing and trial operation. HTM was also aware that there was political pressure to launch regular operations as soon as possible. The Dutch Safety Board is therefore of the opinion that, based on its responsibility for the safety of passengers and personnel, HTM could have made access to safety status information a precondition for approving passenger services and accepting management of the infrastructure. HTM could have made this precondition concrete by requesting to inspect the safety cases and the list of remaining points accompanying the ISA's statement of no objection. It can in any case be said that, in the future, a railway undertaking like HTM can obtain greater certainty about the safety of the infrastructure prior to commencing regular operations by monitoring safety cases if the infrastructure builder uses them to ensure safety.

## **6.2 Forepark derailment and 6.1.4 Transfer of infrastructure management to HTM**

*Day-to-day management was transferred by the municipality of The Hague (PoRR) to RET on 9 September 2006 and HTM on 5 October 2006. The additional information showing the safety of the switches was made available to HTM by PoRR on 6 October 2006. The information comprised documents of the SAT inspection and the list of remaining points. It is incorrect that these documents were only made available to HTM in April 2007. The documents sent by PoRR did not show any remaining points that were critical to safety. This was later confirmed in the report of the Integral RandstadRail Consultation, No. 30 of 30 October 2006 ('Day-to-day management of the switches: the safety of the switches is the responsibility of the railway undertakings as from 29 October.')*

The municipality of The Hague, Haaglanden Urban District and HTM did not submit uniform statements concerning the transfer of management. Based on interviews conducted with the parties involved, it is the Dutch Safety Board's understanding that, during the launch of RandstadRail operations and thereafter, there was a difference of opinion between the municipality of The Hague (PoRR) on the one hand and the Haaglanden Urban District and HTM on the other.

The municipality was of the opinion that management of the infrastructure was transferred to the builder (the municipality of The Hague), to the principal (the Haaglanden Urban District) and to the manager (HTM) at the moment at which HTM commenced passenger services. In the opinion of the municipality of The Hague, nothing more had to be delivered and it only had to settle a number of remaining points.

The Haaglanden Urban District and HTM asserted that the launch of operations had been agreed in mutual consultation. HTM would therefore conduct operational management, such as determining access to the railway, carrying out maintenance work and so on, but for the account and risk of the municipality as long as no formal transfer had taken place in terms of:

- a transfer document signed by the three parties;
- the transfer of all documentation;
- indemnification of the principal against all obligations undertaken by the municipality of The Hague during the building phase.

At its core, this approach requires mutual acceptance that delivery has taken place in accordance with the assignment to effect a transfer: the contractor, in this case the municipality of The Hague, transfers and the principal accepts the transfer.

This difference of opinion is reflected in the comments of the Haaglanden Urban District, HTM and municipality of The Hague; comments that therefore appear to be contradictory. The view of the Haaglanden Urban District and HTM is the established one in the construction and railway sectors. For the Dutch Safety Board, the relevant question was *when* responsibility for safety was transferred. Given the foregoing, the Dutch Safety Board proceeded from the following premise. The responsibility for safe use of the infrastructure rested with HTM. Responsibility for the safety of the infrastructure as built, including the possibility of hidden defects, remained with the municipality of The Hague. The problems with the switches, including those which led to the derailment near the Forepark stop, belonged to this category; the problems relating to the other derailments did not.

### **6.1.4 HTM's decision to commence passenger services**

*The Dutch Safety Board asserts that 'HTM did not independently verify whether RandstadRail was sufficiently safe to commence operations.' HTM has a different view on this matter. It is as follows.*

*HTM is aware that it is, and also feels, responsible for the safety of its passengers and personnel and also wishes to assume that responsibility. At the same time, however, HTM could not reasonably be expected to independently recheck all issues for which safety cases were prepared by other parties pursuant to their primary and/or specific responsibilities (Haaglanden Urban District/PoRR), which were assessed (ISA) or on which supervision was exercised (IVW).*



*In future, how can HTM and other railway undertakings acquire transparent and integral insight into the applicable requirements, the required and delivered or, as the case may be, performed qualities, the relevant test findings and the supervision exercised? The railway undertaking that makes use of the (railway) infrastructure of another party could then monitor the safety management conducted and, on that basis together with practical findings, determine whether the infrastructure is sufficiently safe to commence and maintain operations.*

It is indeed the case that the ISA and IVW issued statements and that management of the infrastructure had not yet been formally transferred. However, these statements had not been sufficiently substantiated at the time HTM commenced passenger services; HTM had only received them informally and verbally during a meeting. In addition, a firmer stance on the part of HTM with regard to the substantiation of infrastructure safety would have been practical, given its future role as infrastructure manager and, in this connection, the transfer of infrastructure management that would later take place.

#### **6.1.5 Refinement and tightening of safety policy**

*The Dutch Safety Board probably wishes to emphasise here that HTM did not form an independent, integral opinion about safety. What the report does not explicitly state is whether HTM should have done so in the opinion of the Dutch Safety Board. It is clear that the other parties did not expect HTM to do so at the time.*

*The monitoring of integral safety was deliberately placed at the level of the Haaglanden Urban District (see page 77). In accordance with that situation, HTM did not have the information required to form an integral opinion. (The Haaglanden Urban District still manages the safety cases file.)*

HTM's viewpoint is correct in formal terms but HTM was the intended infrastructure manager. In view of that role, the Dutch Safety Board would have expected HTM to assume its responsibility and request access to documents substantiating safety for purposes of inspection. The matter in this case does not concern what *others* expect but, rather, how a party *itself* anticipates issues that it will have to deal with.

#### **6.2.2 Trial operation and transfer, box in 6.3.2 about risk of damage in the building phase**

*The supplier of the switches was contractually obliged to cooperate on the Site Acceptance Tests (SATs). These tests were carried out after suspected earlier damage to switch 846 and before the derailment in question. The reason the supplier is involved in such tests is obviously to benefit from its expertise in relation to its own product. This expertise is greater – or at least should be – than that of the receiving party, whose use of technical systems is initially based much more on theory than on experience. The supplier was able to observe the switches during the SATs prior to the start of RandstadRail operations. Having seen the damage pattern of the switch in question, which had also been observed by the RandstadRail Project Bureau (PoRR) of the municipality of The Hague, the supplier did not see a reason to, for example, carry out the Klammer Test. Performance of that test would probably have been a logical step for a railway expert, even if the switches did not exhibit damage patterns; after all, work on or for new railway infrastructure often involves the use of heavy construction equipment. The issue the municipality is presently grappling with concerns the manner in which the responsibility that the draft report attributes to PoRR should be organised and exercised, given that it was precisely in relation to this critical point that PoRR was advised by the party with the greatest expertise in the matter, the supplier. This issue is all the more pertinent given that, contrary to what the draft report appears to be suggesting, the Klammer Test did not form part of the documentation provided by the supplier at the time of the SATs.*

The municipality of The Hague touches on an important question here, namely the extent to which a principal should trust a supplier. The Dutch Safety Board would have accepted the municipality of The Hague's reasoning if the municipality had engaged the supplier to carry out the tests and the supplier had declared upon completion that everything was in proper working order. In this case, however, it was the switch expert of the municipality of The Hague (PoRR) who signed the SAT forms for approval and thereby declared whether the switches were safe to use or not.

#### **6.3.4 Implementation and enforcement of safety policy**

*It is recognised that verification documentation and records of validation activities were missing from the provisional railways and switches safety cases. The Dutch Safety Board does not, however, devote any attention to the alternative scenario that was followed by the parties involved. Three interviews were conducted by the ISA with PoRR representatives in August, September and October 2006 for the sole purpose of reviewing the verification and validation activities for railways and switches. These were recorded in the Overview of Verification, Validation and Authorisation*

memorandum (version 0.2, 19 October 2006).<sup>6</sup>

The alternative scenario will be added to the text of the report. The memorandum referred to lists many remaining points, such as the absence of HTM's clearance profile survey report and railway geometry authorisation. In addition, what the Dutch Safety Board saw on paper – including the railways and switches safety cases, which lacked essential documentation – was not convincing. It may of course be that the ISA was convinced by the parties involved during the interviews.

### **7.1 Time pressure on RandstadRail realisation**

*Another assumption is that the RandstadRail derailments were to a large extent or even primarily rooted in the duration of and pressure on the conversion, testing and trial operation phase. This is incorrect, however. Reference is made to the switches, Muzen Viaduct and Ternoot, for which HTM was responsible.*

The Dutch Safety Board's report does not state that all the derailments were rooted in the brevity of the modification, testing and trial operation phase. The pressure on the project as whole meant that certain issues did not proceed as they should have done.

### **8.5 System-oriented or content-oriented supervision**

*The fact that the switches are new to the Netherlands is not by definition a reason for doubt. After all, movable points, one of the new aspects of these switches, are also used elsewhere in the Netherlands. The problems with the switch on the Amstelveen Line do not have a demonstrable relationship with the problems that occurred at RandstadRail. The statement of conformity was not present but a certification institute of good standing had announced that one would be issued in the immediate future.*

The matter concerned a new type of switch machine with respect to which experience in the Netherlands was still limited. Moreover, the future railway undertakings had doubts of which IVW was probably not aware. The problems relating to the Amstelveen Line were known to IVW, however. That these did not have a demonstrable relationship with the problems at RandstadRail is an observation that can only be made with hindsight.

### **8.6 The measures announced by IVW**

*The report lists the measures taken by the Inspectorate for Transport and Water Management (IVW) following RandstadRail-related experiences but does not give an opinion about the effectiveness of these measures.*

An opinion about the effectiveness of measures taken after the incidents occurred is not appropriate to an investigation into the RandstadRail derailments and the events that preceded them. The Dutch Safety Board therefore confined itself to listing the measures.

### **Conclusion 3 concerning the role of the ISA**

*The Dutch Safety Board concludes that 'The ISA did not substantiate why there was no objection to using the infrastructure nevertheless.' In our opinion, this conclusion is incorrect. The memorandum listing the remaining points in relation to the ISA statement concerning Line 4 (27 October 2006) states why did not have objections to the commencement of operations and lists the outstanding items to be resolved.*

The memorandum referred to is in the possession of the Dutch Safety Board and was used in the investigation. The memorandum lists numerous remaining points, some of which are critical to safety. In addition, the ISA qualified a number of these points by stating that they had to be resolved prior to the start of operations. In the opinion of the Dutch Safety Board, such qualification means a blocking finding, not a remaining point. In such a situation, the Dutch Safety Board would have expected the ISA to withhold its statement of no objection until it had satisfied itself that these findings had been resolved. The conclusion will be amended in this respect to read: 'The ISA issued a statement of no objection. At the time, there were remaining points critical to safety that had to be resolved prior to the start of passenger services. The ISA did not consider this a reason to object to the launch of operations.'

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<sup>6</sup> The document applies to the area from Monstersestraat via the tram tunnel, tram platform and Beatrixlaan to The Hague Laan van NOI, The Hague Central Station to Javalaan (connecting to the Oosterheem Line and Hofplein Line) excluding the Krakeling.



### **Conclusion 6 concerning project realisation and internal supervision**

*The conclusion that the highest level of administration did not set requirements relating to the safety management of the organisation that designed and built the infrastructure, namely the RandstadRail Project Bureau of the municipality of The Hague, is not subscribed to. Reference is made in this regard to the Integral Safety Plan and the procedures governing the conversion, testing and trial operation phase.*

The documents referred to stipulate that contractors, manufacturers and suppliers must have a safety management system in place. The documents do not specify the way in which the RandstadRail Project Bureau of the municipality of The Hague would have to show that rail safety had been ensured in the infrastructure it had commissioned. As evidenced by the allocation of duties for the preparation of the safety cases, the Haaglanden Urban Conurbation retained this duty. In accordance to the stipulations of the documents, the Project Bureau did have a duty relating to the safety of railway-related work, i.e. work safety, but this aspect was outside the scope of the present investigation.

### **Conclusion 8 concerning the role of IVW**

*It is asserted in the main conclusion that the system was not safe. The law does not state that authorisation to commence operations automatically confers the designation of 'safe'. The matter concerns an opinion about actual safety. In accordance with modern views on supervision, that opinion is based on the supervision exercised on the design and building process at system level, which does not include checking all the information supplied in terms of content.*

*IVW's response to the Dutch Safety Board's question as to what was meant by 'actual safety' was: 'Although the law does not state that authorisation is related to safety, IVW obviously does take safety into consideration and indeed accords it a central role. The explanatory notes to the 1875 Railways Act state that authorisation to open a service shall only be granted after 'the railway and its associated structures have been opened'. In a modern context, the term 'opened' can be interpreted as meaning our opinion on the design and building process (system-oriented supervision) in terms of safety. In addition, a more classic inspection was also carried out with respect to RandstadRail; that is, an assessment made as to whether there were no direct, visible risks.'*

The Dutch Safety Board is surprised to learn that IVW initially believed that authorisation to commence operations did not concern safety or, more precisely, that the 1875 Railways Act does not state that authorisation is granted with a view to ensuring safety. After all, what then would be the purpose of requiring authorisation to commence operations and what was IVW's role all that time in relation to RandstadRail? Although the 1875 Railways Act does not explicitly link the term 'safety' to authorisation, the prescribed procedure for the granting of authorisation imposes an obligation to inspect the railway and its associated structures in terms of safety. In its additional response, IVW therefore indicated that it accorded a central role to safety in the granting of authorisation.

*A qualification must be made with respect to the sub-conclusion that IVW did not have a frame of reference for the supervision it exercised. Within the parameters of the working method set out in the Normative Document, companies involved are free to develop solutions to technical problems and implement them. The supervisor plays a following role in this respect and confines itself to determining whether solutions are adequate. Establishing criteria in advance which the solutions would have to satisfy would be inappropriate within this system. Decisions about criteria are indeed made but not in advance. These decisions are, it is true, probably too implicit. As stated earlier in the TNO report, this is a point for improvement for IVW and improvement measures have been introduced accordingly. It was, for that matter, clear within the RandstadRail project that the Normative Document would be adhered to, so it is unclear to IVW why the conclusion referred to was drawn.*

The Dutch Safety Board was not and is not referring to the establishment of criteria for solutions but, rather, to IVW making it clear that it would use the working method set out in the Normative Document as its frame of reference and would explicitly substantiate its opinions according to this working method.

## B. CHARACTERISTICS OF TRAM, TRAIN, METRO AND LIGHT RAIL SYSTEMS

The differences between train, metro, tram and light rail systems are on the one hand considerable but, on the other, cannot be sharply defined. General summaries are given below.

### Train

A train transport system is usually regional, national or international. It is a robust system, suitable for higher speeds and greater axle loads and is equipped with a safety system designed for speeds above 40 km/h. In terms of frequency, services are usually limited to one, two or four an hour. Trains can be combined to comprise several units and are well suited to the transport of large quantities of passengers and/or goods over large distances. The number of boarding and disembarkation points, i.e. stations, is limited. The system is governed by special railway legislation.

### Metro

A metro transport system is urban or regional and includes many stations. The system is characterised by a high frequency of services (one every two minutes in peak hours), an integral safety system and rapidly accelerating rolling stock. Speeds reach 80 to 100 km/h. Several units can be combined. The system is based on fully free railways and therefore does not feature crossing points with other traffic. In city and inner-city areas the system usually operates in tunnels and, outside those areas, on dedicated at-grade railways or on viaducts. In the Netherlands, the system is governed by special metro regulations.

### Tram

A tram transport system is also urban or regional and includes many stops. It provides high-density transport services in urban areas. Trams use dedicated railway lanes or railways placed in a road. In general, trams are relatively short in terms of unit combination and travel at comparatively low speeds in cities. On dedicated lanes and in areas outside cities trams can reach a maximum speed of 80 km/h. Except for special locations, tram networks do not have safety systems and are operated on the basis of visibility, i.e. what the driver sees. Within cities, trams are governed by road traffic regulations and by the Tram Railways Act in outer areas if the route in question has been designated as an inter-local tram line.

### Light rail

The term light rail is used for all new systems that concern a mode of transport between a train and an inter-local tram, for example the RijnGouwe Line and RandstadRail. The system uses regional railway lines or regional connections and provides a higher frequency of services with lighter rolling stock (lower axle loads, simpler and therefore cheaper to operate). Additional stops are usually added during the conversion of existing railway lines. In addition, a light rail system is characterised by an integral safety system.

A metro line can also be built as an express tram or light rail service in the offshoots of a network. Examples include the Amstelveen Line and Rotterdam line to Ommoord. Crossing points occur in this system but safety is comparable to that of metro and train systems.

The website of the Traffic and Transport Knowledge Platform provides the following description of light rail.<sup>7</sup>

#### `Term

Light rail is not an unequivocal term. French and British colleagues already refer to the new city trams as light rail. In Germany, by contrast, street trams are not included in the definition except if they have a connection to the railway network outside the city.<sup>8</sup>

The Ministry of Transport, Public Works and Water Management understands light rail to mean a rail-borne public transport system with characteristics of slow train services on the one hand and metro and tram services on the other, and that is focused on commuting distances of ten to forty kilometres. A light rail system can be characterised by terms like fast, rapid acceleration, frequent, reliable, accessible, comfortable, dynamic and structuring. In other words, it is a high-quality public transport system. In addition, light rail systems are the responsibility of regional public transport authorities.

#### Types

The ministry distinguishes between four types of light rail system:

1. free main connections in the major urban districts, virtually free of crossing points on all sections, high frequency, sometimes making use of former heavy rail lines. Examples: Manchester, RandstadRail and RegioRail KAN;
2. connections between and within (medium-sized) cities with combined use on the rail-

<sup>7</sup> [www.kpvv.nl](http://www.kpvv.nl), consulted on 16 August 2007.

<sup>8</sup> The Dutch Safety Board refers to such trams as 'city trams'.

- way network. Examples: Karlsruhe and RijnGouwe Line;
3. urban district main connections on traditional railway using exclusively relatively light rolling stock with end points outside the city. Examples: local Stockholm trains and Randstadspoor;
  4. regional secondary lines where traditional trains have been replaced by lighter rolling stock with a form of operation tailored to the area in question. Examples: Achterhoek, railway lines in Groningen and Fryslân and Lightrail Zuid-Limburg.

The second type is increasingly being referred to with the French-derived term tram-train. The third and fourth types are now generally referred to by the Anglo-Saxon term light train.

#### Objectives

Regional authorities may have the following objectives with respect to light rail:

- strengthening spatial planning policy
- strengthening the net provision of public transport
- strengthening the regional economic structure
- improving accessibility
- in England: increasing access to the labour market
- improving the quality of life by reducing vehicle emissions
- improving the general quality of life (urban quality)
- maintaining a railway line by means of a cheaper form of operation.

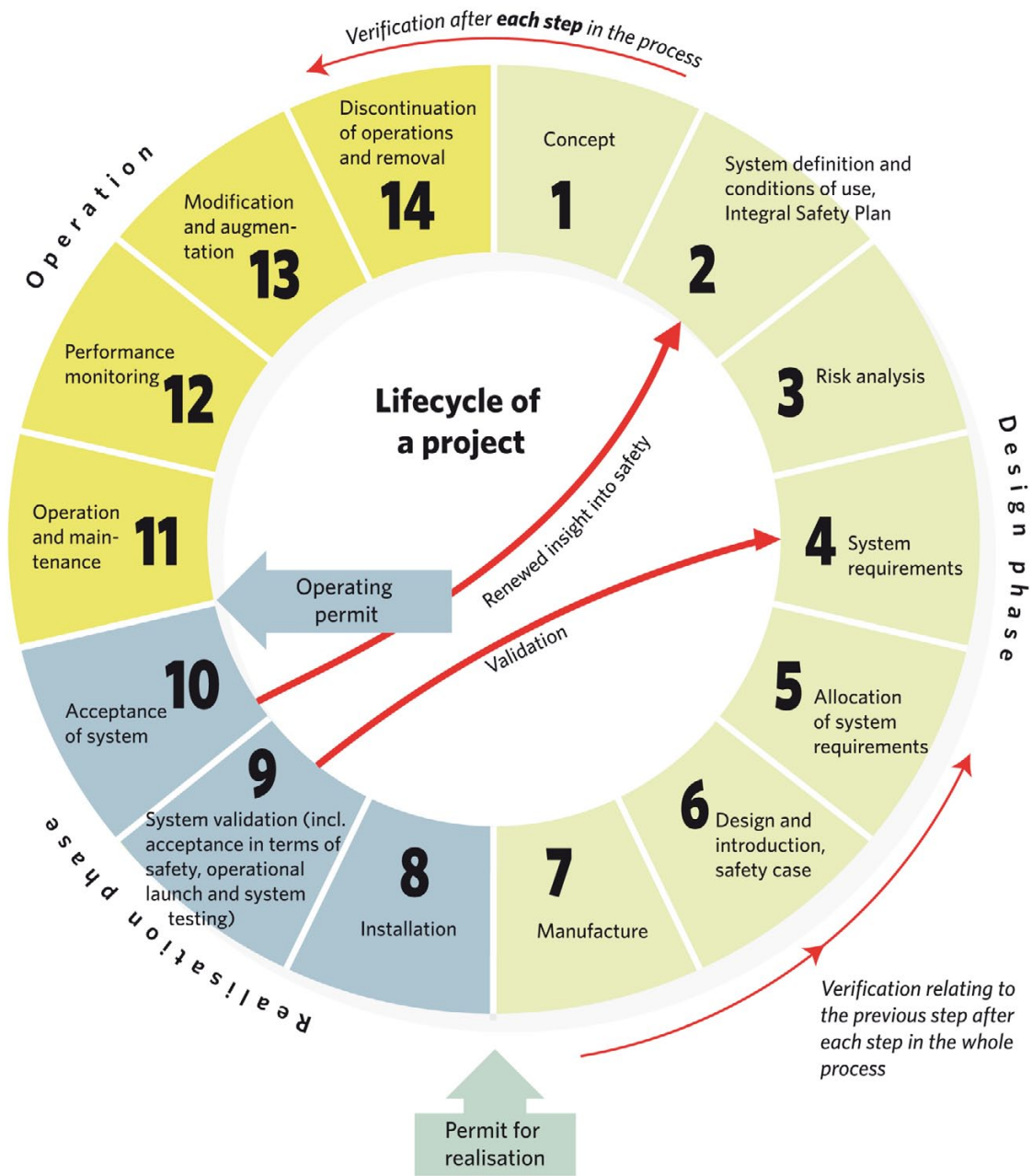
#### Regulations

There are no specific regulations for light rail systems. Heavy rail systems are governed by the Railways Act while local and regional infrastructure is governed by tram and metro regulations. There is a Normative Framework for Light Rail Safety. This guide is intended for regional and local authorities and was prepared by the Ministry of Transport, Public Works and Water Management. It specifies how light rail systems – in this case more specifically light train systems – can be built and operated with a sufficient degree of safety.'

**C.1. NORMATIVE DOCUMENT FOR LIGHT RAIL SAFETY  
(VERSION 5.0, 25 NOVEMBER 2002)**

## C.2. LIFECYCLE OF THE RANDSTADRAIL PROJECT

Based on the Normative Document for Light Rail Safety and modified by the Dutch Safety Board.



©OVV - Dutch Safety Board - RandstadRail/lifecycle of a project

## **D. OTHER LEGISLATION AND REGULATIONS RELEVANT TO SAFETY**

### **Working conditions legislation**

The safety of employees is provided for in, among other things, working conditions legislation.<sup>9</sup> Of importance in this regard are the:

- 1998 Working Conditions Act
- Working Conditions Decree
- Working Conditions Regulations.

Employers and employees have a number of obligations with respect to working conditions. The employer is obliged to ensure that working conditions are as favourable as possible and, taking the current state of science and the professional provision of services into account, that the work performed is organised in such a way as to prevent adverse effects on the safety and health of employees.<sup>10</sup>

With a view to the safety and health of employees, the employer must among other things ensure a proper allocation of powers and responsibilities among employees, taking the skills of employees into account.<sup>11</sup>

The employer must also ensure that employees are effectively informed about the work to be performed and the risks associated with it, as well as about the measures aimed at preventing or limiting these risks.<sup>12</sup>

Employers must furthermore ensure that third parties are not exposed to hazards in the performance of work. If the work an employer has its employees perform in a company, institution or in the immediate environment thereof poses a direct or indirect potential hazard to the safety or health of persons other than the employees, the employer must take effective measures to prevent that hazard.<sup>13</sup>

### **Dutch Civil Code**

Book 8 of the Dutch Civil Code contains provisions relating to the transport of passengers. Part 5, 'Agreement governing domestic public passenger transport' provides for, among other things, the railway undertaking's liability in the provision of public passenger transport.

#### **Section 105**

1. The railway undertaking is liable for damage caused by the death of or injury to a passenger as a result of an accident that occurred in connection with and during the transport of that passenger.
2. In derogation of the provision of the first paragraph, a railway undertaking is not liable insofar as the accident was caused by a circumstance that a duly diligent railway undertaking could not have prevented and insofar as a railway undertaking could not have countered the consequences thereof.
3. Physical or psychological deficiencies on the part of the driver of the vehicle and defective or improperly functioning modes of transport or equipment operated for purposes of transport are deemed to be circumstances that a duly diligent railway undertaking could have prevented and whose consequences it could have countered. Equipment is not understood to mean another mode of transport that is itself being transported.

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<sup>9</sup> The new Working Conditions Act came into force on 1 January 2007. Because the accidents occurred in 2006, the older 1998 Working Conditions Act applied.

<sup>10</sup> 1998 Working Conditions Act, Section 3, paragraph 1, subparagraph a.

<sup>11</sup> Ibid. Section 3, paragraph 2.

<sup>12</sup> Ibid. Section 8, paragraph 1.

<sup>13</sup> Ibid. Section 10, paragraph 1.



## **E. BACKGROUND INFORMATION ON SAFETY CASES AND INDEPENDENT SAFETY ASSESSOR (ISA)**

### **General working method**

At the start of a project, a principal prepares an Integral Safety Plan. This plan sets out the philosophy on safety and the safety requirements arising from this philosophy at the highest level. The plan also specifies the evidence required to demonstrate that the safety requirements thus established have been met. The Integral Safety Plan relates to the system as a whole, which means the infrastructure, rolling stock, operational aspects of the railway undertaking, traffic control and so on. Final proof that the established requirements have been met is provided in the integral safety case.

### **Demonstration**

Based on a description of the system, the principal carries out a risk analysis for the project. Specifications for the system are formulated on the basis of this analysis. The contractor is obliged to demonstrate that the construction work or delivery has been carried out according to the specifications established by the principal. This means that evidence must be provided to prove that the specifications and any additional requirements have been met. The document used for this purpose is the safety case; that is, the proof of safety or, more precisely, proof that safety requirements have been and are being met. The safety case system was first developed in the UK. Its purpose is to identify and mitigate new risks. Risks can arise in the design of new, complex systems. The system was developed following the disaster with the Piper Alpha oil production platform.

In larger projects, safety cases are usually prepared for constituent parts. This can also be done with respect to certain technologies, such as the safety system. These cases are seen as constituent safety cases that ultimately form part of a Top Level Safety Case.

Sometimes a Generic Application Safety Case (GASC) is prepared, for example for the construction of tunnels. For tunnels in general, requirements apply to the technical installations used. These are described in a GASC. Every tunnel has its own characteristics and uses specific technical systems. These are therefore described for each tunnel in a Specific Application Safety Case (SASC) and referred to in the GASC.

Separate Top Level Safety Cases are prepared for the infrastructure and rolling stock, respectively. For a new system like the High Speed Line (HSL), an Integral Safety Case is prepared to show that the vehicles and infrastructure interact properly.

It is not difficult to prove that safety requirements have been met in the case of structures and materials that are in common use and that have already proven their worth in practice. In the case of new technologies and/or systems, the starting point is theoretical. Practical tests at a later stage provide additional evidence to validate the theory.

This means that in certain situations a safety case cannot be completed before testing and trial runs have been carried out. In such situations, it is common to complete the safety case to the greatest extent possible and draw up a list of outstanding points which specifies both the aspects for which evidence must still be provided and the scheduling of this process. Once the additional evidence has been obtained, it is recorded in a new version of the safety case.

Good management is therefore required on the part of both the principal and contractor to ensure that the safety case structure is clear in terms of Integral, Top Level and constituent safety cases and so that it is clear which versions are in circulation. Each document must always be authorised by the person duly empowered to do so. Maintaining proper oversight on the outstanding points listed for each safety case and constituent safety case is also essential.

Safety case is a relatively new term in the Netherlands. Opinions on the matter differ. Certain documents which do not actually constitute a safety case are referred to by the term, for example. The opposite also occurs. An important aspect in this regard is full compliance with the EN 50126,<sup>14</sup> EN 50128,<sup>15</sup> and EN 50129<sup>16</sup> standards.

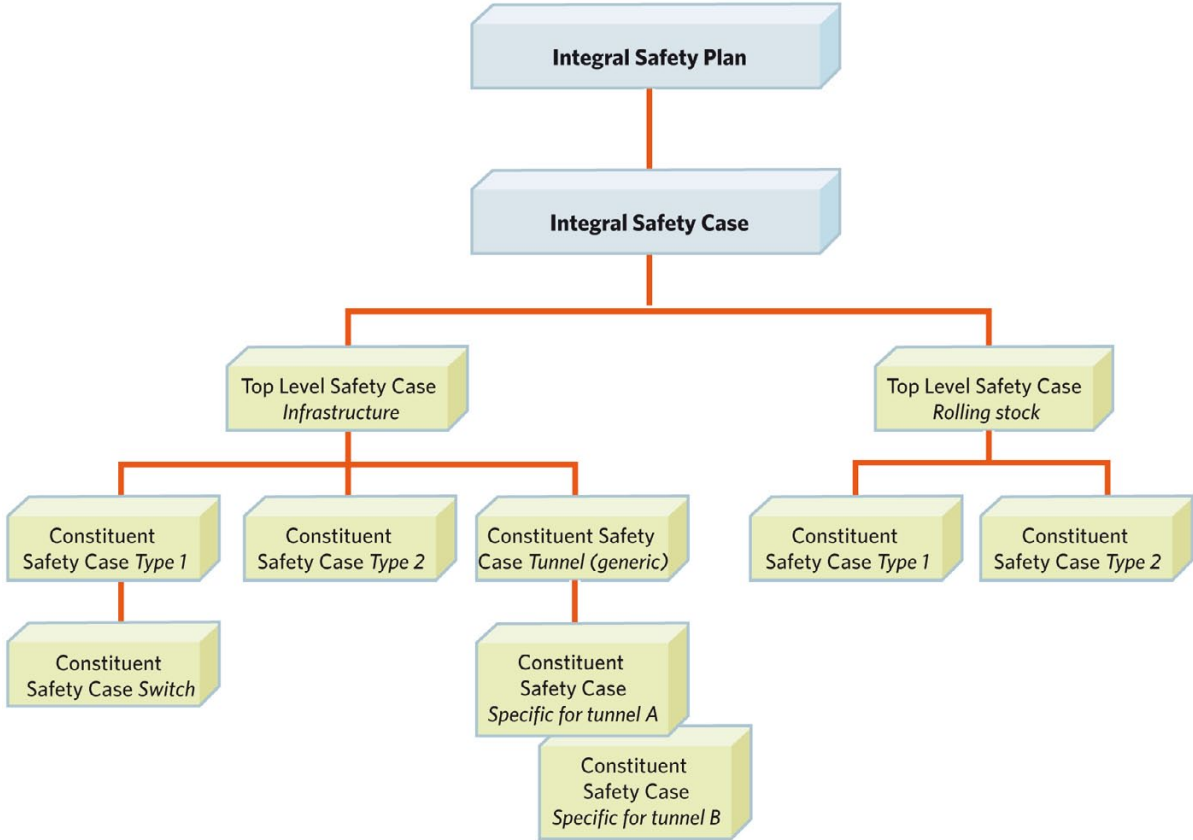
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<sup>14</sup> NEN-EN 50126-1:1999 and Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS): Part 1: Basic requirements.

<sup>15</sup> NEN-EN 50128:2001 and Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems.

<sup>16</sup> NEN-EN 50129:2003 and Railway applications - Communication, signalling and processing system - Safety related electronic systems for signalling.

Although structure and names can differ per project, the following figure illustrates the typical organisation and interrelation of safety cases. This structure was also used in RandstadRail.



©OVV - Dutch Safety Board - Randstadrail / Safety Cases

Figure 1 – Schematic representation of safety case structure

**Contents of a safety case**

Although applicable regulations stipulate that evidence must be provided, they do not say much about *how* this has to be done. The question as to how is answered in a safety case, which may state, for example, that certain tests must be performed to check theoretical considerations. If proven systems are used, such tests can be relatively simple and performed to ensure that the systems have been properly installed and function according to specifications.

When a system that has been proven abroad is used in the Netherlands, the testing programme is more comprehensive. It must then be shown that the system also functions properly in conditions specific to the Netherlands. A comprehensive testing programme is necessary when completely new systems are used.

**Assessment of safety cases**

Safety cases must be assessed by an independent party. This party may not be related in any way with the work of the principal or author of the safety case in question.

For projects subject to European regulations on interoperability, assessment is carried out by a Notified Body (NoBo). An organisation that wishes to become a NoBo must apply for accreditation in one of the Member States of the European Union. If NoBo status is granted, it applies throughout the EU. The Member State which handled the application must monitor the quality of the NoBo. In the Netherlands, NoBos are monitored by the Ministry of Transport, Public Works and Water Management. NoBo status can be obtained for, among other things, infrastructure, rolling stock, command control, power systems and maintenance. In addition, NoBo status can be obtained for one or more systems.

If projects are not subject to mandatory European regulations, assessment can be carried out by a NoBo or by an Independent Safety Assessor (ISA). The ISA is selected by the principal. The Normative Document for Light Rail Safety recommends that the selection of the ISA be submitted to the supervisor. Unlike NoBos, ISAs are not accredited.

An ISA therefore does not have any formal authority, although in practice is an authoritative party. There are no formal provisions for the accreditation of ISAs in the Netherlands. The performance of ISA work can be seen as a specific elaboration of an inspection according to the ISO 17020 standard.<sup>17</sup> Accreditation according to this standard is granted by the Dutch Accreditation Council. In the performance of its work, an ISA can work according to the guidelines set out in the EN 50126,<sup>18</sup> EN 50128,<sup>19</sup> and EN 50129<sup>20</sup> standards and in the Yellow Book and accompanying Application Notes.<sup>21</sup>

Unlike NoBos, ISAs are not accredited. In practice, organisations that have NoBo status are expected to be able to operate as an ISA. In addition, an ISA can apply for accreditation from the Dutch Accreditation Council.

The ISA only assesses system safety and therefore the characteristics inherent to a given system as a result of its design, materials used in construction and so on. The ISA does *not* assess the work-related safety of the people that have to operate a given system. This aspect is provided for in working conditions legislation and regulations.<sup>22</sup>

A safety case must describe *how* evidence is to be provided. If it is based on theoretical considerations, it must also state that practical tests will have to be carried out. The ISA must ultimately assess whether the evidence provided is convincing. If, for example, a safety case only contains theoretical considerations and the ISA deems these to be insufficient as evidence, it can request additional information based on practical testing. The safety case will then also have to be adjusted accordingly.

The ISA usually does not pronounce on the processes executed in terms of, for example, manufacture, construction and installation, or on the safe progress of a process.<sup>23</sup> Future operation and maintenance are likewise outside the scope of the ISA's work. The ISA is not allowed either to issue an opinion as to whether the established safety criteria have resulted or will result in a safe system. An opinion is, however, issued as to whether, as a result of a system's design, construction and installation, as well as documentation and the training of personnel, situations can arise that undermine safe operation and/or maintenance because of an inability to meet the established safety requirements. In principle, the ISA assessment is concluded by the launch of operations. Execution of maintenance work and actual train services are not considered.

### **The ISA statement**

The ISA statement relating to the infrastructure expresses the following:

- the safety case contains sufficient evidence that safety requirements have been met;
- the ISA believes that, when completed, the infrastructure's safety features will function properly;
- these safety features will continue to function properly if the future infrastructure manager performs maintenance and conducts management in accordance with the maintenance file made available to it.

A similar ISA statement must be prepared for the rolling stock and ultimately also for the integral safety case.

The ISA statement is therefore not a 'statement of no objection' based on a consideration of a number of issues, but an opinion based on facts. This opinion can in principle state one of the following:

1. The safety case has provided sufficient evidence.
2. The safety case has not yet provided sufficient evidence but, subject to certain conditions, the next phase can be started with an adequate degree of safety.
3. The safety case has not provided sufficient evidence.

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<sup>17</sup> NEN-EN-ISO/IEC 17020:2004, General criteria for the operation of various types of bodies performing inspection.

<sup>18</sup> NEN-EN 50126-1:1999 and Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS): Part 1: Basic requirements.

<sup>19</sup> NEN-EN 50128:2001 and Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems.

<sup>20</sup> NEN-EN 50129:2003 and Railway applications - Communication, signalling and processing system - Safety related electronic systems for signalling.

<sup>21</sup> RSSB (on behalf of the UK Rail Industry), 2000. Engineering Safety Management Issue 3 Fundamentals and Guidance, Yellow Book 3, London.

<sup>22</sup> See also EN 50129, 'Scope', p. 7.

<sup>23</sup> This chapter describes the general course of events. There are no regulations or guidelines stipulating what an ISA must do. Additional issues can be examined at the request of the principal. In the case of Randstad-Rail, the process formed part of the assessment (quality audits, assessment of independent verification).

In the first case, the transition to the next phase can be made.

In the second case, the evidence may be complete but the formal signature of the authorising party is absent or definitive evidence will only be provided in the next phase, for example during testing.

The third case concerns a so-called blocking finding. The evidence provided is insufficient and must be improved before the transition to the next phase can be made.

### **The process**

The principal for project realisation is responsible for the integral safety case. This integral safety case is assessed by the principal's ISA.

The project manager that will realise the infrastructure project will also contract an ISA. This may be the same ISA as the principal's or another one. The railway undertaking must do the same with respect to the rolling stock.

When awarding an assignment, it is usual for a project manager to require the delivery of a safety case, whether or not with an ISA statement, upon completion of systems like a safety installation. If there is no ISA statement, the project manager's ISA will carry out the assessment. If an ISA statement has been issued, it may be one of the following in terms of origin and applicability:

- a. The statement was issued by a Dutch ISA and applies in the Netherlands.
- b. The system was approved in another EU country by an accredited ISA and approved for use by the competent authority.

In the first case, the ISA will only check whether the ISA in question is accredited to issue such an opinion. If so, the ISA's conclusion will be adopted without qualification. This is referred to as the Formal Check.

In the second case, a so-called Cross Acceptance may be carried out. The author of the safety case will then have to show that the conditions in which the system or product in question will be used in the Netherlands exactly match those of the country in which the system or product was approved. The Dutch ISA will formally check this evidence.

When the Top Level Safety Cases for infrastructure and rolling stock, respectively, are ready, the principal can complete the Integral Safety Case. This case shows, usually on the basis of a comprehensive testing programme, that the infrastructure and rolling stock interact safely. An ISA statement is issued on this matter.

The ISA statement about the Top Level Safety Cases and the Integral Safety Case, together with the underlying technical file of the assessment reports, must be available so that IVW's Railways Supervisory Division can advise the minister concerned about commencing use of the infrastructure.

### **No formal regulations**

The way in which safety and safety risks in the construction and operation of railway systems are assessed has changed in recent years, partly as a result of European regulations. In the Netherlands, there are as yet no formal, legal provisions in this regard. This means that safety frameworks, integral safety plans and the provision of evidence that safety requirements have been met are organised on an individual project basis. In practice, these elements are prepared in joint consultation between the principal, project manager and ISA.

The question as to *when* a system of safety cases and ISA statement are required is therefore not provided for, nor is the minimum content that a safety case must contain, including in terms of testing, and, ultimately, what must be submitted to IVW for authorisation to commence operations. At the present time, these matters are provided for on a case-by-case basis, with the attendant risk that something is overlooked in the process or that additional evidence is required retrospectively.

An ISA usually prepares an ISA plan that describes how the assessment will be carried out and therefore how the evidence will be checked. If proper arrangements are in place, the ISA plan is approved by the ISA's principal and checked by the final principal and IVW.

## F. ASSESSMENT FRAMEWORK FOR SAFETY MANAGEMENT

The structure and practical organisation of the safety management system play a crucial role in the demonstrable management and continuous improvement of safety. This applies to all organisations that are directly or indirectly engaged in activities that pose a potential danger to citizens and residents of the Netherlands. The organisations in question vary in terms of their respective roles and responsibilities and include ministries, provincial and municipal authorities, and private companies. The way in which a safety management system must be structured and organised in practice is directly dependent on the applicable context. This context is determined by, among other things, the nature, size and responsibilities of the parties involved. The lifecycle phase in question, such as design, realisation, management and so on, also determines the context. Based on national and international legislation and regulations as well as a large number of broadly accepted and implemented standards, the Dutch Safety Board has defined a number of safety-related points of attention that must be incorporated into the safety management systems of the organisations involved. These points are listed below.

**Insight into risks as the foundation for safety policy:** the starting point to achieve the required level of safety entails:

- i. a survey of the system, followed by
- ii. an inventory of the associated risks. This information must be used to identify the hazards that must be managed and the preventative and repressive measures required to that end.

**Demonstrable and realistic safety policy:** a realistic and practically applicable safety policy, including its basic principles, must be put in place to prevent undesirable events and manage them if and when they do occur. This safety policy must be embedded and directed at management level. This safety policy must be based on:

- i. relevant, prevailing legislation and regulations,
- ii. standards, guidelines and best practices available in the sector and the organisation's own insights and experiences as well as safety objectives specifically formulated for the organisation.

**Implementation and enforcement of safety policy:** the implementation and enforcement of safety policy and management of identified risks must take place by means of:

- i. a description of the way in which safety policy is to be implemented, with due attention to concrete objectives and plans, including the preventative and repressive measures arising from them.
- ii. transparent, unequivocal and universally accessible division of responsibilities on the shop floor for the implementation and enforcement of safety plans and measures.
- iii. a clear record of the personnel and expertise required for performance of the various duties.
- iv. clear and active central coordination of safety-related activities.

**Refinement and tightening of safety policy:** the safety policy must undergo continuous refinement and tightening based on:

- i. the periodic performance of analyses and risk analyses, observations, inspections and audits (proactive approach), and in any case whenever basic principles are altered.
- ii. a system of monitoring and the investigation of incidents, near accidents and accidents as well as expert analysis of such events (reactive approach). These activities must be used as the basis for evaluations and, if necessary, the adjustment of safety policy by management. They must in addition reveal points for improvement that can actively be used in the conduct of management.

**Management control, involvement and communication:** the management of the parties/organisation involved must:

- i. in internal terms, ensure clear and realistic expectations with respect to the targeted level of safety and foster a climate of continuous improvement in terms of safety on the shop floor by in any case setting a good example and making enough people and resources available to make safety a reality.
- ii. In external terms, clearly communicate the general working method, the way in which this method is reviewed, procedures in the case of deviations and so on based on unambiguous agreements concluded with parties in the wider environment.

## **G. OTHER PARTIES INVOLVED IN RANDSTADRAIL**

### Independent Safety Assessors

- both for the project as a whole and for each supplier
- approved as ISA by the Ministry of Transport, Public Works and Water Management
- received instructions from the Haaglanden Urban District
- prepared own Plan of Action
- were charged with assessing ISA statements of the suppliers and, if these were not available, the safety cases of the suppliers
- were charged with assessing the integral safety case
- were charged with issuing a statement of no objection

### **Manufacturers, suppliers and contractors**

#### Manufacturer/supplier of low-floor railway vehicles to HTM

- received instructions from HTM according to specifications
- was charged with delivering according to the Schedule of Requirements and certain standards and guidelines
- was charged with supplying a safety case that had been assessed by the ISA for rolling stock
- delivery

#### Manufacturer/supplier of switch machines

- received instructions from the RandstadRail Project Bureau (PoRR) of the municipality of The Hague according to management delivery
- was charged with delivering according to the Schedule of Requirements and certain standards and guidelines
- delivery

#### Manufacturer/supplier of railway safety system

- received instructions from the municipality of The Hague (PoRR) according to specifications
- was charged with delivering according to the Schedule of Requirements for the railway safety system
- was charged with supplying a safety case that had been assessed by the ISA for the railway safety system
- delivery

#### Contractors

- received instructions according to RandstadRail specifications
- were charged with building according to the instructions of suppliers and Schedule of Requirements
- were charged with coordinating work with the Railway Coordination Centre, which included reporting the opening of switches by vehicles
- delivery



## H. DUTIES AND RESPONSIBILITIES IN THE RANDSTADRAIL PROJECT

The Coordination Agreement sets out arrangements concerning the structure of the RandstadRail project.<sup>24</sup> It provides for a steering group, joint management board and project management team. The steering group consists of the Traffic and Transport portfolio holders of the Haaglanden Urban District and Rotterdam City Region.

The steering group is responsible for supervising project progress and implementation of the Coordination Agreement by the parties and is authorised to represent the Haaglanden Urban District and Rotterdam City Region in this connection as well as:

- monitor compliance with funding terms and conditions (Article 7.2);
- approve planning and the design or functional description of subprojects prepared at the initiative of the joint management board (Article 9.3);
- approve planning and the budget and design or functional description of subprojects prepared at the initiative of the joint management board (Article 10.4);
- approve the operational concept and the management and maintenance concept, and proposals concerning the granting of concessions (Article 11.3);
- approve alterations to the scope and planning (Article 15.2);
- consult with the minister in cases of deviations from the Administrative Agreement (Articles 9.3, 10.5, 11.4 and 15.2);
- approve representation of the joint management board (Article 16.1);
- approve amendments to the agreement (Article 18.1).

In addition, a joint management board was established. This management board consists of managing directors appointed by the Haaglanden Urban District and Rotterdam City Region, project managers of the Haaglanden Urban District and Rotterdam City Region, and an independent chairman.

The joint management board is responsible for guiding the project management team and implementing the Coordination Agreement and is authorised to represent the Haaglanden Urban District and Rotterdam City Region in this connection as well as:

- assess and approve applications for funding with regard to the jointly agreed plan in the Administrative Agreement (Article 6.1.4);
- assess and approve planning concerning the interaction between the subprojects and joint responsibility in relation to the minister (Article 6.2.2);
- enter into agreements (Articles 8.1, 8.2, 8.3 and 8.5);
- assess and approve planning and the design or functional description of subprojects concerning the interaction between the subprojects and joint responsibility in relation to the minister (Article 9.2);
- assess and approve planning and the budget and design or functional description of joint subprojects (Articles 10.3 and 10.4);
- assess and approve products (Article 11.2);
- alter the scope and planning (Article 15.2).

A project management team (PMT) was also set up. The PMT consists of the project managers of the Haaglanden Urban District and Rotterdam City Region. They may be assisted by other persons appointed by the PMT.

The PMT is responsible for preparing resolutions of the joint management board and implementing resolutions adopted by the joint management board and/or steering group as well as for:

- preparing applications for funding and submitting these for approval (Article 6.1.4);
- preparing the planning and submitting it for approval (Article 6.2.3);
- preparing subprojects and submitting these for approval (Article 9.2);
- preparing joint subprojects and submitting these for approval (Articles 10.1, 10.2, 10.3 and 10.4);
- realising products and submitting these for approval (Article 11.1);
- informing the joint management board about alterations to the scope and planning (Article 15.3).

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<sup>24</sup> Haaglanden Urban District-Rotterdam City Region Coordination Agreement, April 2002, Appendix 2 (the articles refer to the agreement).

## I. ANALYSIS OF DERAILMENT ON SWITCH 846 NEAR THE FOREPARK STOP

This appendix provides the factual information and analysis of the derailment of a RandstadRail vehicle on switch 846 near the Forepark stop on 29 November 2006. Answers are provided to the following questions:

- What was the actual situation at the location? Section I.1 sets out the factual information concerning the prior history of the switch in question.
- What happened prior to and during the derailment? Section I.2 sets out the facts of the derailment.
- Why did the vehicle derail? Section I.3 contains an analysis of the direct causes of the derailment.
- How could this situation arise? Section I.4 describes the way in which the organisations involved structured and organised their respective responsibilities in relation to the situation that led to the derailment.
- Section I.5 sets out the key conclusions in relation to this derailment.
- Had the risks related to the derailment been recognised and, if so, how were they managed? Section I.6 contains an analysis of the safety management aimed at managing these risks.

In answering the first two questions, use was made of the results of the investigation carried out by the Inspectorate for Transport and Water Management (IVW)<sup>25</sup> and internal investigation reports prepared or commissioned by HTM.

### I.1 FACTUAL INFORMATION CONCERNING THIS DERAILMENT

The municipality of The Hague (PoRR) divided the RandstadRail project into a number of sub-projects. As a result of this division, the physical switch, including the switch machine, became part of the railway subproject while operation of the switch became part of the safety subproject.<sup>26</sup>

The municipality of The Hague (PoRR) had to decide which type of switch to use for the Hofplein Line and Zoetermeer Line once management of both lines had been transferred. RandstadRail vehicles belonging to RET (metro type) have a different wheel profile in terms of running surfaces and flanges than that of RandstadRail vehicles belonging to HTM (RegioCitadis type, low-floor tram).

On the shared section used by both HTM and RET vehicles, these differences in wheel profile led to differences in the design of the switch, particularly with respect to the switch points. Modification of the wheel running surfaces was not an option because doing so would have necessitated either major modifications to the entire Rotterdam metro network or major modifications to The Hague tram network, which also runs through streets. A compromise therefore had to be found. To limit the derailment risk arising from different wheel profiles, the Haaglanden Urban District decided to use new switches and introduce movable points for all switches on the shared section. Switches with fixed points were used on the other sections of the Zoetermeer Line and Hofplein Line and on the new Oosterheem Line. Because only one type of vehicle makes use of this line, a standard switch design appropriate to metro or tram vehicles could be used. The municipality of The Hague (PoRR) was responsible for the purchase of the switches.

### I.2 EVENTS PRIOR TO AND DURING THE DERAILMENT

#### **Actions of the drivers and central traffic controllers**

The actions of the drivers and central traffic controllers were not included in the description of the facts and direct and underlying causes of the derailment. This is because these actions were already comprehensively detailed in IVW's investigation report.<sup>27</sup> A switch may not be traversed in a direction other than the one for which it is set, i.e. thrown open, although this can occur in practice. If it does occur, it may not result in an unsafe situation. In an area that has been safe, such as the one in question, the opening of a switch by a vehicle movement must always generate a report since, after such an opening, the position of the switch may differ from the one indicated in the safety system. Such a situation constitutes a hazard for a subsequent railway vehicle. Opening movements were not reported during the building phase. The switch was damaged during that pe-

<sup>25</sup> Inspectorate for Transport and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

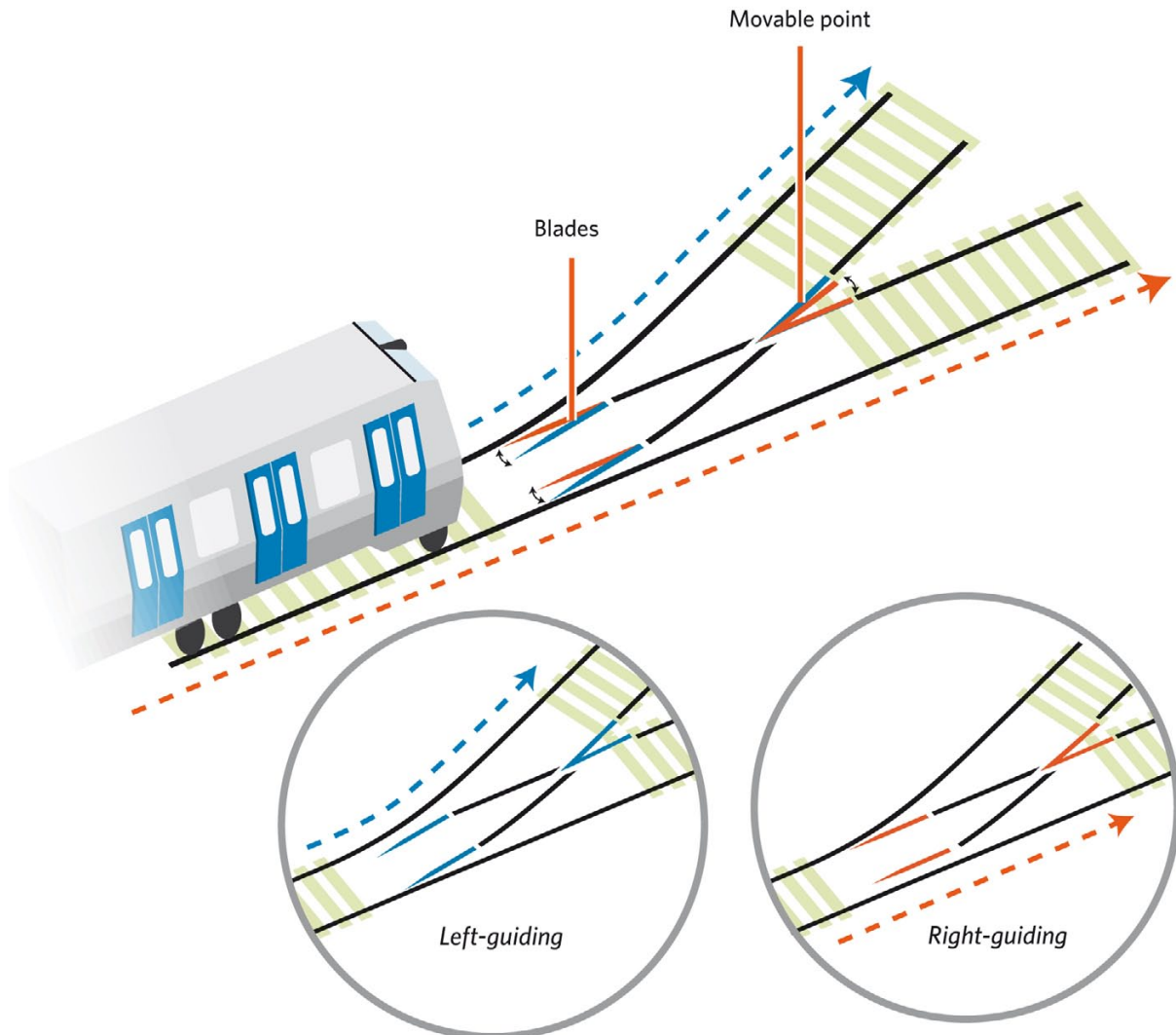
<sup>26</sup> See Appendix E for an explanation of the operation of switches, movable points and the quality of being openable.

<sup>27</sup> Inspectorate for Transport and Water Management, 2007. Onderzoeksrapport 29 november 2006 Ontsporing van RandstadRail voertuig nabij Forepark, Utrecht, RV-06U1018.

riod, and that damage played a role in the breaking of the switch without a report being generated. The Dutch Safety Board therefore limited its considerations to this aspect.

### The breaking of switch 846 prior to the derailment

At 18:10, a RandstadRail metro vehicle broke down before the Pijnacker stop. The traffic controller therefore decided to direct the vehicle to the Leidschendam workshop. When the driver of the vehicle was instructed by the traffic controller to pass a stop signal, switch 846 was in the so-called right-guiding position.<sup>28</sup> However, to facilitate the proper movement of this vehicle, the switch should have been in the left-hand position. When the defective vehicle traversed the switch, one of its blades was pushed into the left-hand position (see figure below).<sup>29</sup>



©Dutch Safety Board - RandstadRail/switch with a movable point

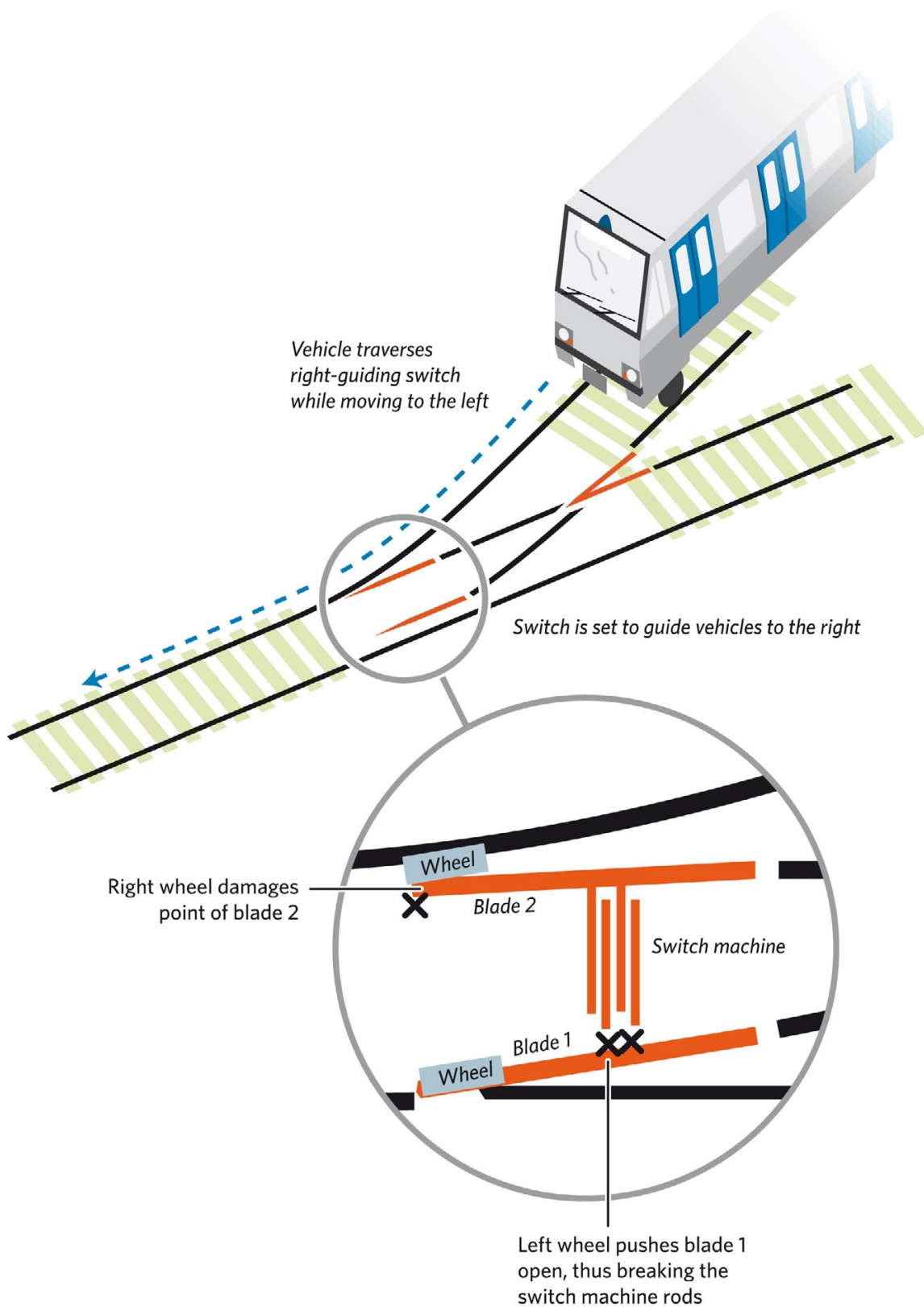
Figure 2 – Switch with a movable point (red: right-guiding position, blue: left-guiding position)

Tremendous force was required to push away the parallel blade because the opening mechanism was broken and blocked. This force was so great that the blade was ultimately not pushed away but broke off from the control rod of the switch machine.<sup>30</sup> Rather than being pushed away, the other blade was simply driven over. In addition, because the opening mechanism blocked, no signal was generated in the safety system to indicate that the switch was no longer in the safe position.

<sup>28</sup> See Appendix J on switches for an explanation of their operation.

<sup>29</sup> The switch should have been in the correct position and the driver should have made sure that this was the case. These aspects were addressed in the IVW investigation.

<sup>30</sup> The strength of the control bolts between the blade and switch machine control rod met specifications and should not have broken in the case of normal use. They would break, however, if subjected to exceptionally high forces, for example, as in the present case, as a result of the blocking of the opening mechanism.



©Dutch Safety Board - RandstadRail/blade breaks from switch machine

Figure 3 – Blade breaks off from machine when traversed by defective vehicle

**The derailment**

Because the parallel blade was no longer attached to the switch machine rods, it came to rest in the left-hand position while the abutting blade remained in the straight position. This is also referred to as a spread position. In such a position, a switch is no longer safe.

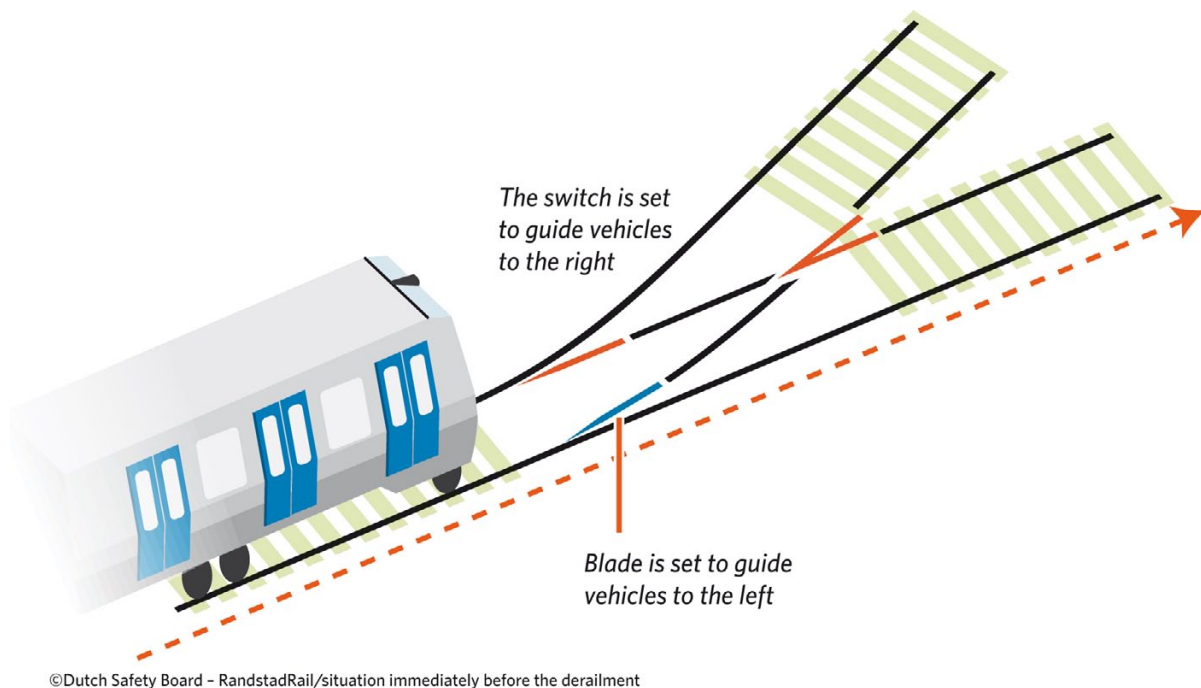


Figure 4 – Situation immediately before the derailment

The next RandstadRail vehicle had to traverse the switch in the straight direction and derailed on the right blade, which was in the left-hand position. At the time, the vehicle was travelling at approximately 50 km/h. The maximum permissible speed on that section is 70 km/h. This accident resulted in the injury of 17 passengers, two of whom were taken to hospital.

#### After the derailment

After the derailment on 29 November 2006, the municipality of The Hague (PoRR) removed all movable switches in the shared section, section to Zoetermeer and line to Rotterdam and had them checked by the supplier. In addition, the supplier carried out an on-location check of the switch machines. The relevant components of the damaged switches, including those of switch 846, were replaced.

### I.3 WHY THE VEHICLE DERAILED<sup>31</sup>

#### Damage to the switch during the building phase

Analysis of the operation of and damage to various components of the switch indicated that the switch was most probably damaged during RandstadRail conversion work as a result of having been passed by construction vehicles in a direction other than the one for which it was set and becoming blocked as a result.<sup>32</sup> Two scenarios are possible in terms of the switch having come to be in the straight position.

The first scenario is that the control bolts broke when the switch was passed by a vehicle in a direction other than the one for which it was set, as a result of which the opening mechanism of the switch machine failed to activate. With regard to the abutting blade, the passing wheel pushed the wheel flange in between the blade and rail with tremendous force, thus causing the damage.

The second scenario is that the switch became stuck in the straight position (parallel blade) during the construction phase (June-August 2006). The stuck switch was subsequently set to the left-hand position by the passage of a construction vehicle. With regard to the abutting blade, the passing wheel pushed the wheel flange between the blade and rail with tremendous force, thus causing the damage. It is possible in this scenario that the wheel at the abutting blade derailed (the wheel on the other side would then already have passed over the parallel blade), thus forcing the full width of the wheel in between the blade and stock rail.

<sup>31</sup> See Appendix J for a comprehensive description of the operation of the switch in question.

<sup>32</sup> The control and safety system of the switches was not operational during the construction phase. To ensure that switches cannot be manually operated without permission and/or passed in a direction other than the intended one, the blades are secured in place by means of switch clamps. This is prescribed in the basic documentation on switches.



The result of the damage caused by either of these scenarios was that the sliding component of the switch's opening mechanism could no longer move in relation to the locking arms (Klammer). The switch was therefore no longer openable.<sup>33</sup> If a switch is openable, a vehicle movement like the one shown in Figure 3 would push away the blades. This opening movement would then generate a report in the safety system. This does, for that matter, only apply to the blades of the switch; the movable point is not openable, thereby rendering the whole switch not openable.

RandstadRail operations were launched at the end of October 2006. During operations, it emerged that the switch was difficult to set and regularly required adjustment. The malfunction-related information indicated that this problem could be traced to damage sustained during the building phase. Because more switches were difficult to set, albeit for different reasons, the problem did not result in specific attention being paid to the switch or in its inspection by the RandstadRail Project Bureau.

#### I.4 WHY THE SITUATION AROSE

##### **Schedule of Requirements**

In terms of the derailment, the Haaglanden Urban District included the following requirements of relevance in the functional Schedule of Requirements for RandstadRail:<sup>34</sup>

'SI.05.01.021 junction safety 21

A junction safety feature must terminate authorisation of an established route if:

The opening of a switch by a vehicle movement is reported (no longer in the controlled final position)

The municipality of The Hague (PoRR) prepared specifications which included technical requirements for the switch tendering process.<sup>35</sup> These included the following with respect to openability:

'19. ... The switches must be non-openable. ...'

A switch is openable if two conditions are met:

- the switch sustains no or virtually no damage when it is opened by a vehicle movement;
- the opening movement generates a report in the safety system.

##### **Tried and tested versus innovative**

This section addresses the choice for a switch that was virtually unknown in the Netherlands. This aspect is relevant to the estimate of problems that could be expected during installation, testing and trial operation. When a system is known, parties involved largely know what to expect: where problems often arise, the system's relative weaknesses and so on. In the case of RandstadRail, a new type of switch machine unknown in practical terms to the municipality of The Hague (PoRR), HTM and RET was used on a large scale.

##### **The market for switch machines**

At first sight, there appear to be several suppliers of switches and switch machines on the market. Many producers operate within the same group, however. This means that the market is not actually that large and that it is dominated by four large European groups that supply switches and an equal number of companies that supply switch machines.

Consultation with market parties took place prior to the invitation to tender. The municipality of The Hague (PoRR), HTM and RET were informed by different suppliers about the possibilities and limitations.

The supplier of the switches used on the shared section of the Zoetermeer lines of RandstadRail is a relative newcomer to the light and heavy rail market. In the Netherlands, the use of switches from this supplier had previously remained limited to a number of trials and the installation of eight switches in the extension of the Amstelveen Line.

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<sup>33</sup> See Appendix J on switches for an explanation of the term openability.

<sup>34</sup> RandstadRail Schedule of Requirements - Part: C - Document and date of publication: System Specifications for Infrastructure - 18 December 2002.

<sup>35</sup> RandstadRail Project Bureau, Tendering File SB2005-AI50420, version 1.0, RandstadRail Project, Switches and Crossing Points Subproject, The Design and Delivery of Switches and Crossing Points for RandstadRail, Technical Schedule of Requirements.



### **Consideration and selection of switch machine**

The specifications that the municipality of The Hague (PoRR) issued to market parties assumed a type of switch machine that was widely used in the Netherlands and in other countries. As is usual in the case of a European invitation to tender, the supplier is given the opportunity to also offer what must at least be an equivalent alternative. The supplier must prove this equivalent status. During the tendering procedure, it emerged that the offer of the supplier ultimately chosen to supply switches for RandstadRail was the most attractive in economic terms. In addition to the switch required by the municipality of The Hague (PoRR), this offer included another type of switch machine supplied by another company belonging to the same parent group.

The cost benefit of this offer relative to the ones made by the other suppliers was limited (2%) because closer examination by the municipality of The Hague revealed that a large number of switches would have to be fitted with two machines to enable the proper functioning of the switch blades. After the choice was made for this type of switch machine, discussion on whether an openable or non-openable switch would be used was resumed. Following a reconsideration and consultations with HTM and RET, the municipality of The Hague (PoRR) opted for openable switch machines. This type of machine only applied, for that matter, to those used for the blades, not those used for the movable points. This meant that the benefit in question did not apply to 19 of the 25 switches on the shared section.

### **Involvement of the future infrastructure managers**

Most of the costs associated with the maintenance of railway infrastructure are determined by the choices made during the design and construction phases. It is therefore sound practice to involve the future infrastructure manager in the selection process.

Because the Haaglanden Urban District was relatively slow in deciding who would be the operator and manager of RandstadRail, for a long time there was no formally designated future manager. Only on 25 March 2003 did HTM become aware in informal terms that it would become the future manager. The formal decision was made on 21 September 2005. As RET and HTM had the required operational and technical experience, they had already been involved in the selection process for some time, first as advisors on behalf of the Haaglanden Urban District and later as future managers.

In the early spring of 2005, RET and HTM technicians made joint visits to a large number of switch and switch machine suppliers in the Netherlands and Germany. These visits also involved discussions with local managers. The final report of 30 March 2005 submitted to the municipality of The Hague (PoRR) stated that the type of switch machine ultimately selected by the municipality of The Hague (PoRR) was not a proven technology and that the supplier had indicated that there were still many problems with it. As future infrastructure managers, RET and HTM advised against the use of the type of switch machine in question. The report made no mention of the application at GVB in Amsterdam, where – given the time of the visits – there had already been problems for a number of months as a result of a derailment.

The reports of the supervisory group for the selection of switches and switch machines reveal that the municipality of The Hague (PoRR) persisted in its choice for the type of switch machine ultimately selected. The municipality of The Hague (PoRR) still had a preference for the type of switch machine in question at the end of September 2005. RET and HTM objected to it on the basis of the report referred to. Moreover, it was argued that the introduction on a large scale of a third type of switch machine in addition to the types already being used by HTM and RET would result in considerable management-related problems and additional costs for stocks of spare parts. In addition, a large number of technicians would have to be trained and manuals prepared. A further objection was that the type of switch machine in question was installed in between the rails rather than alongside them, which made inspection and maintenance more difficult during regular operations.

On 23 September 2005 RET reiterated its point of view to the municipality of The Hague (PoRR) in writing. The municipality of The Hague (PoRR) responded to these objections by securing additional guarantees from the supplier and offering free training to the technicians. The municipality of The Hague (PoRR) finally cut the Gordian knot on 6 October 2006 and definitively placed the order with the supplier ultimately chosen. This led to a breach of faith with RET's representative in the supervisory group. RET would not, for that matter, have to maintain any of these switches.

### **Management delivery**

In recent years, it has become common practice in the tendering procedures of large railway structure infrastructure projects for contractors' offers to include the supply of all materials. It goes without saying that the principal is responsible for specifying exactly what it requires. However, in the case of exceptional and complex situations, the principal may decide to make the choice itself and place an order with a supplier. The product to be delivered is then made available to contractors by project management. The contractors then install the product. Because the present matter involved a new type of switch with a long delivery time, the municipality of The Hague (PoRR) decided to accelerate tendering for the switches in the planning. As a result, the planning was out of synch with the tendering process for the other railway materials, and the decision was consequently made to obtain the switches and switch machines by means of a management delivery. If the contractors had had to order the switches, they would not have arrived on time for the project's realisation phase. The connection and design of these switches in terms of safety remained part of the duties of the supplier contracted for the safety system. Due to the purchase of switches and switch machines by means of a management delivery, responsibility for quality after delivery rested with the municipality of The Hague (PoRR).

### **Experiences in Amsterdam**

Transporter GVB had some experience with the type of switch machine used in the RandstadRail project. When the Amstelveen Line was extended to Westwijk, GVB did not wish to remain dependent on its sole supplier up to that time. Based on a comprehensive offer, an order was awarded at the end of 2001 for the delivery of eight switch machines by the same supplier and of the same type as those later used in RandstadRail. Delivery took place in the middle of 2004. These switches are not fitted with a movable point because they are traversed at relatively low speeds by only one type of railway vehicle. The switches for guiding a vehicle onto another railway track are not used very often; the switches at the turning point of the line are used slightly more frequently.

In terms of power supply, the type of switch in question was originally designed to function with alternating current. GVB wished to use direct current, however, which was not a problem for the supplier. In the initial period, GVB did experience a lot of problems with burning feed cables and end contacts. On 22 December 2004 an empty GVB vehicle travelling at low speed derailed at the turning point of the Westwijk terminus. Closer investigation revealed that the switch had generated a report that the blade in question was in its final position, as a result of which traffic control issued a 'safe passage' message. Following the derailment, on-location inspection established that the switch had in fact not completely altered its position. Both blades were therefore not in a final, locked position but in a 'split' position; that is, the left wheel was guided to the left and the right wheel was guided to the right. The vehicle therefore derailed. It also emerged that the malfunctioning blade was not broken.

The switch machine controls the position of the blade through a rod, which is connected by a spring mechanism to the positioning rod. When traversed by a railway vehicle, a contact is broken that must be re-established by a spring action. These contacts got stuck, however. The switch did indeed alter its position, but GVB's safety system does not check contradictions in reports generated by a switch machine.

GVB maintains the basic principle that a switch must be fail-safe and that it should not be necessary to modify the entire safety system.<sup>36</sup> The supplier therefore redesigned and rebuilt the switch machine. The contact is now mechanically linked to the control rod. The position of the blades is therefore determined by the control rod and it is not possible for an incorrect position to go undetected. This modification was applied to all of the relevant eight switches in Amsterdam at the beginning of 2006.

In Germany, this problem does not occur because all movements and signals are checked. To that end, the fail-safe check is incorporated into the safety system. In the Netherlands, and also at GVB, the approach is to include the fail-safe element at the source and not rely exclusively on the safety system.

The aspect of openability is not an issue at GVB. The switches form part of the express tram network, which is subject to the Metro Regulations. A safety system is used and the possibility of a switch being thrown open by a vehicle movement is not a factor.

### **EBA statements**

At RandstadRail, two types of switch machines are used for the blades and one type for the mov-

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<sup>36</sup> Fail-safe is a concept that is incorporated into the design of a product to ensure that a safe situation arises or is maintained in the case of a malfunction (NEN-EN 50129:2003 and Railway applications).

able points. These were approved by the EBA.<sup>37</sup> The EBA statements received indicated that they would remain valid for the types of switch machines referred to until August 2008. For all types, the electrical control system, i.e. connection to the safety system, must be demonstrated for each application. In other words, an ISA statement confirming that the switch machine functions properly with the safety system must be issued. That statement can only be issued after the relevant safety case has been formally completed.

Documents from the suppliers indicated that the switch machines for the blades had been modified. In addition, the accompanying explanations indicated that the modifications had been made at several companies. Even for RandstadRail there are two modification pages for each type of switch machine. Each type of switch machine nevertheless has the same type number. It is therefore impossible to determine the type/version/modification in question on the basis of the type number.

Moreover, an EBA statement formally loses its validity if a modification is made. A new inspection is then required to determine whether the applicable safety requirements have been met. Such an inspection did not take place for the switch machines delivered to RandstadRail.

### **Damage during the building phase**

The original RandstadRail plan did not provide for rail replacement on a large scale. Railway-related activity for RandstadRail would remain limited to the replacement and building of switch connections. During an inspection carried out in the spring of 2005 the Haaglanden Urban District observed that the quality of the rails in Zoetermeer (the 'Krakeling'<sup>38</sup>) and the connection to the former Hofplein Line was such that the remaining service life was considerably shorter than had originally been assumed. During conversion work in the summer of 2006, the decision was made to convert 36 km of railway. This conversion was included by the municipality of The Hague (PoRR) in the RandstadRail implementation plan. The conversion, testing and trial operation period was therefore extended from 6 to 12 weeks.

The switches had already been put in place during the building phase but the safety system was not yet operational. During that period, construction vehicles traversed the switches. During an inspection of all switch machines following the derailment on 29 November 2006, the municipality of The Hague (PoRR) and HTM discovered that 13 of the 19 switches with movable points had been opened by railway vehicles at an earlier stage. Some of the switch machines had been damaged to such a degree that they needed to be repaired. The municipality of The Hague (PoRR) stated that the damage had probably been caused during the conversion phase by construction railway vehicles and lorry-mounted cranes that opened the switches incorrectly, and that these occurrences were not reported by the works supervisor. The fact that incorrect use of the switches could result in damage was recognised in, among other things, the basic documentation on switches.

De wissels op het DRVR gebied van RandstadRail zijn openrijdbaar, behalve de wissels met een beweegbaar puntstuk. Deze wissels zijn echter niet vergelijkbaar met de klapwissels op het Haagse tramnetwerk. Bij het openrijden van een wissel op RandstadRail kan het wissel namelijk beschadigd worden, wat niet door de spoorbeveiliging wordt opgemerkt. Wanneer een volgend voertuig het wissel dan met hoge snelheid passeert, kan dit tot een ontsporing leiden. Om deze reden dient een RandstadRail wissel na openrijden gecontroleerd te worden. Dit in tegenstelling tot een klapwissel dat bij openrijden niet beschadigd wordt.

Figure 5 – Excerpt from the basic documentation on switches

### **Inspection of the switch prior to the start of operations**

The Site Acceptance Test (SAT) on 7 August 2006 revealed that switch 846 was damaged. A SAT involves taking measurements of various settings and performing a functional test of the switch in combination with the safety system.

A note was made on the SAT form of switch 846 that the point of the switch had been opened by a vehicle movement during the building phase and that the switch could no longer be manually operated. The vehicle opening movement could not actually have been observed. The inspector probably concluded that the point of the switch had been opened in that manner based on the damage pattern observed.

<sup>37</sup> The Eisenbahn-Bundesamt (EBA) is the German railways safety supervisor. Among other things, it must approve vehicles, infrastructures and railway undertakings.

<sup>38</sup> Part of the Zoetermeer City Line (ring line) in the municipality of Zoetermeer.

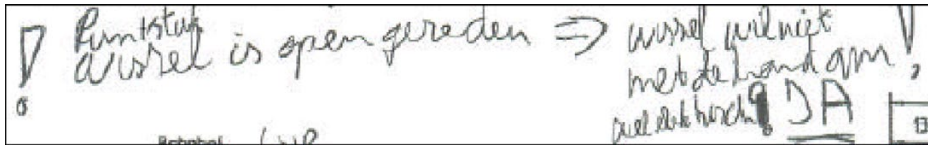


Figure 6 – Excerpt from the SAT form

The impossibility of manual operation constituted an operational limitation. This limitation was resolved on 22 August 2006. The measures taken to resolve the limitation were not documented. Verbal explanation provided by the municipality of The Hague (PoRR) indicated that the oil line of the switch’s hydraulic drive was replaced.

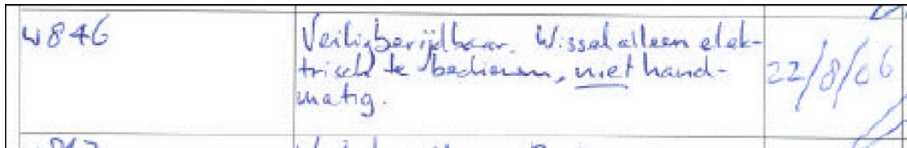


Figure 7 – Excerpt from the SAT form

The internal components of the switch were not checked for damage after the SAT. At the time, the control bolt in the switch was almost certainly already damaged, as a result of which it could not be moved. A Klammer Test in combination with a test to determine whether both control bolts could be moved would probably have revealed the problem.<sup>39</sup> These tests were not performed. Although the tests did not form part of the SAT procedure, they were specified in the basic documentation on switches. The basic documentation specifies a range of tests to identify technical problems with switches. The note concerning damage made on the SAT form could have been reason to perform such tests, given the stipulation in the basic documentation that a RandstadRail switch must be checked for damage after being opened by a vehicle (see Figure 5 excerpt).

**ISA statement**

A range of statements relating to specific components of the safety system and the tests performed were prepared by the ISA for the safety system. These statements date from the middle of 2006.

In one of the statements, the ISA for the safety system noted that during the alteration of the switch position, the switch machine already indicated ‘in final position’ status while the mechanical lock had not yet been activated.

This note was included in additional conformity-related investigation. A statement of the overall ISA is required for the railways part and, in particular, for the switches and their interaction with the safety system. These statements were absent at the time of the derailment. A conformity statement evidencing that the switch functioned safely in combination with the safety system was issued in December 2006.

**I.6 SAFETY MANAGEMENT CONDUCTED IN RELATION TO RISKS OF DERAILMENT ON A SWITCH**

Switches are critical to the safety of a railway system. The User Instructions to the Normative Document for Light Rail Safety states the following with respect to switches:

‘Derailments are cause mainly by improperly functioning switches.’

As described in the foregoing, the crucial factor in the Forepark derailment was damage to the switch that had occurred during conversion work when the newly placed switches were traversed by construction vehicles. The damage to the switch meant that the connection between the switch blade and switch machine could no longer take greater forces and broke.<sup>40</sup> This resulted in an unsafe switch position that was not reported in the safety system.

<sup>39</sup> The Klammer Test is performed to check the position of the bolt (described on p. 34 of the switch machine manual of 25 April 2006).

<sup>40</sup> The connection met specifications but there was little safety margin.

The following constituent safety cases were relevant to the derailment in question:<sup>41</sup>

- constituent safety case for railways (switches section);
- constituent safety case for safety systems and process control systems.

Final responsibility for supplying a constituent safety case for railways as prepared by an engineering firm rested with the Haaglanden Urban District and Rotterdam City Region. This safety case had to show that the railway infrastructure satisfied the Schedule of Requirements in terms of design, construction and layout. Of relevance to the derailments, the Schedule of Requirements stated the following with respect to the switches:<sup>42</sup>

'Switches may not be located at stops and crossings. RET switches with movable points are used on the shared section; RET switches are used on the Hofplein Line. HTM tram switches adjusted to the maximum permissible speed of the section in question are used on the Zoetermeer Line. All convergence switches must be electrically driven, mechanically locked and made safe electronically. [Schedule of Requirements, requirement 5 1 1 5]

For sections 5, 8, 9, 10 and 12, switches with half embedded blades and movable points must be used. A technical specification of these switches will be prepared. [Schedule of Requirements, requirement 5 1 5 9]'

No requirements relevant to the derailment were included in the constituent safety case for safety systems and process control systems. The Top Level Safety Case indicates that the interface between switches and the safety system must be shown in the constituent safety case of the safety system.<sup>43</sup>

A separate part was prepared in this constituent safety case for the switches.<sup>44</sup> The purpose of the switches part was to show that the use of switches for RandstadRail was safe and satisfied the Schedule of Requirements. The scope of the document was limited to the design, physical construction and installation of the switches. The Forepark derailment showed that the safety of a switch could also be compromised after its construction and installation, in the present case due to damage caused by incorrect use of the railway and newly installed switches by construction vehicles at a time when the safety system was not in operation. These risks were outside the scope of the safety case. This shortcoming is addressed again in the further description of the contents of the switches part.

A closer study of the contents of the switches part revealed that they were incomplete. A variety of questions were included in the document which indicate that certain information was lacking and still had to be obtained. The way in which the design would be assessed and verified in the building phase was not described, for example. (A section title was included for the matter in question but there is no accompanying text.)

The process for inspecting and testing the switches was described, however. Among other things, this description included the openability test. In that regard, the author made the following the qualification:

'... openability itself is, for that matter, not critical to the safety of the switches. It ensures that if a component critical to safety fails (signals system) or a vehicle passes a stop signal, damage to the switch will remain limited.'

In addition, the safety case refers to the Site Acceptance Test (SAT), which was performed under the supervision of the supplier to check that the switches had been placed and functioned properly. A SAT consists of an external inspection of a switch after it has been incorporated into the railway. Measurements are taken and checks carried out to determine whether the switch can be operated manually and by the electronic control system. The SAT procedure does not include an internal inspection of the switch and the checking of components for damage.

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<sup>41</sup> The Inspectorate for Transport and Water Management comprehensively addressed the role of the drivers involved and central traffic control in its report. The Dutch Safety Board did not include this aspect in its consideration. The constituent safety cases for traffic control and operations are therefore not addressed here.

<sup>42</sup> RandstadRail Safety Management Plan prepared by the Haaglanden Urban District (definitive, 22 May 2006).

<sup>43</sup> RandstadRail Top Level Safety Case prepared by the Haaglanden Urban District (version 0.4, 7 September 2006, draft status).

<sup>44</sup> Constituent safety cases for railways, switches part. The front page states version 0.1 14 November 2006; the document history states version 0.3 22 December 2006 (draft publication for the derailment investigation).



The risk of damage to switches as a result of incorrect use and how this risk was to be managed was not described in the switches part. In addition, the way in which use would be made of the railway and newly installed switches by construction vehicles during the building phase while the safety system was not operational was not addressed. This meant that switches could be passed by vehicles travelling in a direction for which the switches were not set without any reports of such movements being generated in the safety system. Moreover, it has since become clear that switches were incorrectly traversed by vehicles, i.e. attempts were made to open them by vehicle movements, while they were clamped in position, resulting in damage.

Due to the tight planning of the conversion, testing and trial operation period, performance of the SATs and their results were not described in the switches part. That doing so would not be possible had already been announced in the SMP. By way of substantiation, reference was made to the 'evolving' file with SAT documents. It was furthermore stated that, 'based on the current SAT file, the municipality of The Hague, HTM and RET have concluded that there are no problems critical to safety'.

The SAT form for switch 846 indicates that, based on the damage pattern observed, the switch was believed to have been opened by a vehicle movement. The form also specifies an operational limitation, namely that it was not possible to operate the switch manually. This limitation was resolved two weeks later. The municipality of The Hague (PoRR) did not keep written records of the measures taken and whether those measures included an internal inspection of the switch. Verbal explanation indicated that components were replaced due to problems in the oil reservoir that formed part of the manual operating system and that no issues relevant to safety were observed. The damage in the switch caused by incorrect use during the building phase was already present during the SAT and could have been detected by a Klammer Test, which is performed to check the position of the locking arm (Klammer). This test, in combination with one to ascertain whether both control bolts could be moved manually, would probably have revealed the problem. These tests are described in the basic documentation on switches. There is no information to suggest that this test was carried out.

Another check is the carrying out of trial runs on one of the switches. The safety case refers in this connection to the testing plan. As had already been announced in the SMP, the results of the trial runs were not included in the safety case. In addition, the trial operation period was short.

As described in Chapter 5, there were a variety of reasons to devote specific attention to the switches and switch machines. A number of problems might have been detected earlier had the following factors been taken into account:

- the type of switch machine used was relatively new and untested in the Netherlands;
- the EBA statement was no longer valid because modifications had been made;
- the ISA for the safety system had doubts about the type of switch machine used;
- there was no conformity statement.

In summary, the risk of damage to the switches during the building phase was not recognised in the relevant safety cases. There was reason to recognise that risk, however, given the intensity and scale of the work carried out and associated construction traffic volume after the switches had already been installed but before the safety system was operational. The municipality of The Hague (PoRR) had indeed issued working instructions for the construction traffic. However, based on interviews and reports of meetings between the municipality of The Hague (PoRR), the suppliers and HTM/RET, the Dutch Safety Board concludes that these working instructions were insufficiently complied with during the building phase, as switches were repeatedly opened and consequently damaged by vehicle movements. In addition, the railway contractors were not responsible for the quality of the switches upon completion because they had been made available by the municipality of The Hague (PoRR) as a management delivery. Nevertheless, these issues did not lead to the introduction of additional measures to manage the risk of damage to the switches. Making the functional tests of switches more comprehensive by including a thorough check for damaged components would have been a logical course of action.



## J. SWITCHES

A switch enables railway vehicles to be guided from one railway track to another. A railway vehicle may either be leaving the railway it is on (diverging route) or travelling on a railway that is merging with another (converging route).



Figure 8 - Switch without movable point

### Divergence

A switch may lead to the right or to the left. Blades at the beginning of a switch move in order to determine the direction taken. Movement of the blades is effected by a switch machine. The switch machine can itself be operated in a variety of ways; manually or hydraulically on the spot, remotely by means of electric power or automatically based on train recognition.

The rails of a switch cross at its point. In order to enable the wheel flange to pass in one direction, a small gap is required in the point in the other direction. In most cases this is not a problem. If the vehicle has small wheels, however, such as in the case of trams, the probability that a wheel will be guided in the wrong direction on a point is relatively high. In terms of passenger comfort, a small gap in the rail is also not desirable at higher speeds. In those cases, use is made of a movable point. In a movable point, blades also move to guide a vehicle to the left or to the right. There is therefore no gap in the direction of travel. This movable point is operated at the same time as the blades at the beginning of the switch.



Figure 9 - Movable point

### Convergence

From the perspective of a railway vehicle's direction of travel, a switch may either be in the correct or incorrect position to enable smooth passage.

In the latter case, a signal will indicate that the vehicle may not pass. If for whatever reason the railway vehicle continues over the switch, the blades will be forced into the position that is correct for the vehicle's direction of travel, i.e. the switch will be thrown open.

### Openable and non-openable switches

The forced opening of a switch by a railway vehicle is very likely to result in damage to the blades, the switch machine or the wheels of the vehicle. Moreover, the vehicle is very likely to be guided onto a railway on which another vehicle is already travelling or for which a safe route has already been established. In such cases, the probability of a serious collision is high.

After an unintended opening of a switch, it is therefore usual for the switch to be tested in terms of its functioning and checked for any damage. If no damage is observed and the switch is functioning properly, rail traffic can be safely resumed.

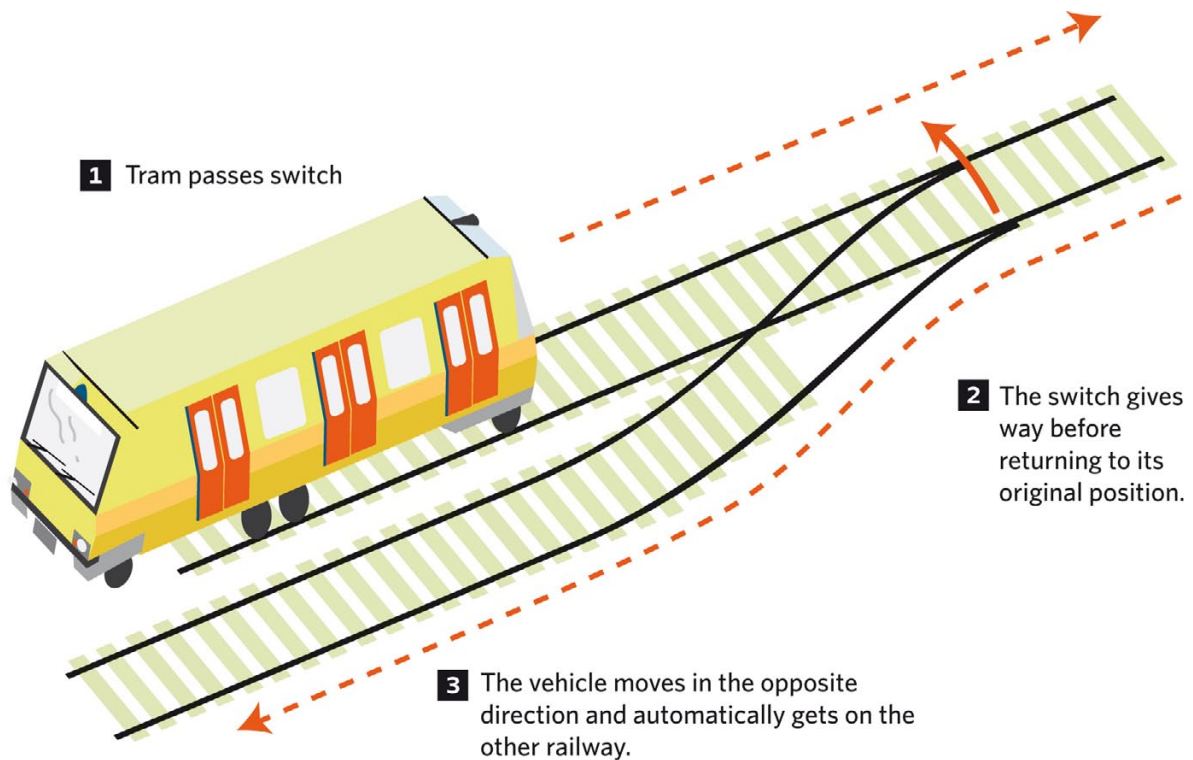
The openable switch was developed to enable operations to be resumed more quickly after an opening by a vehicle movement. An openable switch must meet two conditions: (1) the unintended

opening of a switch must be detected and (2) the switch must not be damaged when thrown open by a vehicle movement. A switch is only openable when it guarantees fulfilment of these two conditions. In all other cases the switch is a non-openable one.

The first condition can be incorporated into the safety system. To meet the second condition, a number of switch machines are available to enable the blades to shift smoothly to the desired position following a certain movement or an exertion of force. Such switch machines are as yet unavailable for movable points. A movable point is more likely to be damaged as a result of being thrown open. Detection by the safety system is also not guaranteed by suppliers. A switch with a movable point is therefore by definition non-openable.

### Openable switch

Especially in city tram networks, simple switches are used that are not electrically operated but whose switch machines feature a mechanism that enables opening movements to take place without resulting in damage. This type of openable switch returns to its original position after the railway vehicle has passed; the switch gives way, as it were, when the tram passes and subsequently returns to its original position. Such switches are usually located where two railway tracks converge and at the end of railway routes where a tram has to switch tracks to travel the route in the opposite direction. The entire tram first passes the switch, which gives way during this passage (1). The vehicle can then move in the opposite direction (2) and will automatically be guided to the other track.



©Dutch Safety Board - RandstadRail/openable switch

Figure 10 - Openable switch

## L. ANALYSIS OF SPONTANEOUS DERAILMENT NEAR THE TERNOOT STOP

This appendix describes the analysis of the derailment of a RandstadRail vehicle near the Ternoot stop on 29 November 2006. Answers are provided to the following questions:

- What was the actual situation at the location? Section L.1 sets out the factual information concerning the prior history of the track layout near the Ternoot stop and the rolling stock involved.
- What happened during the derailment? Section L.2 sets out the facts of the derailment.
- Why did the vehicle derail? Section L.3 summarises the causes of the derailment.
- How could this situation arise? Section L.4 describes the way in which the organisations involved structured and organised their respective responsibilities in relation to the situation that led to the derailment.
- Section L.5 sets out the key conclusions in relation to this derailment.
- Had the risks related to the derailment been recognised and, if so, how were they managed? Section L.6 contains an analysis of the safety management aimed at managing these risks.

In answering the first two questions, use was made of the results of the internal investigation reports prepared or commissioned by HTM.

### L.1 FACTUAL INFORMATION CONCERNING THIS DERAILMENT

The curve at Ternoot was an existing feature of the network, located between the 'Tramplatform Den Haag CS' and 'Prinses Beatrixlaan' RandstadRail stops. The curve is used by both RandstadRail lines 3 and 4 and city tram lines 2 and 6. The RandstadRail Erasmus Line does not use the curve. The curve comprises a concrete viaduct onto which the rails have been directly attached and has a curve radius of 200 metres towards the left (as seen from Central Station). The superstructure was not modified for RandstadRail.

The curve at Ternoot is particular in certain respects.<sup>45</sup> It has a high degree of superelevation (150 mm instead of the maximum 100 mm permitted by the RandstadRail Schedule of Requirements), for example. Superelevation is the difference in height between the two rails of a track and is made by elevating the outer rail or depressing the inner rail. Superelevation is used to counteract centrifugal force in curves. Without superelevation, the lateral acceleration of a vehicle would be higher. The curve at Ternoot has a high degree of superelevation because it was designed to accommodate a travelling speed of 70 km/h. The advent of faster vehicles had been predicted at the time the curve was designed 30 years ago.

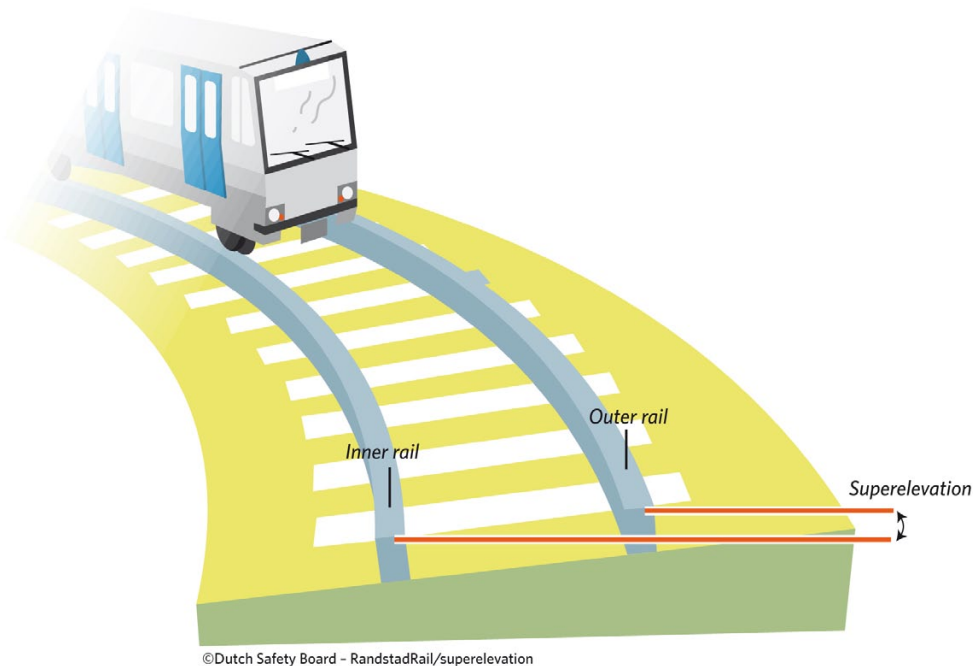
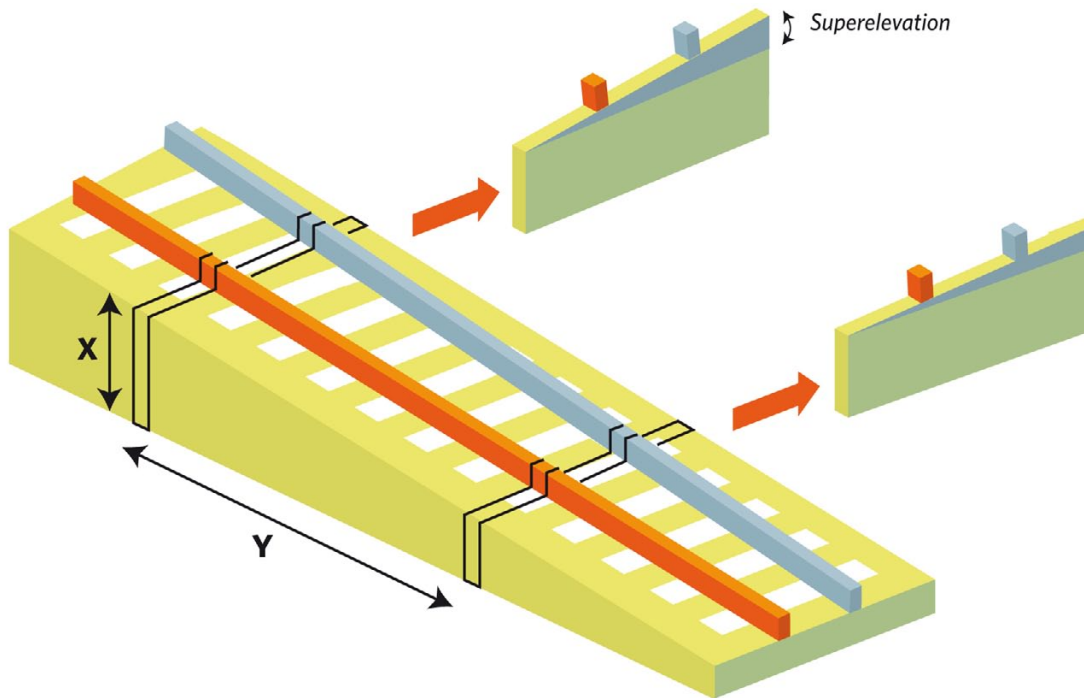


Figure 11 - Superelevation

<sup>45</sup> See Appendix M for an explanation of the terms superelevation, transition spiral and distortion.

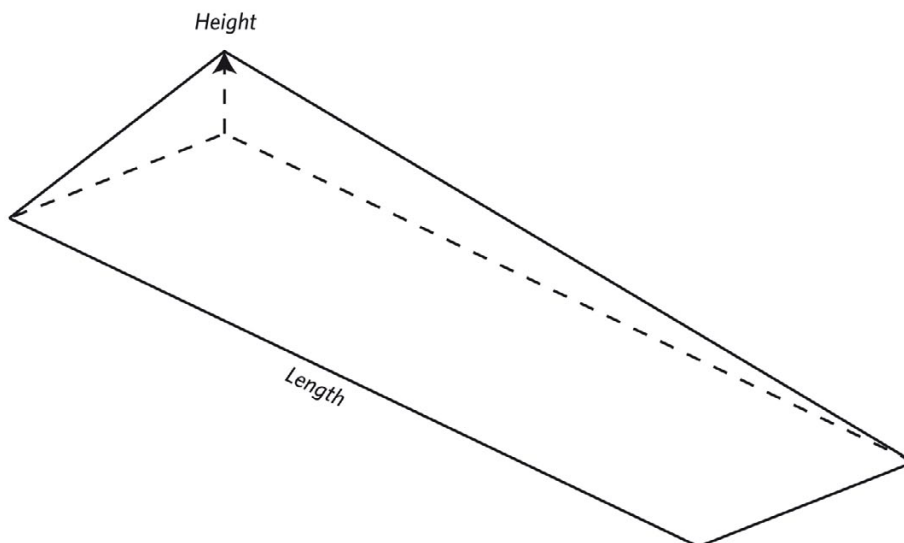
On behalf of the Haaglanden Urban District, HTM made the requirements relating to the existing infrastructure and the infrastructure to be built available to the vehicle manufacturer for the calculation of the derailment risk in the curve at Ternoot. Because the values in the Schedule of Requirements were insufficiently accurate, the vehicle manufacturer itself also specified preconditions that the infrastructure would have to meet in order to be used safely. These preconditions were based on German guidelines for the design of railway lines. According to these specifications, a transition spiral of 1:500 at most is permitted in the case of 150 mm of superelevation. The transition spiral is the rate (angle) at which the required degree of superelevation is built up or reduced to zero (level tracks). The transition spiral of the Ternoot curve is 1:300, which means that superelevation is built up at a faster rate than permitted by the specifications.



©Dutch Safety Board - RandstadRail/transition spiral

Figure 12 - Transition spiral ( $X Y$ )

The building up or reduction of superelevation results in distortion of the track. Distortion can be represented as a level plane of which one of the corners has been raised. Excessive distortion increases the risk of derailment. The shorter the transition spiral, the greater the distortion required.



©Dutch Safety Board - RandstadRail/distortion

Figure 13 - Distortion ( $h/l$ )

## L.2 THE DERAILMENT

At 18:04 on 29 November 2006, HTM's RandstadRail vehicle 4021 was travelling at low speed (the vehicle had started from a stationary position shortly before the actual derailment) through the curve when the right front wheel of the second bogie (running bogie) derailed.

The new RandstadRail vehicles are so-called low-floor trams of the RegioCitadis type. Given that the vehicles were new, little practical experience had been acquired with respect to the running characteristics of the bogies on city tram rails at the time RandstadRail operations were launched.<sup>46</sup> The new vehicles have different running characteristics than the old HTM city trams because they have greater torsion stiffness.<sup>47</sup> This is necessary to counteract the rotation of the sections of an articulated tram in relation to each other.<sup>48</sup> In addition, it is known that the wheels of bogies without axles such as those fitted to RegioCitadis vehicles 'stick' to the rails at low speeds.

When a vehicle travels at low speed through a superelevated curve, wheel loads are redistributed: the vehicle's centre of gravity shifts to the inside of the curve, which means that the wheel loads of the outer wheels decrease. Measurements taken of the actual track layout after the derailment on 29 November revealed that the distortion was greater than the permitted maximum (37 mm instead of 20 mm over a length of 10 m<sup>49</sup>). This greater distortion meant that the vehicle was subjected to a greater twisting momentum than anticipated. Given the greater torsion stiffness of the RegioCitadis model, such a vehicle will not follow this twisting momentum but, rather, certain wheels will lose contact with the rail (reduction of wheel load).

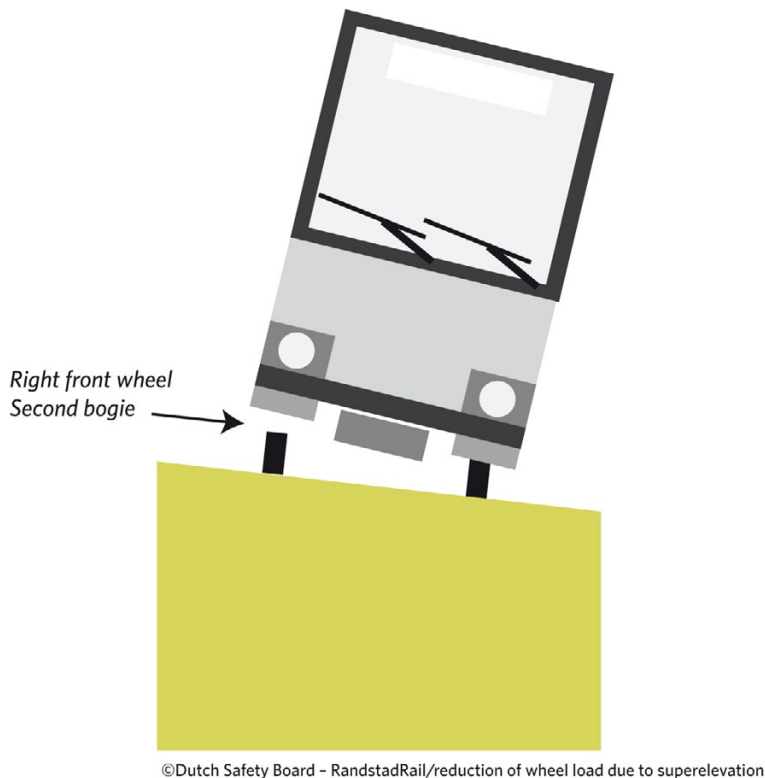


Figure 14 – Reduction of wheel load due to superelevation and distortion (as seen when facing the vehicle)

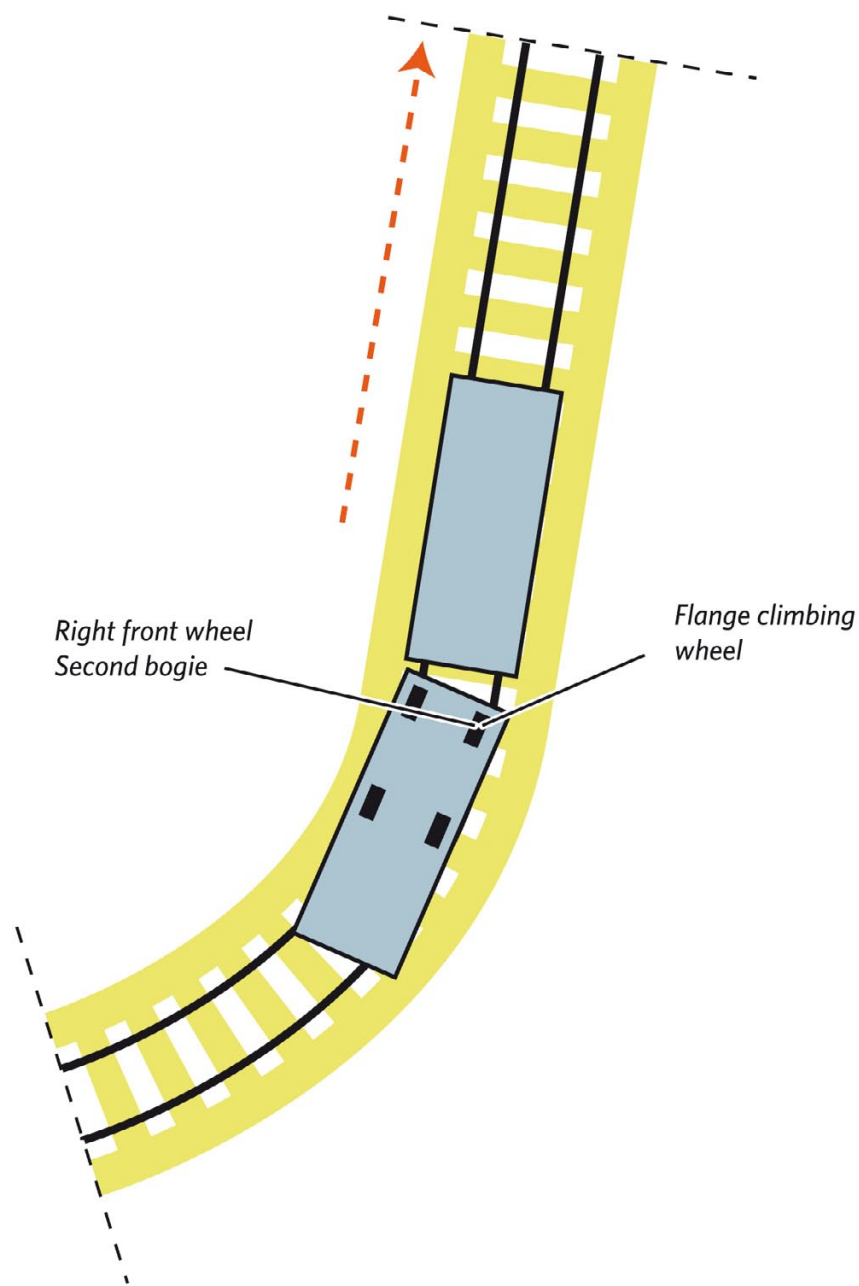
In addition, it had been dry for a number of days. In dry weather, a considerable amount of friction occurs between the rail and wheel. Flange climbing is more likely to occur as a result. The combination of these factors caused flange climbing and the derailment of the right front wheel of the first bogie.

<sup>46</sup> Inspection runs did take place, however, in Germany and the Netherlands for the approval of the vehicles by EBA in Germany and the ISA in the Netherlands.

<sup>47</sup> See Appendix N on low-floor trams and consequences for handling characteristics.

<sup>48</sup> An articulated tram consists of several, flexibly joined sections.

<sup>49</sup> In additional calculations for the Ternoot curve, the vehicle manufacturer considered a situation comprising a distortion of 33 mm over a length of 10 m acceptable for a period of 5-6 months.



©Dutch Safety Board - RandstadRail/flange climbing wheels

Figure 15 - Flange climbing due to friction between rail and wheel flange

### After the derailment

After the derailment on 29 November 2006, the track layout on the viaduct was modified and brought into line with the preconditions of the vehicle manufacturer. In addition, measurements were taken of the rest of the RandstadRail network to determine whether the infrastructure deviated from the preconditions at other locations so that appropriate measures could be taken if necessary.

Moreover, international experts were engaged to assess track layout in the 'Krakeling'<sup>50</sup> of the Zoetermeer City Line and formulate 'new standards'.<sup>51</sup>

<sup>50</sup> Part of the Zoetermeer City Line (ring line) in the municipality of Zoetermeer.

<sup>51</sup> RandstadRail Update, September 2007, [www.randstadrail.nl](http://www.randstadrail.nl), 26 September 2007.



### L.3 WHY THE VEHICLE DERAILED

The direct cause of the derailment was the track layout. The curve is superelevated to accommodate higher speeds than the ones with which it was used. This superelevation is built up at a considerably faster rate than the maximum permitted by the vehicle manufacturer's preconditions. Slow moving vehicles in particular are therefore at greater risk of derailing in the curve's transition spiral.

Another crucial factor is the specific characteristics of low-floor trams.<sup>52</sup> Railway vehicles with low floors are usually stiffer in terms of construction than conventional rolling stock. The vehicles used on the RandstadRail network have a greater torsion stiffness than the older trams used on The Hague city tram network. Stiffer rolling stock is more sensitive to deviations in track layout.

In addition, it is important to note that the derailment occurred at the end of the derailment construction that was put in place on the rest of the Ternoot viaduct. This construction does not prevent derailments but, rather, prevents a derailed vehicle from continuing off the rail head.

### L.4 WHY THE SITUATION AROSE

#### **Infrastructure requirements from the perspective of vehicle operation**

As stated in the previous section, low-floor vehicles tend to be more sensitive to deviations in the infrastructure than conventional rolling stock. In principle, new vehicles should be able to use existing infrastructure without any problems. It is therefore usual for the infrastructure manager to specify the requirements that the infrastructure meets. These are not design requirements, i.e. the requirements that newly constructed infrastructure must meet but, rather, operational requirements, i.e. minimum requirements before maintenance work must be carried out; in other words, the lowest permitted level of quality. The infrastructure manager must specify the minimum requirements that the infrastructure must continue to meet. A more favourable situation is often the case; a less favourable situation is not permitted.

It may be, however, that new vehicles impose special requirements on the railway. This is certainly the case when, rather than having custom work carried out, which was common in the past, increasing use is made of standard products. Based on the preconditions specified by the vehicle manufacturer, the infrastructure manager can be expected to determine whether the infrastructure meets the established requirements at all times. If it does not, the infrastructure manager must take special measures like adjusting the infrastructure or intensifying the inspection regime.

#### **Assessment of interface between the vehicle and the infrastructure**

Because derailment calculations carried out by the vehicle manufacturer for the new RandstadRail vehicles belonging to HTM (low-floor tram, RegioCitadis type) indicated that the distortion in combination with the high degree of superelevation could in the longer term damage the vehicles and the short transition spiral increased the probability of derailment, the vehicle manufacturer advised HTM in July 2006 to take a number of measures.<sup>53</sup> The inner rail would have to be raised by 50 mm within six to eight months to create a superelevation of 100 mm and a transition spiral of 1:450. In addition, to reduce the probability of a derailment and damage to the vehicles during the period referred to, vehicles were to travel in the curve at a minimum speed of 50 km/h.

In its consideration of this advice, HTM failed to take a number of issues sufficiently into account.<sup>54</sup> The maximum deviation in terms of track layout had to be limited to 10 mm. In addition, new signals had been placed in the Ternoot curve. A signal can indicate that a vehicle must stop. A switch was put in place for the branch in the direction of Beatrixlaan immediately after the curve. This is the normal route for the RegioCitadis vehicles that serve RandstadRail lines 3 and 4. The switch may only be traversed at a maximum speed of 25 km/h, however. This means that the RegioCitadis trams could never reach the recommended speed of 50 km/h in the Ternoot curve. Information provided by HTM, for that matter, indicated that prohibitions on stopping or mandatory minimum speeds do not apply anywhere on the tram network. Vehicles must always be able to stop for safety reasons.

In addition, the vehicle manufacturer's calculations indicated that flange climbing of 5 mm could occur. This situation would apply if, in addition to the already present distortion over a distance of

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<sup>52</sup> See also Appendix N for further explanation about specific characteristics of low-floor trams.

<sup>53</sup> Report entitled Berechnungen der Sicherheit gegen Entgleisen im Bogen auf dem Streckenabschnitt CS-Ternoot.

<sup>54</sup> In its response to the present report, the vehicle manufacturer indicated that it had not been able to take these points into account, as they concerned technical and infrastructural specifics unknown to it.

10 m, there was a deviation of 20 mm in the track layout. According to the vehicle manufacturer, the vehicle would not derail because the vehicle manufacturer had determined the so-called safety section of the contact surface between the wheel and rail as being 9 mm. In terms of railway safety and the prevention of derailment, flange climbing constitutes an uncontrolled situation, so flange climbing in itself already indicates a risk of derailment. In addition, the degree of rail wear is an important factor in terms of the probability of derailment. HTM's investigation into the derailments that occurred near The Hague Central Station on 3 and 4 November 2006 revealed that the rails in the curves had been worn to an extreme degree at several locations in the city tram network, also in the Ternoot curve.

## L.6 SAFETY MANAGEMENT CONDUCTED IN RELATION TO RISKS OF DERAILMENT IN THE TERNOOT CURVE

As described in Chapter 6, the Ternoot derailment was essentially caused by the interface between track layout and the specific characteristics of low-floor trams, in combination with a low speed of travel (the least favourable situation in terms of railway safety and the prevention of derailment). The following constituent safety cases were further analysed to ascertain whether and how these risks had been recognised in advance and to determine the measures taken as a result:

- Constituent safety case for the railways
- Constituent safety case for HTM low-floor rolling stock

The Top Level Safety Case stipulated that the wheel-rail interface had to be demonstrated in the constituent safety case for HTM low-floor rolling stock.

The constituent safety case for the railways was prepared by a consultancy and engineering firm on the instructions of the Haaglanden Urban District;<sup>55</sup> safety management staff of the Haaglanden Urban District bore final responsibility for supplying this constituent safety case. The purpose of the safety case was to demonstrate that RandstadRail's infrastructure met the safety-related requirements set out in the Schedule of Requirements. Track layout at Ternoot was not described in this constituent safety case. Interviews conducted revealed that the Haaglanden Urban District and the ISA charged with overall assessment implicitly assumed that the unmodified infrastructure already complied with the RandstadRail Schedule of Requirements in terms of track layout.

Checks were carried out, for that matter, with respect to other aspects, such as whether the new RandstadRail vehicle could use the existing city tram railways due to its greater width and, in that connection, whether the curves and stops had been properly modified.<sup>56</sup>

The vehicle manufacturer was the author of the constituent safety case for HTM low-floor rolling stock; the head of HTM's rolling stock department bore final responsibility for supplying this constituent safety case. The Haaglanden Urban District is responsible for approving the vehicles HTM operates, including HTM's low-floor rolling stock.<sup>57</sup> This approval is based on safety cases, in the present matter the constituent safety case for HTM low-floor rolling stock that was approved by the ISA.

This constituent safety case concerns the safety of the vehicle as part of the RandstadRail transport system. This relates to both autonomous safety aspects, for example fire safety, and to vehicle characteristics relevant to risks of collision, derailment, collision at crossings and fire. The safety case must demonstrate that the requirements set out in the Schedule of Requirements have been met. The requirements for RandstadRail rolling stock are set out in the Approval Requirements for RandstadRail Passenger Rolling Stock document.<sup>58</sup> The following requirements were relevant to the Ternoot derailment:<sup>59</sup>

**'Top wheel-rail requirement:** The railway vehicle must be suitable for use on RandstadRail infrastructure and may not cause damage or excessive wear to the infrastructure. This top requirement is further specified in the railway standards appendix:

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<sup>55</sup> RandstadRail safety case for railways, 7 August 2006 (version 0.4, draft status).

<sup>56</sup> RandstadRail safety case for ground-level lines of 11 July 2006 (version 0.3, draft status).

<sup>57</sup> Approval requirements for RandstadRail passenger rolling stock of 13 July 2005 (version 3.0, definitive status).

<sup>58</sup> Approval requirements for RandstadRail passenger rolling stock.

<sup>59</sup> These railway standards seem to apply to straight sections. The Schedule of Requirements is not clear on this point.

Distortion (over 6 m)	Construction max. 4 mm	Rejection measurement <sup>1</sup> max. 14 mm
Superelevation (over 6 m)	Construction max. 2 mm	Rejection measurement max. 8 mm
Transition spiral	max. 1:1000	

**Prevention of derailment safety requirement:** Safety concerning the prevention of derailment in the given operational and infrastructural conditions must be demonstrated. Fulfilment of this requirement must be substantiated on the basis of the EN 14363 standard<sup>60</sup> or in a demonstrably similar manner.<sup>61</sup>

The following requirements were contractually agreed between HTM and the vehicle manufacturer:<sup>61</sup>

Parameter	Nomi-naal	Grenswaarden normale exploitatie	Wij voldoen, extreme overgangen van de spoorwijdte dienen met gereduceerde snelheid gepasseerd te worden. Wij gaan er vanuit dat het gestelde in de ORE B55 RP8 door de infrastructuur gehaald wordt, de hier genoemde waarden vallen binnen deze standaard.
Spoorwijdte	1435 mm	min. 1432 mm max. 1455 mm	
Afwijking spoorwijdte	0 mm	1:300	
Horizontale boogstraal	Nvt	min. 28 meter	
Verticale boogstraal (top en dal)	Nvt	min. 300 meter	
Combinatie verticale/horizontale boog	nvt	min. horizontaal 30 meter en verticaal 300 meter	
Afwijking spoorligging horizontaal (schiff)	0 mm	koorde 1 meter: pijl max. 4 mm koorde 4-11 meter: pijl max. 8 mm	
Afwijking spoorligging verticaal (hoopte, per spoorstaaf)	0 mm	koorde 1 meter: pijl max. 2 mm koorde 4-9 meter: pijl max. 20 mm	
Scheluwte	0 mm	12 mm op meetbasis 2 meter 20 mm op meetbasis 6 meter 20 mm op meetbasis 10 meter	

This table does not state either that the combination of distortion and superelevation constitutes a limiting condition, which was later revealed by the derailment calculations carried out.

The vehicle manufacturer prepared a constituent safety case for the vehicle entitled *Sicherheitsbericht Fahrzeug RegioCitadis RandstadRail*.<sup>62</sup> This constituent safety case describes the measures taken by the manufacturer to prove the safety of the vehicle. Development of the RegioCitadis RandstadRail vehicle was based on the RegioCitadis vehicle used for RegioTram services in Kassel (RTK), Germany. In the constituent safety case the manufacturer indicated that RTK experiences were used to substantiate safety.

The ways in which requirements relating to the prevention of derailment were met were substantiated by the vehicle manufacturer in the *Berechnung der Sicherheit gegen Entgleisen* document.<sup>63</sup> The vehicle manufacturer used a simulation model to calculate the maximum permissible superelevation and transition spiral. This document indicates that, in the given conditions, the maximum permissible transition spiral was 1:500 in the case of a superelevation of 150 mm and 1:300 in the case of a superelevation of 75 mm.

The Ternoot curve did not meet the vehicle manufacturer's preconditions. HTM therefore issued instructions for the risk of derailment in the Ternoot curve to be calculated using data it provided about track layout (based on design drawings, curve radius of 199.5 m, superelevation of 150 mm and a transition spiral of 1:300 mm).<sup>64</sup> Prior to the issue of this document, the vehicle manufacturer informed HTM that provided the maximum permissible deviation was 10 mm at most and the distortion did not exceed the value of 6% (to be guaranteed by the operator), the risk of derailment would not manifest itself.<sup>65</sup> In addition, the vehicle manufacturer recommended maintaining

<sup>60</sup> NEN-EN 14363:2005 Railway applications - Approval tests for the handling characteristics of railway vehicles - Tests of dynamic handling characteristics and stationary tests.

<sup>61</sup> Pflichtenheft HTM, vehicle manufacturer (1 December 2004).

<sup>62</sup> Sicherheitsbericht Fahrzeug RegioCitadis RandstadRail of 29 August 2006 (version 1.0). The vehicle manufacturer did not use the title of safety case for this document because the EN50129 structure was not adhered to in full.

<sup>63</sup> RegioCitadis für RandstadRail Zoetermeerlijn: Berechnung der Sicherheit gegen Entgleisen, 21 July 2006.

<sup>64</sup> RegioCitadis für RandstadRail Zoetermeerlijn: Berechnung der Sicherheit gegen Entgleisen im Bogen auf dem Streckenabschnitt CS-Ternoot, 22 October 2006.

<sup>65</sup> Betriebsbedingungen zum Bogen vor dem Bahnhof Den Haag, 5 September 2006.

a travelling speed of 50 km/h to prevent damage to vehicles and, within six to eight months, to reduce the superelevation to a maximum of 100 mm and the transition spiral to a maximum of 1:450. The calculations make clear why the maximum deviation applied in the basic assumptions was important: if the deviation was greater, i.e. 20 mm, wheel loads would drop and flange climbing of up to 5 mm would occur with one of the wheels.<sup>66</sup> According to the vehicle manufacturer, the vehicle would not derail even then, as this would only occur after flange climbing of 9 mm. It must be noted in this regard that the vehicle manufacturer was assuming a rail that was not worn out. This is of relevance given that information recently received from HTM indicated that the rails in the Ternoot curve were worn out (see following section).

With respect to the recommended speed, the system of signals and the presence of a switch were not sufficiently taken into account. These meant that vehicles regularly had to travel at lower speeds (a maximum speed of 25 km/h in the case of traversing a curving switch) or even stop (if instructed by a signal to do so).<sup>67</sup>

After the derailment on 29 November 2006, it became clear that track layout in the Ternoot curve was more critical than indicated in the design drawings. One of the problems was that the distortion over a longer distance is 37 mm, almost twice as much as the standard 20 mm. In itself this is not exceptional. For this reason, it is common in civil engineering projects to require that 'as built drawings' which contain measurements of actual layout be supplied after completion of the work. The railway at Ternoot had been in place for around 30 years. A logical course of action would therefore have been to take measurements prior to the arrival of the new RandstadRail vehicles. Track layout in the heavy rail network is frequently measured by a Eurailscout train specially equipped for the purpose. This means that track layout is continuously monitored. In the approval process for the use of new rolling stock on existing infrastructure, it is usual for the new type of vehicle to be fitted with measuring equipment to obtain data on the vehicle's dynamic handling characteristics in different conditions. The matter concerns the interaction between the vehicle and the infrastructure. The matter does not concern measuring track layout, although layout could possibly have been derived from the measurements recorded.

The ISA who assessed the safety case for rolling stock indicated in his assessment report that he had insufficient information at his disposal to assess whether the interaction referred to was as it should be.<sup>68</sup> The ISA noted in that regard that fulfilment of the requirements imposed by the vehicle on infrastructural layout would have to be monitored in the constituent safety cases for the infrastructure (in the case of Ternoot this concerned the constituent safety case for railways) based on the vehicle manufacturer's specifications. Given that the constituent safety case for railways does not contain any information about actual track layout at Ternoot, the Dutch Safety Board concludes that no assessment of the de facto situation was carried out.

In summary, it can be said that HTM recognised that the situation at Ternoot was not in compliance with the RandstadRail Schedule of Requirements and that therefore there was a potential risk of derailment. This issue was only recognised at a late stage when, following delivery of the vehicles and first trial runs, it became clear that the specifications for superelevation and distortion in curves were more critical than those indicated in the RandstadRail Schedule of Requirements. HTM therefore took a control measure by asking the vehicle manufacturer to carry out additional calculations of the derailment risk in the Ternoot curve. No check was carried out, however, to determine whether the basic assumptions used by the vehicle manufacturer on the basis of design drawings supplied by HTM actually matched actual track layout. Such a check should have been carried out, as the vehicle manufacturer had clearly stated the importance of accurate basic assumptions to HTM when issuing its recommendations.

Safety management staff members of the Haaglanden Urban District were not aware of the recommendations made to HTM by the vehicle manufacturer. The ISA of the Top Level Safety Case was aware of them, however, but assumed that the matter would be properly resolved, given that the parties concerned, i.e. the vehicle manufacturer as the specialist on vehicle handling characteristics and HTM as the supplier of data on track layout, were in contact with each other. In addition, in his assessment report on the safety case for rolling stock, the vehicle manufacturer's ISA noted that the safety of the interface between vehicle and infrastructure was not in fact ensured. Nevertheless, the Haaglanden Urban District and HTM did not take measures to manage the risk by determining through measurements whether the existing infrastructure was in compliance with the Schedule of Requirements and requesting a second opinion about the risk of derailment.

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<sup>66</sup> RegioCitadis für RandstadRail Zoetermeerlijn: Berechnung der Sicherheit gegen Entgleisen im Bogen auf dem Streckenabschnitt CS-Ternoot, 22 October 2006.

<sup>67</sup> In its response to the present report, the vehicle manufacturer indicated that it had not been able to take these points into account, as they concerned technical and infrastructural specifics unknown to it.

<sup>68</sup> RegioCitadis Assessment Report for RandstadRail, 17 August 2006 (version 0.2, provisional status).

## M. SUPERELEVATION AND DISTORTION

### Superelevation

Superelevation is the banking of a road or railway. Superelevation is used in curves to counteract centrifugal force. In addition, the edges of roads are slightly cambered to ensure the proper drainage of water from the road surface. Superelevation in road construction is usually expressed as a gradient  $i$ , while in railway construction it is usually defined as the difference in height between the rails expressed in millimetres.

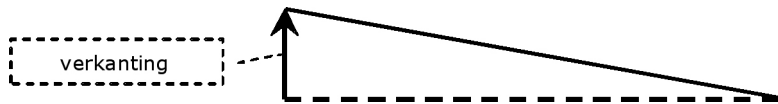


Figure 16 - Superelevation

### Superelevation of railways

Without superelevation, centrifugal forces operating on a train would cause additional wear to the rails and wheels and adversely affect passenger comfort. The risk of derailment would also be greater. Superelevation is expressed as the difference in height between the two rails. In the Netherlands, the maximum superelevation permitted is normally 150 mm. Along a platform, the maximum is 60 mm and, at a crossing, 75 mm.

### Excessive and deficient superelevation

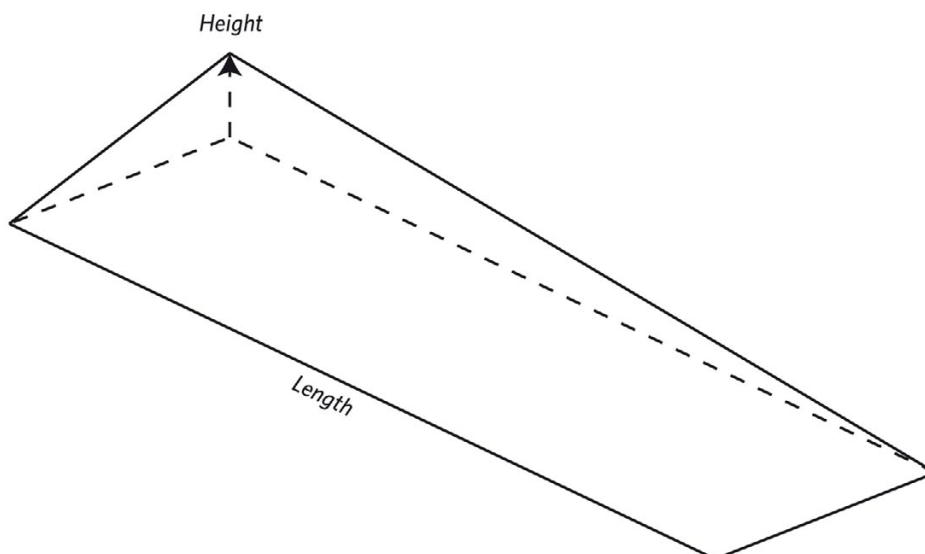
The superelevation of a railway is intended for a certain speed. Trains that travel too slowly or even stop in a superelevated curve experience excessive superelevation. These trains will lean too much to the inside of the curve. Trains that travel at an excessive speed through a superelevated curve will experience deficient superelevation and lean too much towards the outside of the curve. A maximum superelevation deficiency of 120 mm is adhered to in the Netherlands.

### Transition spiral

The transition spiral is the rate at which a certain level of superelevation is built up or, in other words, the distance over which the transition is made from straight level rails to superelevation of the rails in a curve.

### Distortion

Distortion can be represented as a level plane of which one of the four corners has been raised (see following figure). Distortion is defined as height 'h' over length 'l' (6 metres is usually adhered to for this purpose). There is no standard for distortion in the Netherlands. The standard for distortion in Germany is 100 millimetres. The build up of superelevation results in distortion. The greater the degree of superelevation required, the greater the distortion.



©Dutch Safety Board - RandstadRail/distortion

Figure 17 - Distortion

## **N. LOW-FLOOR TRAMS AND CONSEQUENCES FOR HANDLING CHARACTERISTICS**

In public transport, the term low-floor is used to refer to vehicles like buses and trams whose floors are considerably lower than those of traditional vehicles. Low-floor vehicles have become increasingly common in recent years. This is the result of efforts to make public transport more accessible to, for example, wheelchair users and individuals with perambulators. In addition, low-floor vehicles make it easier for passengers in general to board and disembark.

Traditional, non-low-floor railway vehicles have heavy bogies with individually suspended wheels or axles. Irregularities in the railway are absorbed by a double bulk suspension system before they are felt in the vehicle's body: the axles in a bogie are suspended within the bogie and the bogie is suspended relative to the vehicle's body. Bogies are located either underneath vehicle bodies or underneath the connection between two vehicle bodies.

In the case of a low-floor tram, the floor is much closer to the top of the rail heads. This is because the floor must remain low throughout the vehicle, certainly at the connections between the vehicle's sections. There is therefore no space to use traditional bogies. Alternatives are used, such as smaller wheels or independent wheels instead of two wheels to a single axle.

One result is that irregularities are not absorbed by a double bulk suspension system as is the case with traditional bogies but, rather, by a single, often simplified, bulk suspension system. In addition, placement on traditional bogies is not possible, which means that sections of the vehicle body must be connected to each other in a different way. This results in stiffer connections between vehicle bodies than is the case with traditional rolling stock, where each vehicle body or section can move more freely in relation to each other. The stiffer connections turn a low-floor tram into of a long, stiff container, so to speak, that is more sensitive to curves, distortion and railway irregularities than a vehicle comprising multiple shorter bodies or sections which are connected to each other more flexibly (the traditional tram).

The design of a low-floor tram also means that certain components have to be incorporated into the top of the vehicle rather than underneath the vehicle body. This results in a different weight distribution than is the case with traditional models and therefore in different handling characteristics.



## **O. ANALYSIS OF DERAILMENTS NEAR THE HAGUE CENTRAL STATION**

This appendix describes the analysis of the derailments of RandstadRail vehicles near the tram platform of The Hague Central Station on 3 and 4 November 2006. Answers are provided to the following questions:

- What was the actual situation at the location? Section O.1 sets out the factual information concerning the rails near The Hague Central Station and the rolling stock involved.
- What happened during the derailments? Section O.2 sets out the facts of the derailments.
- Why did the vehicles derail? Section O.3 summarises the causes of the derailments.
- How could this situation arise? Section O.4 describes the way in which the organisations involved structured and organised their respective responsibilities in relation to the situation that led to the derailments.
- Had the risks related to the derailment been recognised and, if so, how were they managed? Section O.5 contains an analysis of the safety management aimed at managing these risks.

In answering the first two questions, use was made of the results of the internal investigation reports prepared or commissioned by HTM.

### **O.1 FACTUAL INFORMATION CONCERNING THESE DERAILMENTS**

Shortly after departing on railway 1 from the tram platform of The Hague Central Station in the direction of the city centre, vehicles traverse a viaduct above Rijnstraat (the Muzen Viaduct). The railway on this viaduct curves to the left with a curve radius of 60 metres. The railway is of type S49 (Vignoles type with a rail head rather than the grooved rails often used in city tram networks) and 900 quality, i.e. a rail type with a tensile strength of 900 N/mm<sup>2</sup>. The rails were replaced in April 2006. In addition, all axles of a certain type of bogie used by The Hague city trams were replaced in the period 2004-2006.

### **O.2 THE DERAILMENTS**

A vehicle derailed in this curve on 12 August and two other ones on 3 and 4 November 2006. The 12 August incident involved a city tram of The Hague, while those that occurred on 3 and 4 November involved new RandstadRail vehicles belonging to HTM (low-floor tram, RegioCitadis type). The vehicles were travelling at 20 km/h. The maximum permitted speed on the section is 50 km/h. No one was injured in the derailments.

After the derailments, HTM modified all curves at The Hague Central Station to bring them into line with the new construction standards. HTM also applies lubrication in the curves. The curves are not currently in use, however, which means that monitoring their state of maintenance is not expedient at the present time.

### **O.3 WHY THE VEHICLES DERAILED**

In all three cases, it subsequently became clear that the head of the right rail was extremely worn, as a result of which it was slanted to a degree close to the rejection standard. In addition, the sides of the running surface had become very rough and the standard for distortion had been exceeded (see left section of the following figure).

The rough edges and pronounced slant caused flange climbing of primarily the wheels not fitted to an axle (sticking to the rail) in the running bogies (lighter than drive bogies) to occur in a curve with distortion (see right section of the following figure).

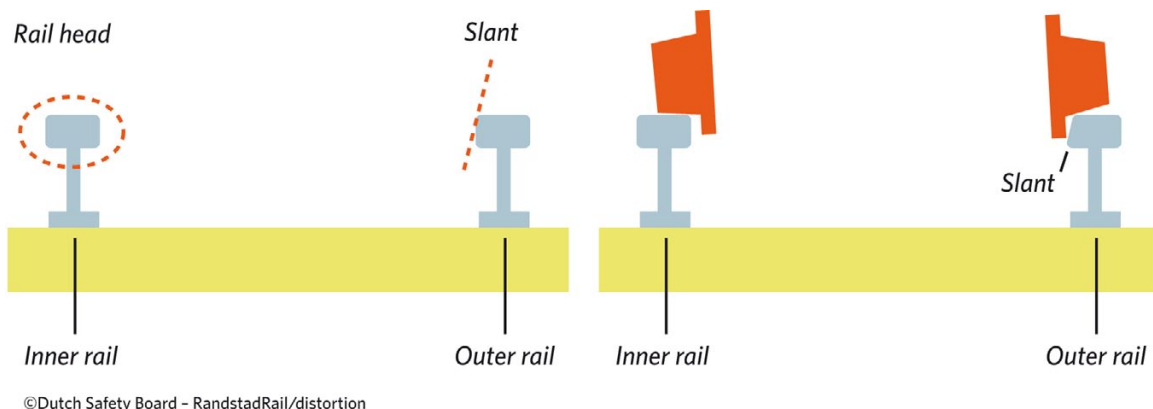


Figure 18 – Rail head and slant (left) and flange climbing of right wheel (right)

#### O.4 WHY THE SITUATION AROSE

Contact between a vehicle's wheel and the rail is a complex phenomenon. It has exercised the minds of many experts and will continue to do so for a long time to come. Proper wheel-rail contact consists of one-point contact; the wheel rolls on the rail. In curves, the wheel flange presses against the outer rail. This results in two-point contact, as the flange performs a guiding function. In curves with a radius greater than 3000 m, the vehicle will behave as if on a straight. In curves with a radius of between 750 and 3000 m, an AHC profile<sup>69</sup> is applied which results in two-point contact to ensure smooth progression through the curve and even out wear of the rails, and to prevent flaking of the rail head. In curves with a radius of less than 750 m, another lifecycle applies: wear of the side of the rail head determines the service life. In this case, there is two-point contact by definition, as the flange presses against the rail head.

The ideal contact surface between a wheel and rail takes some time to evolve. The rail and wheel must wear together until a stable situation is reached. All operators try to use a wheel profile that ensures even wear; that is, the occurrence of wear while maintaining the original shape. Practical experience shows, however, that a considerable degree of wear occurs to the rail and wheel in the initial period, which is followed by a long period of reasonable stability before manifestations of fatigue increase wear at the end of the service life.<sup>70</sup>

However, when new rolling stock is introduced or other wheels with a different profile are fitted to old rolling stock, a new initial period characterised by a high rate of wear is likely to occur. If the differences between the two types of wheel profile are significant and they continue to be used together for an extended period of time, an unstable situation can arise. This can be noticed in practice by the lurching or shaking of a vehicle during travel.

The evidence suggests that the derailments near The Hague Central Station were not caused by the introduction of new RandstadRail rolling stock (RegioCitadis) or the change in wheel profile of the old rolling stock but, rather, by a combination of the two factors. The first factor came into play following the correction of the slanted bogies (type B3) of The Hague city trams (type GTL), which resulted in the rails being worn with a far more pronounced slant than usual. This overhaul of the bogies had the unintended and unexpected effect of altering the wheel-rail contact substantially. The second factor was the use of rails of a different hardness relative to the ones previously used, namely of quality 900 instead of quality 700. This hardness was more or less equal to the hardness of the wheels of HTM vehicles. An investigation carried out by external experts revealed that when wheels and rails of more or less equal hardness are used, the rate of wear is accelerated and the running surfaces of both the rail and wheel become rough.<sup>71</sup> This can be countered by using rails and wheels that are not of the same hardness and/or by applying lubrication to reduce friction between the wheel and rail.

<sup>69</sup> Anti-Head Check profile: because a rail head is finished according to a certain profile, the contact point between the wheel and the rail can shift. The rail head is therefore more optimally loaded and less flaking and tearing occur.

<sup>70</sup> In response to the present report, the vehicle manufacturer indicated that, in its view, this is incorrect. The wear of a wheel must always occur evenly. The wheel's running surface will harden to a certain degree, though this does not usually cause excessive wear.

<sup>71</sup> Stork FDO BV, Onderzoek naar de oorzaak van het overmatig slijten van tramspoor (in opdracht van HTM). Amsterdam, February 2007.

## O.5 SAFETY MANAGEMENT CONDUCTED IN RELATION TO RISKS OF WEAR

As described in the foregoing, the derailments near The Hague Central Station were the result of excessive wear to the rails. This wear was caused by a change in the construction of the bogies of a particular type of existing city tram of The Hague. The following constituent safety cases were further analysed to ascertain whether and how these risks had been recognised in advance and to determine the measures taken as a result:

- Constituent safety case for HTM low-floor rolling stock
- Constituent safety case for infrastructure management and maintenance

As described in the previous section, the vehicle manufacturer prepared a constituent safety case entitled *Sicherheitsbericht Fahrzeug RegioCitadis RandstadRail*.<sup>72</sup> This safety case was based on the assumption that the RandstadRail infrastructure complied with the Schedule of Requirements. The aspect of wear had to be monitored as part of the constituent safety case for infrastructure management and maintenance.

The constituent safety case for infrastructure management and maintenance was prepared on the basis of HTM's RandstadRail management and maintenance programme.<sup>73</sup> The manager of HTM Infra bore final responsibility for supplying the constituent safety case. The purpose of this safety case was to provide documentary evidence that HTM Infra's activities in relation to RandstadRail met the specified safety-related requirements. The interfaces with other constituent areas, such as rolling stock, were described in the Top Level Safety Case.

A distinction is maintained in the safety case between system safety and work safety. The risks that essentially caused the derailment concerned system safety. The safety case indicates that, with respect to system safety, the Haaglanden Urban Conurbation stipulated in the Operational Safety Plan (OSP) that the following issues would have to be included in HTM Infra's implementation regulations:

- minimum requirements that the infrastructure must meet (rejection standards);
- the infrastructure inspection method and frequency;
- maintenance regulations.

The first two aspects in particular were of crucial importance to the derailments at The Hague Central Station.

In the safety case HTM Infra stated the following concerning the status of the internal regulations: An inventory of existing implementation regulations was made on the basis of these requirements. This inventory is currently being used to adjust internal regulations. New regulations specifically applicable to RandstadRail are also being developed.

The safety case's appendix includes a status overview of HTM Infra's implementation regulations. This overview shows that the following sets of regulations were of relevance:

- HTM Infra Railways Regulations
- HTM Infra SVZ Regulations
- HTM Infra WST Regulations
- Maintenance concepts
- Rail wheel guide measurements table

At the time the safety case was issued, all the sets of regulations had been adopted in full or in part for tram operations. The sets of regulations for RandstadRail were still being developed or had been placed on the backburner. Of relevance to the derailments near The Hague Central Station was the fact that rail tolerances for light rail systems still had to be added to the Railways Regulations.

The Plan-Do-Check-Act Cycles for HTM Infra's implementation and management are described in the safety case. The parts relevant to the timely detection of excessive wear are the preparation of inspection plans (Plan), the carrying out of inspections (Do), the analysis of inspection data (Check) and the appropriate adjustment of maintenance plans (Act).

The interface between the infrastructure and its state of maintenance on the one hand and the rolling stock on the other was partly recognised in the safety case principally in terms of the interface with the new RandstadRail rolling stock (the RegioCitadis vehicles):

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<sup>72</sup> Sicherheitsbericht Fahrzeug RegioCitadis RandstadRail, 29 August 2006 (version 1.0).

<sup>73</sup> HTM, safety case for the management and maintenance of infrastructure; HTM Infra's safety case within the context of RandstadRail, 1 September 2006 (version 1, definitive status).

**'HTM Rolling Stock:** This HTM department will maintain the new light rail vehicles. Because these will interact strongly with the railway infrastructure, HTM's Infra and Rolling Stock departments have concluded agreements about the compatibility of the various components. The adoption of these agreements is an integral part of this safety case.'

Agreements concerning modifications to existing city trams that make use of the same infrastructure as RandstadRail in the city were not mentioned in the safety case.

The management and maintenance of the part which included The Hague Central Station was to be carried out by HTM Infra's implementation sector. This concerned primarily the existing tram infrastructure with the exception of the Beatrix Viaduct ('Netkous'). The City Management Department of the municipality of The Hague was responsible for the management and maintenance of the entire civil engineering substructure.

HTM Infra makes decisions about the method and frequency of maintenance activities, including inspections, on the basis of technical regulations and wear rates and patterns exhibited by the infrastructure. The safety case recognised that new factors would come into play in this regard due to RandstadRail:

'... Moreover, the infrastructure will be subjected to different loads due to use of the new vehicles and high frequency of services. Alternative ways of conducting maintenance were therefore sought. ... A generic maintenance plan was developed for the initial phase of operations which devoted additional attention to grinding, mending, shifting and raising newly built railway.'

A risk inventory was also included in the safety case. This stated that the rate and pattern of wear for new objects and subsystems were unknown and that this factor could constitute a derailment risk. The associated management measure was the carrying out of a comprehensive inspection programme.

The safety case also described HTM's safety organisation. Among other things, the description detailed the consultative structures within HTM in the area of rail safety. The derailment committee was of relevance to the derailments near The Hague Central Station:

'The derailment committee investigates all derailments and incidents of incorrectly guided vehicles that occur on the HTM network. The committee consists of the heads of the departments specified in the organisation chart and each is supported by a departmental expert. The rail safety coordinator and technical advisor are also members. The committee is chaired by the head of the Infra department. The head of claims settlement acts as committee secretary. The committee meets once a month.'

On 12 August 2006, a city tram derailed near The Hague Central Station at the same location at which two RandstadRail vehicles would also derail on 3 and 4 November 2006, respectively. This derailment was investigated by the derailment committee.<sup>74</sup> The investigation revealed that the derailment had been caused by excessive wear that occurred shortly after the rails had been replaced in April 2006, which resulted in a pronounced slant and roughness of the right rail head. This was judged as being extremely unusual, as rails of the type in question had a nominal service life of several years, not merely four months. The rail was reprofiled.<sup>75</sup> An investigation was launched into the effect of the bogies used by a certain type of existing city tram on the wear and quality of the rails. Before this investigation had been completed, RandstadRail vehicles derailed on 3 and 4 November 2006, respectively. Following the derailment on 3 November 2006, HTM initially thought that the incident had occurred after a brake had broken away from the vehicle. Shortly after clearance had been given for the railway, a RandstadRail vehicle belonging to HTM again derailed. It then became clear to HTM that the derailments had been caused by the extremely rough and slanted wear of the rails.

In summary, it can be said that the risks of wear due to the introduction of new elements were in principle recognised in the constituent safety case for management and maintenance. The emphasis in that regard, however, was on the new elements introduced as a result of RandstadRail. The derailments near The Hague Central Station made clear that the introduction of new elements in HTM's tram operations could also cause excessive wear. After the derailment of a city tram, it became clear that the slanted position of bogies used by a certain type of city tram was possibly accelerating the rate and pattern of rail wear. Before clarity had been obtained on the issue, two

<sup>74</sup> HTM, Central Station Derailments: 3072 12 August 2006, 4024 3 November 2006, 4002 4 November 2006 (2007).

<sup>75</sup> Reprofileing involves redesigning track layout and implementing the new design.

further RandstadRail vehicles derailed. To prevent such derailments in the future, all modifications to all vehicles should be reported by HTM Rolling Stock to HTM Infra and result in intensified inspections of the infrastructure.

## P. ANALYSIS OF DERAILMENTS ON SWITCHES IN THE HAGUE CITY TRAM NETWORK

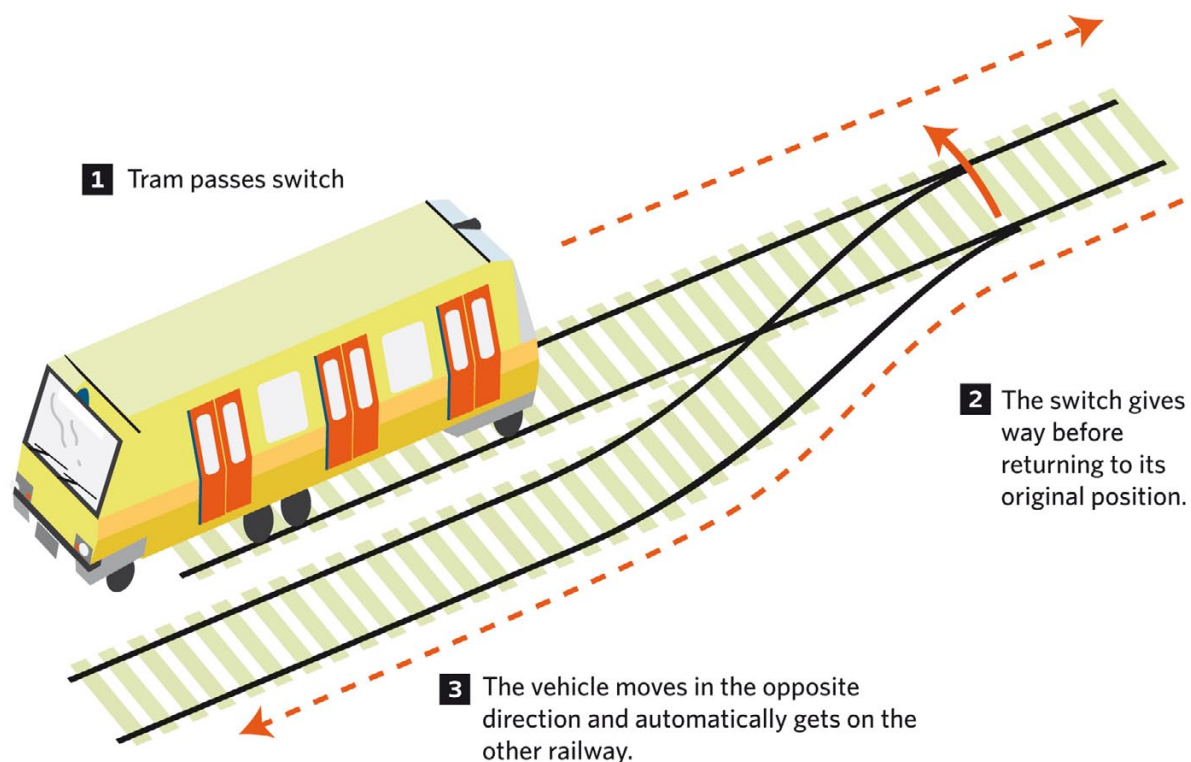
This appendix describes the analysis of the derailments of RandstadRail vehicles on 24 November 2006, 24 and 26 January, 25 May and 20 July 2007 on openable switches in The Hague city tram network. Answers are provided to the following questions:

- What was the actual situation at the location? Section P.1 sets out the factual information about openable switches in The Hague city tram network and the rolling stock involved.
- What happened during the derailments? Section P.2 sets out the facts of the derailments.
- Why did the vehicles derail? Section P.3 summarises the causes of the derailments.
- How could this situation arise? Section P.4 describes the way in which the organisations involved structured and organised their respective responsibilities in relation to the situation that led to the derailments.
- Had the risks related to the derailment been recognised and, if so, how were they managed? Section P.5 contains an analysis of the safety management aimed at managing these risks.

In answering the first two questions, use was made of the results of the internal investigation reports prepared or commissioned by HTM.

### P.1 FACTUAL INFORMATION CONCERNING THESE DERAILMENTS

Especially in city tram networks, simple switches are used that are not electrically operated but whose switch machines feature a mechanism that enables opening movements to take place without resulting in damage. This type of openable switch returns to its original position after the railway vehicle has passed; the switch gives way, as it were, when the tram passes and subsequently returns to its original position. Such switches are usually located where two railway tracks converge and at the end of railway routes where a tram has to switch tracks to travel the route in the opposite direction. The entire tram first passes the switch, which gives way during this passage (1). The vehicle can then move in the opposite direction (2) and will automatically be guided to the other track.



©Dutch Safety Board - RandstadRail/openable switch

Figure 19 – Schematic illustration of an openable switch's operation

Openable switches were specifically introduced for RandstadRail. The new RandstadRail vehicles have doors and a driver's cabin on both sides and can therefore change their direction of travel on



tail tracks (sections of rail with openable switches) at end points instead of having to use a turning loop. Openable switches are not otherwise used in The Hague city tram network, though were used 10-15 years ago on the routes of tram lines 1 and 12.

## P.2 THE DERAILMENTS

A RandstadRail vehicle belonging to HTM (RegioCitadis type, low-floor tram) derailed on a switch in The Hague city tram network on five occasions. On 24 November 2006 a vehicle derailed on Monstersestraat and two others on 24 and 26 January 2007 on Arnold Spoelplein. The vehicles are always empty at these locations. On 25 May and 20 July 2007 derailments occurred on Meppelweg. Passengers are on the vehicles at this location. These derailments all had the same cause; in all cases, the driver did not continue far enough when traversing the switch. No one was injured during these derailments.

### After the derailments

After the derailments, HTM drivers again received instructions on how to use openable switches. In addition, HTM placed signs at the openable switches so that drivers could see when the switches had been sufficiently passed.

## P.3 WHY THE VEHICLES DERAILED

The primary cause of the derailments was incorrect use of the openable switches: in each case, the driver started to travel in the opposite direction before all of the vehicle's wheels had passed the switch. The point at which all wheels had passed the switch was apparently not clear to them.

## P.4 HOW THE SITUATION AROSE

Openable switches were newly introduced for RandstadRail. In addition, the RegioCitadis vehicle is longer and somewhat wider than a regular tram. Almost all of the derailments occurred during evening hours and on one of the first days on which the tail track section in question was used. The vehicles involved derailed when they were using the respective tail track sections for the first time. At the time the derailments occurred, HTM had not yet placed signs and markings which could be used by the drivers for purposes of orientation and the immediate environment around the switches had not yet been finalised.

The drivers involved were definite in their statement that, as seen from their position in the driver's cabin, the blades of the switch were in the correct position and that the vehicle nevertheless inexplicably derailed. HTM representatives reported that the log files and trip recording data of the RegioCitadis vehicles clearly showed that when the manoeuvre to switch the direction of travel was being executed, the first axle of the vehicles did *not* pass over the blades. As a possible explanation, it was suggested that the drivers, looking out from behind slightly curved windows, might in fact have been looking at the root point of the blade. Shadows caused by the interplay of darkness and sole illumination of the headlights may have given the drivers the impression that the blade had moved when in fact it had been the root point, which is further away from the blade (see following image).

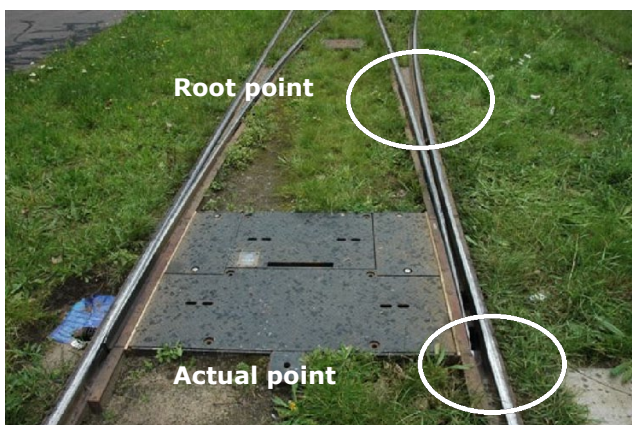


Figure 20 - Root point and actual point of an openable switch's blade

## P.5 SAFETY MANAGEMENT CONDUCTED IN RELATION TO RISKS ASSOCIATED WITH OPENABLE SWITCHES

As described in the foregoing, the derailments on the openable switches in The Hague city tram network were the result of vehicles having insufficiently traversed them, so that they returned to their original positions before all the wheels of the vehicles had passed them. An underlying cause was the inability of drivers to clearly see from the RandstadRail vehicle when the switch had been completely passed. The following constituent safety cases were further analysed to ascertain whether and how these risks had been recognised in advance and to determine the measures taken in response:

- Constituent safety case for ground-level sections
- Constituent safety case for HTM operations

The constituent safety case for ground-level sections was prepared by a consultancy and engineering firm; final responsibility for supplying the constituent safety case rested with the Haaglanden Urban District.<sup>76</sup> The purpose of this safety case was to demonstrate that the city tram network that would be used by RandstadRail vehicles complied with the Schedule of Requirements. In terms of geographic scope, the safety case focused only on the RandstadRail sections within the municipality of The Hague from the Arnold Spoelplein (RR3) and Monstersestraat (RR4) end points to the entrance of the tram tunnel under Grote Marktstraat. Railways formed one part of the safety case. Of importance to the safety of RandstadRail were the consequences of the changes made to the railways of the ground-level sections. Due to the fact that the new RandstadRail vehicles have doors and a driver's cabin on both sides, one of the changes made was the introduction of tail tracks (sections with openable switches for switching the direction of travel) at end points rather than turning loops. Openable switches are not otherwise used in The Hague city tram network, though were used 10-15 years ago on the routes of tram lines 1 and 12.

Closer study of the constituent safety case for ground-level sections revealed that it was incomplete. The document includes several questions which indicate that certain information was still lacking or still had to be augmented. The document states, for example, that the test of the design and realisation against the RandstadRail Schedule of Requirements was still weak because the available results were limited to a review of the preliminary design by the Haaglanden Urban District.

A safety analysis of ground-level sections was included in the safety case as a reference document.<sup>77</sup> The safety case does not specify the relevance of this document to the substantiation of safety. A Failure Mode and Effects Analysis (FMEA)<sup>78</sup> was carried out within the context of this safety analysis to estimate the effects of the changes due to the introduction of RandstadRail on the safety of passengers, personnel and road traffic.

This document refers to the tail track (sections with openable switches for switching the direction of travel) as a relevant change:

'Tail track (Monstersestraat, Arnold Spoelplein). Event: collision between railway vehicles.  
Remark: driver must be more alert.'

The risk of derailment due to the failure of all wheels to pass the switch is not recognised in this analysis. In addition, the remark that a 'driver must be more alert' is an example of a soft barrier in the management of safety risks.

The interface of the use of the infrastructure by the new RandstadRail vehicles was recognised in the constituent safety case for ground-level sections. Reference is made to the Top Level Safety Case for substantiation of the safety of this interface.

The parties involved in the transport process are the railway undertakings RET and HTM and their respective traffic control organisations. RET and HTM prepared separate safety cases. The purpose of these safety cases was to demonstrate the safety of the transport process. Relevant items in relation to the derailments on the openable switches were:

- Process description, procedures and regulations concerning regular operations. The RandstadRail Service Regulations (DRVR) was an important document in this respect because it played a role in the granting of a permit by the Railways Supervisory Division of the Inspectorate for Transport and Water Management (IVW). Focal areas included withdrawal and deployment, stops, the placement of components used by vehicles to switch to another voltage, communication between traffic controllers and drivers, communication between

<sup>76</sup> Safety case for RandstadRail ground-level lines, 11 July 2006 (version 0.3, draft status).

<sup>77</sup> RandstadRail safety analysis, ground-level lines 3 and 6, 17 January 2006.

<sup>78</sup> Faalwijzen- en gevolgenanalyse in Dutch.

traffic controllers and the transition from HTM traffic control jurisdiction to RET traffic control jurisdiction and vice versa.

- Training requirements and training plans for personnel, and plans for emergency scenario exercises. Attention was also devoted in the training plans to ensuring that training resources such as simulators were kept up-to-date.
- Process description and procedures for the recording of incidents in terms of accidents, malfunctions of systems relevant to safety and other, comparatively minor incidents relevant to safety.
- Information management concerning the infrastructure, updating of plans and scenarios. Risk analyses also had to be carried out for the first two items and subsequently used to adjust procedures and plans where necessary.

The transport process was described in the constituent safety cases for operations and traffic control, respectively. As traffic control does not play a role with respect to the openable switches, this safety case was not further analysed.

In terms of scope, the constituent safety case for HTM operations focuses on RandstadRail lines 3 and 4.<sup>79</sup> These safety cases were prepared by the railway undertakings (HTM), while final responsibility for supplying the safety case rested with the head of HTM operations.

The RandstadRail Service Regulations (DRVR) set out rules to which personnel that perform work for RandstadRail must adhere.<sup>80</sup> These rules are based on legal provisions, the RandstadRail Operational Safety Plan (OSP), the provisions approved by IVW's Railways Supervisory Division and the provisions issued by RandstadRail management (HTM and RET management). The provisions of the DRVR do not apply, however, in the area where the derailments on the openable switches occurred (the HTM tram network):<sup>81</sup>

'These Regulations apply to the RandstadRail network with the exception of the sections belonging to the RET metro network and HTM tram network.'

The Tram Driver Handbook (HBT) applies to the HTM tram network.<sup>82</sup> This is an internal HTM handbook. It was not assessed by the ISA or IVW as part of the RandstadRail approval process. The HBT includes instructions on how switches should be operated and traversed by vehicles. With regard to the operation and traversing of switches, it states the following:

'An openable switch:

- cannot be manually set to another position;
- must be passed by the vehicle in full before being traversed again.'

An important point was the training of new RandstadRail drivers. HTM required about 200 drivers for RandstadRail services. These included individuals already serving as tram drivers who would have to undergo training to operate the new vehicles and entirely new drivers (previously bus drivers or having another professional background). HTM had to deal with the challenge of training all of them in a very short time (summer of 2006). This was because RandstadRail was being built on existing lines. Disruption to passenger services had to be kept to a minimum. The time available to build the system was therefore relatively short. In addition, the railway in Zoetermeer had to be replaced and a new power supply system installed. Ultimately, only a very short time would remain (approximately 6 to 8 weeks in the planning at the time) for the new RandstadRail drivers to undergo practical training (new procedures, vehicles, routes).

HTM aimed to resolve the training issue by having a simulator developed at an early stage which could be used to complete large sections of what would become the RandstadRail network. The simulator was used for training from the spring of 2006. In addition to the new parts of the network, one of the routes through the city was also included in the simulator. The simulator could be used to complete 85 to 90% of the training hours. The remaining 10 to 15% involved completing actual trips which could therefore remain limited in terms of extent. According to HTM, by using the simulator, the first 60 RandstadRail drivers had been sufficiently trained by the end of August 2006 to be deployed in regular services. The training programme continued throughout the autumn of 2006 for the other drivers and, thereafter, continued for purposes of retraining and the training of new drivers.

In addition, learning to traverse an openable switch was also done in practice. During training,

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<sup>79</sup> HTM, HTM constituent safety case for operations, 31 August 2006 (version 0.5).

<sup>80</sup> RandstadRail (RET, HTM), RandstadRail Service Regulations (DRVR), September 2006 (version 1.0).

<sup>81</sup> DRVR, Chapter 1, Article 4.1.

<sup>82</sup> HTM, Tram Driver Handbook (HBT), November 2004.

explanation about openable switches was provided and the openable switch at Zichtenburg was traversed a number of times during the practical part of training.

Despite the instructions and training provided, RandstadRail vehicles derailed on 24 November 2006 and 24 and 26 January 2007 on openable switches because these returned to their original positions while not having been fully passed by the vehicles.<sup>83</sup> All of these derailments were investigated by HTM's derailment committee (whose duties were explained in the previous section). The results of this investigation prompted HTM to again instruct its RandstadRail drivers on the use of openable switches. In addition, HTM introduced infrastructural measures to enable drivers to see whether they are still on an openable switch (marking, signs, installation that indicates the position of the switch).

In summary, it can be said that the risk of derailment on an openable switch was not recognised in the safety case. Even though attention was paid to the use of openable switches in the training and instructions provided to RandstadRail drivers, this was a soft barrier as its effectiveness depended on a driver's ability to properly assess the situation. This shortcoming was recognised after the derailments and HTM introduced physical measures to enable a driver to see more clearly whether he had continued far enough, thereby reducing the risk of derailment.

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<sup>83</sup> RandstadRail vehicles belonging to HTM also derailed on openable switches on 25 May and 20 July 2007.

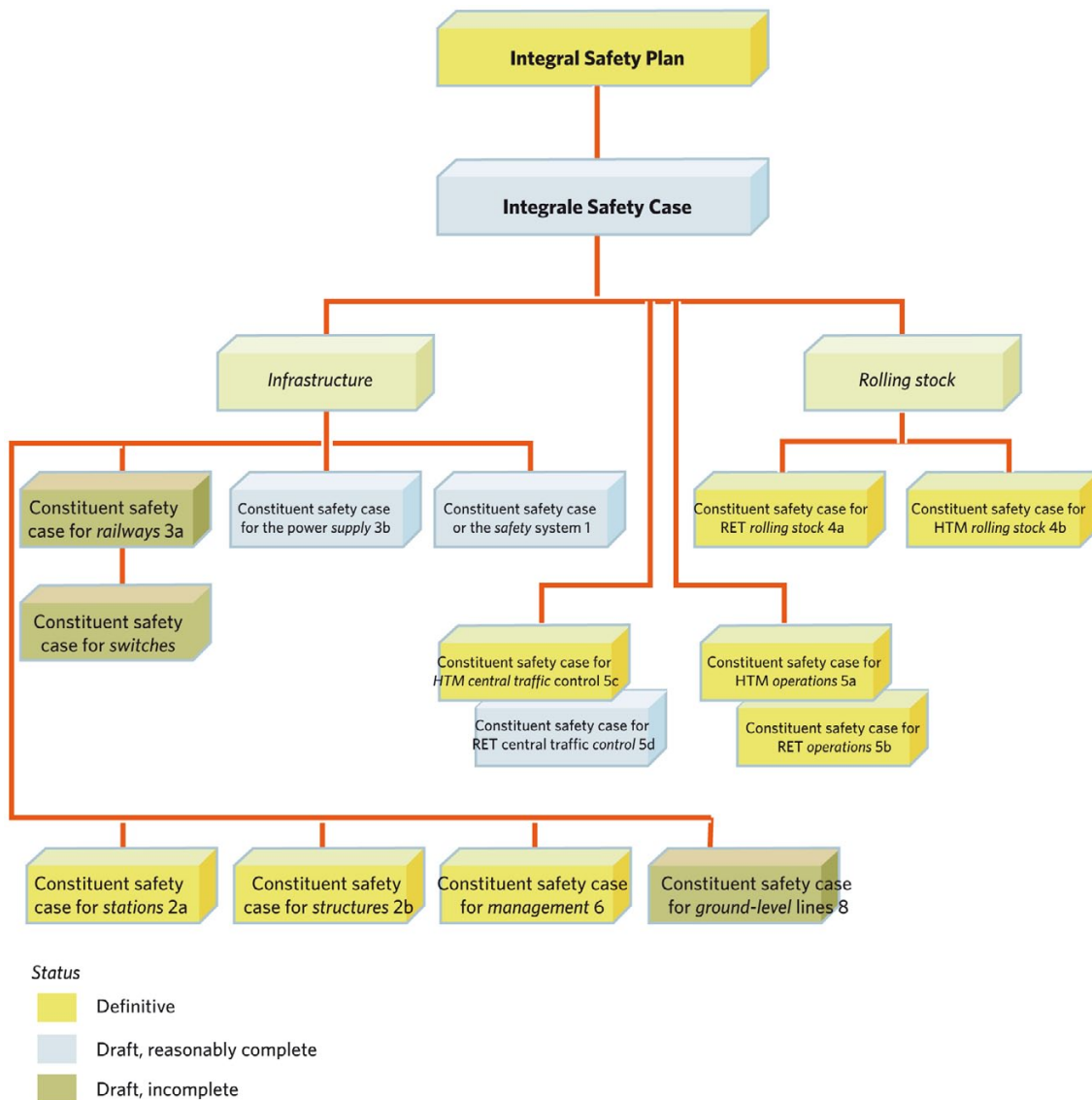
## Q. OVERVIEW OF RANDSTADRAIL SAFETY CASES

	Author	Party with final responsibility	ISA
1. Systems for safety and process control	System supplier	Municipality of The Hague (PoRR), manager of ET systems	ISA for safety
2. Architectural and civil engineering constructions			
2a. Stops and stations	Consultancy and engineering firm	Rotterdam City Region/ Haaglanden Urban District	ISA for the system as a whole
2b. Structures	Consultancy and engineering firm	Rotterdam City Region/ Haaglanden Urban District	
2c. Statenweg tunnel incl. Blijdorp station	Not stated	Rotterdam City Region	Not stated
3. Railway infrastructure			
3a. Railway (including the switches)	Consultancy and engineering firm	Rotterdam City Region/ Haaglanden Urban District	ISA for the system as a whole
3b. Overhead power cables and traction feed	Consultancy and engineering firm	Municipality of The Hague (PoRR), manager of ET systems	ISA for the system as a whole
4. Rolling stock			
4a. High-floor rolling stock (modification of SG2)	Transporter RET	RET project leader	ISA for the system as a whole
4b. Low-floor rolling stock	Rolling stock supplier	HTM/RET project leader or contract manager	ISA for rolling stock
5. Transport process			
5a. HTM operations	Transporter HTM	Head of HTM operations	ISA for the system as a whole
5b. RET operations	Transporter RET	Head of RET operations	ISA for the system as a whole
5c. HTM traffic control	Transporter HTM	Head of HTM central traffic control	ISA for the system as a whole
5d. RET traffic control	Transporter RET	Head of RET central traffic control	ISA for the system as a whole
6. Management and maintenance			
6a. HTM management jurisdiction	Infrastructure manager HTM	Head of HTM Infra	ISA for the system as a whole
6b. RET management jurisdiction	Infrastructure manager RET	Head of RET Infra	ISA for the system as a whole
6c. High-floor rolling stock	Rolling stock maintainer RET	Head of RET Rolling Stock	ISA for the system as a whole
6d. Low-floor rolling stock	Rolling stock maintainer HTM/RET	Head of HTM/RET Rolling Stock	ISA for the system as a whole
7. The Hague tram tunnel	Haaglanden Urban District	Haaglanden Urban District	Not assessed
8. The Hague ground-level lines	Consultancy and engineering firm	Haaglanden Urban District	ISA for the system as a whole

Source: RandstadRail Safety Management Plan, version 1.1, definitive from 21 May 2006

## R. STATUS OF RANDSTADRAIL SAFETY CASES AROUND 29 NOVEMBER 2006

The numbers in the diagram correspond with the overview of safety cases in Appendix Q.





## S. MEASURES TAKEN FOLLOWING RANDSTADRAIL DERAILMENTS

During the investigation, the Dutch Safety Board asked the parties involved (Haaglanden Urban District and HTM) about the measures they took following the RandstadRail derailments. The answers provided by the Haaglanden Urban District and HTM are set out below.

### S.1 MEASURES TAKEN BY THE HAAGLANDEN URBAN DISTRICT<sup>84</sup>

#### **After the Forepark derailment**

Management of the infrastructure at this location has not yet been transferred by the builder to the manager, which means that the railway undertakings' responsibility for it is limited. Following this incident, a team investigated the relevant technical and organisational aspects on the instructions of IVW and the Haaglanden Urban District. Three studies were carried out into the switch by research agency DeltaRail.

The first study focused on the direct cause of the incident. The findings of this study were used to introduce modifications to the switch to prevent the breaking of the bolts in the future. Moreover, the switch has as yet not been declared openable, which restricts use of the switch by the transport companies. These measures were assessed by our safety manager and the ISA to ensure safety.

The second study focused on the approval process and found that this had proceeded correctly.

The third study assessed the quality of the switch. Its findings were used to formulate recommendations for maintenance of the switch. These recommendations would be adopted by future infrastructure manager HTM.

The investigation into the procedural aspects relevant to the derailment was carried out by HTM itself, as well as by IVW. The transport companies used the conclusions of these investigations to make procedural adjustments and modify the instructions given to personnel. These adjustments and modifications are being implemented. IVW is also monitoring implementation.

#### **After the Ternoot derailment**

HTM carried out its own investigation into this derailment in cooperation with research agency DeltaRail. This has since resulted in modification of the track layout on the viaduct. Since the derailment, the railway has been rigorously checked in terms of distortion that does not comply with the applicable standards. Track layout is one of the criteria that will be used to approve the railway. The Haaglanden Urban District's Executive Committee decided that a Haaglanden Urban District decision would be required to start the testing and trial operation and passenger services. The Haaglanden Urban District is being advised on this matter by an independent consultant that also issues ISA statements.

#### **Other derailments**

The other derailments being investigated by the Dutch Safety Board were caused by a range of factors, such as human error and wear to rails caused by city trams already in operation before RandstadRail. Some of these derailments occurred during the testing and trial operation. One of the purposes of this operation is to test the infrastructure and vehicles and to enable personnel to become familiar with the new vehicles before the start of passenger services. Insofar as necessary, the railway undertaking took measures following these incidents. As an operator and infrastructure manager, HTM is carrying out a study into wheel-rail contact as regards the requirements imposed on rails by RandstadRail vehicles. In addition, HTM is intensively taking measurements to ascertain the quality of the rails. The Haaglanden Urban District is making arrangements with HTM to be kept informed about the quality of the rails and the progress of the studies. As already stated in the section of this letter concerning the Ternoot derailment, the quality of the rails will be one of the assessment criteria used for approval.

### S.2 MEASURES TAKEN BY HTM<sup>85</sup>

#### **After the Forepark accident**

Investigation by HTM's derailment committee into the process involved in the Forepark accident and the investigations of IVW and DeltaRail into the technology involved resulted in a number of

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<sup>84</sup> Excerpt from a letter of the Haaglanden Urban District to the Dutch Safety Board of 14 June 2007.

<sup>85</sup> Excerpt from a letter of HTM to the Dutch Safety Board of 5 October 2007.

recommendations. These recommendations and the follow-up action taken by HTM are described below.

### *Process*

#### *1. Improvement of means of communication*

The complaints concerning poor communication are not specific to the accident but, rather, are structural in nature. Recommendations to be implemented:

- make an inventory of the functionality of operating assets;
- make an inventory of instructions and training;
- make an inventory of response time, i.e. the time it takes to respond to an incoming call;
- assess operating assets and the use of processes and procedures;
- assess instructions and training;
- assess manageability of operating assets (man-machine interface);
- adjust operating assets if necessary;
- adjust instructions;
- implementation.

All of the above recommendations have been implemented except the one concerning the adjustment of operating assets. This is still ongoing and will result in a new telephone system that will enable the CVL operator to see all incoming calls and decide which one he wishes to respond to first.<sup>86</sup>

#### *2. Improve display and archiving in railway safety system of actions taken by central traffic control*

The matter will be dealt with on a project basis in cooperation with the supplier of the safety system:

- investigate the incidents reported up to the present time;
- investigate the status of the change requests made up to the present time, in particular the proposal to change the monitor colours;
- develop technical means to enable the actions of the operator to be recorded in the railway safety system on a one-to-one basis.

The necessary updates have since been made to the railway safety system.

#### *3. Define responsibilities of central traffic control personnel more clearly*

The division of responsibilities, both within HTM's central traffic control organisation and in terms of coordination between HTM and RET, needs to be improved.

- the procedures and working methods of HTM's central traffic control organisation must be optimised;
- the division of responsibilities of HTM on the one hand and RET on the other must be defined more closely;
- the transition areas must be more explicitly framed and defined in terms of each aspect involved (traffic control, infrastructure maintenance and the switch to another overhead power cable);
- there must be clarity with respect to technology, processes and procedures.

This recommendation has since been implemented.

#### *4. Improve the training of central traffic control personnel*

The impression at the present time is that while central traffic control personnel do their work well, there is room for improvement. This applies in particular to HTM's traffic control personnel for whom guiding train services is a relatively new phenomenon. Recommendations to be implemented:

- make an inventory of instructions;
- make an inventory of training;
- assess instructions and training to determine whether they are adequate;
- make adjustments if necessary;
- implementation in terms of further training and professionalisation.

A further recommendation concerns improved cooperation between HTM and RET in the training of central traffic control personnel. An option being considered in this regard is the exchange of personnel between the central traffic control organisations of HTM and RET to enable the direct transfer of experiences to take place.

The committee believes that it would be good to purchase simulation equipment for central traffic personnel in the way that was done for drivers. This would have the benefit of allowing all kinds of

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<sup>86</sup> CVL stands for central traffic control.

situations to be practiced without disrupting regular services. Such equipment can be used for both initial and follow-up training. The committee would prefer the purchase of one simulator to be used jointly by HTM and RET.

This recommendation has been partly implemented. The first part concerning training documentation and training was completed this spring; the associated documentation is already in the possession of the Dutch Safety Board. The second aspect, the exchange of personnel, was not implemented due to a lack of capacity (scheduling problem). The third recommendation concerning simulation equipment has not been implemented as yet but remains a wish of HTM's central traffic control organisation.

#### 5. *Improve the training of RandstadRail drivers*

The impression at the present time is that while drivers do their work well, there is room for improvement. This applies in particular to visually-based driving in situations of potential malfunction. Special attention must be paid to the traversing of switches. Recommendations to be implemented:

- make an inventory of instructions;
- make an inventory of the training provided;
- assess instructions and training to determine whether they are adequate;
- make adjustments if necessary;
- implementation in terms of further training and professionalisation.

In addition to the above recommendations, it is absolutely necessary to provide practical training to drivers with respect to switches, including switches with movable points. This recommendation has been implemented in full at HTM. Documentation is already in the possession of the Dutch Safety Board.

#### 6. *Reduce level of RandstadRail malfunctions*

The level of malfunctions is generally experienced as being too high. This adversely affects the provision of passenger services. Recommendations to be implemented:

- adequate and uniform logging of malfunctions by both central traffic control organisations;
- a single centre to report to;
- adequate action by response organisation;
- conclusion of service level agreements with suppliers which focus on:
- readiness time;
- recovery time.

This recommendation was implemented in full. Since 15 March 2007, a report on day-to-day affairs has been prepared on a daily basis. The one of 1 October 2007 has been included as Enclosure II to this letter as an example.

#### 7. *Improve the switching of overhead power cables*

It is absolutely necessary to speed up the switching of overhead power cable voltage. The following recommendations are made in this regard:

- set a minimum requirement;
- compare HTM and RET procedures and make them uniform;
- coordinate the matter with Eneco;
- conclude service level agreements.

This recommendation was implemented, though a test carried out in September 2007 revealed that the response speed is still inadequate. The matter will be addressed again.

#### 8. *Regain the confidence of personnel*

The problems that have occurred at RandstadRail have undermined the confidence of some of the personnel in the signals safety system. This confidence must be regained to enable operations to take place normally. Recommendations to be implemented:

- prepare a clear explanation of the signals safety system, maintaining a distinction between:
  - operation
  - control
  - safety
- method of presentation on monitors
- the logging and replay capabilities of the system;
- explain the accident to make clear exactly what went wrong;
- explain that the situation was truly an exception.

This recommendation was implemented in full in cooperation with the supplier of the safety system. All CVL operators received additional training in the training centre of the supplier of the safety system. A clear explanation of what exactly happened on 29 November and relevant information on the safety system supplied and fail safe aspect were provided.

### *Technology*

The following actions were subsequently taken:

- All switches and movable points were inspected to ascertain whether other switches besides switch 846 had sustained the same sort of damage. Repairs were carried out where necessary.
- The interfacing between the switches and railway safety system was investigated. Based on a report published by an engineering firm, DeltaRail concluded that the electrical interfacing was found to be functioning properly. The ISA reviewed the investigation.
- The switch machines were specified as being openable. The aforementioned inspection, however, revealed that a number of switches were adversely affected by vehicle opening movements. Based on the findings of the inspection and the DeltaRail reports, the decision was made to declare all switches non-openable. This was already the case for switches with movable points. Routes are usually set using the operating mechanisms of the railway safety system. The procedure already in place, based on prohibiting opening movements, will therefore be tightened and enforced. If an opening movement nevertheless occurs, an inspection of the vehicle and switch must take place immediately. This had already been included in the procedures but the foregoing matters will have to be strictly monitored, particularly when work is being carried out on the railway.
- The procedure governing a signal's instruction to stop will be tightened in terms of its application (no, except in exceptional cases) and determining the position of the switch in question. Drivers will be given additional instructions in this regard which focus in particular in the position of a switch with a movable point. In these kinds of cases, an expert technician must also be on location.

Switches in a secured position may not under any circumstances be thrown open by vehicle movement, as this may cause serious damage. This rule is not in itself new but, in practice, any switch clamps, active or otherwise, will actually have to be removed in areas where contractors are working on the railway. In addition, the procedure for cranking switches has since been tightened.

The investigation revealed that the switch machines of switches with movable points did not report the occurrence of opening movements. The RandstadRail Project Bureau is studying a modification that would guarantee reports of opening movements in the safety system.

The direct cause was the breaking of the control bolts connecting the switch machine to the switch blade. The blade was therefore not attached to its controlling mechanism. These bolts were replaced in all switches. The claw couplings between the switch machine and blade were also checked and replaced where necessary.

With these measures having been taken, it may be assumed that the position of the blades of movable points will be reported correctly to the interlocking of the railway safety system.

As regards the problem with switches, the railway was approved for trial runs in the middle of March of 2007. Definitive approval for passenger services was only granted in the first week of October 2007, however. It was agreed with IVW that the switch machines of the blades would all be openable on 1 December.

### *Investigation of Schedule of Requirements and safety cases*

As a follow-up to its technical investigation, DeltaRail was instructed to investigate the Schedule of Requirements, specifications of the switches supplied, safety case, approval procedure and associated documentation. A report on this investigation was submitted on 9 February. The conclusions were as follows:

- The switch was supplied in accordance with specifications.
- The formal procedure applicable to approval and the preparation of safety cases was completed properly.
- The safety cases had not been definitively completed.
- A conformity statement for the switch machine which subsequently had to be assessed by an ISA was only supplied in December 2006.
- The monitoring of remaining points listed in the safety cases was not properly structured and documented.

The RandstadRail Project Bureau has since settled the remaining documentation issues and the safety cases have also been completed.

### **After the accidents on the openable switches**

Training was again provided to all RandstadRail drivers (see Appendix III). In addition, signs were placed along the openable switches to enable drivers to see when they had cleared the switch (see image below).



### **After the accident near Ternoot**

Although the viaduct near Ternoot could be used by vehicles travelling at an adjusted speed in combination with lubrication of the rails, HTM opted – in part due to the fact that far-reaching measures would in time have to be carried out with respect to the viaduct – to use the suspension of RandstadRail services imposed to definitively alter track layout. This work was carried out in February and March 2007. Distortion on the viaduct is now compliant with the applicable standards.

Distortion was again a factor in the approval process for the outer sections of the RandstadRail network because IVW's Railways Supervisory Division had doubts about the standard and, subsequently, maintainability. This problem was solved after comprehensive discussion; it was agreed that HTM Infra would maintain an exceptionally intensive inspection regime.

### **After the accidents near The Hague Central Station**

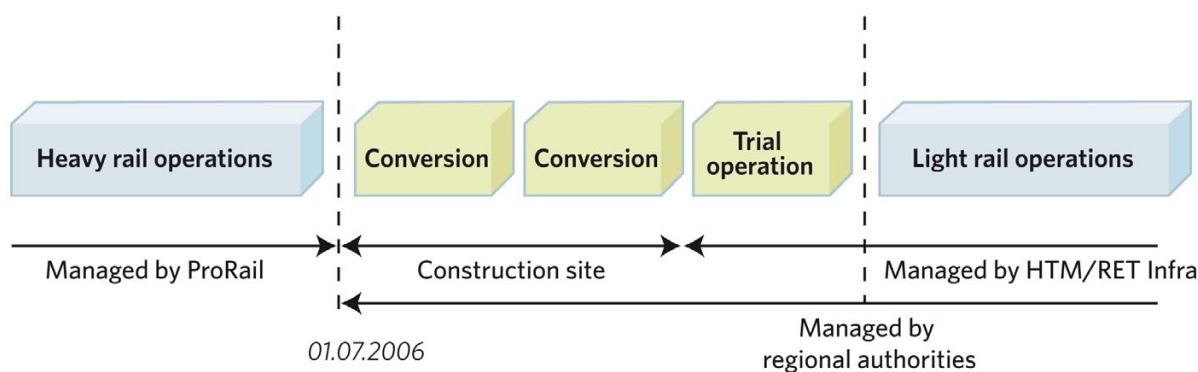
All curves at The Hague Central Station were brought technically into line with the new-construction standard. Lubrication is also used. The curves in question are currently not being used, however. Monitoring at the present time is therefore not expedient.

## T. RANDSTADRAIL TRANSFER PROCEDURE

Management of the infrastructure must first be transferred to HTM before HTM can exercise its role as infrastructure manager. The transfer is a complex process, because almost everything was either built or commissioned by the municipality of The Hague (PoRR) that first had to transfer management of what it had built to its principal, the Haaglanden Urban District. In its turn, the Haaglanden Urban District had to transfer management of the infrastructure to HTM.

The Haaglanden Urban District prepared a transfer protocol for the transfer.<sup>87</sup> It stated that this memorandum was discussed in the PMT and approved by the Haaglanden Urban District, municipality of The Hague (PoRR) and Rotterdam City Region.<sup>88</sup> This approval is not recorded in the agendas and reports of the PMT. The procedure as described in this memorandum entails the transfer by contractors and suppliers to the project leaders of the conversion, testing and trial operation. The project leaders are part of the municipality of The Hague (PoRR). Direct transfer to railway undertakings HTM and RET is subsequently effected.

At the end of the building phase and before the launch of RandstadRail operations, it will have to be shown that the completed system meets requirements (SATs). There will also be a moment at which responsibility for the completed works will be formally transferred from the project leaders to the managers.



©Dutch Safety Board - RandstadRail/responsibilities in the transfer of management of RandstadRail infrastructure

Figure 21 – Responsibilities relating to the transfer of RandstadRail infrastructure management

Before and in particular during the conversion, testing and trial operation, various activities will take place outside their specific management organisation in connection with the realisation of objects. Examples in this regard are deliveries, the installation and connection of rectifier substations, the conversion of stops, the delivery, installation and safety testing of ICT systems and so on.

Both for the preliminary phase and the conversion, testing and trial operation, agreements will have to be concluded between the project leaders and future managers about the role of management with respect to:

- testing moments of intermediate products (manufacturing and purchasing tests and the like);
- attendance moments in the development process (e.g. meetings on building progress);
- daily supervision by management of the performance of work; and
- regular contact between the executive head and the manager.

The following six steps can be referred to as checking moments. In formal terms, each step must be checked by the principal, the Haaglanden Urban District. The Haaglanden Urban District asked HTM Infra, the future manager, to carry out these checks on its behalf.

<sup>87</sup> Memorandum on the transfer of management and maintenance (version 1.21, 21 February 2006).

<sup>88</sup> Letter of the Haaglanden Urban District to the Dutch Safety Board of 22 November 2007 which states that the memorandum was discussed and approved in the PL coordinators' meeting of the Haaglanden Urban District, Rotterdam City Region and PoRR on 16 March 2006.



### *Step 1 Operational launch*

The first step involves the transition from building to a completed subsystem (object). Technical components must be tested upon the delivery of every subsystem in accordance with the FAT, SAT and operational specifications. These tests must show that all subsystems meet the technical and functional specifications. Testing and measuring protocols must be provided as evidence.

The project leaders of the municipality of The Hague (PoRR) are responsible for the performance of these tests. The manager must check and approve the results on behalf of the principal.

### *Step 2 Integration test*

The second step involves a test to show that the combination of subsystems (e.g. substructure-railway-traction-safety-railway vehicle, station-installations-ICT-railway vehicle) meets the specifications (the integration test focuses on the harmonisation of specifications) in both technical and functional terms. Among other things, one to two vehicles are used for this test. It must be shown that there are no serious shortcomings or delays in the subsystems. There must be a clear safety regime in place which sets out procedures for commissioning and decommissioning railways or railway sections.

Completion of this step is the responsibility of a project leader for integration. The manager will check and approve the results on behalf of the principal. This step must determine whether the rolling stock and infrastructural subsystems interact properly.

### *Step 3 Performance test (from 20 August 2006)*

The third step comprises the performance test, which must demonstrate that the system as a whole meets the established performance requirements (system performance). Several vehicles are used to complete this step and exceptional operational circumstances are simulated (e.g. speed profile, situations in which corrections are made, using a single railway, replacing a vehicle on the rails, capacity test and merging and branching off). Special attention must be paid to the main risks and safety aspects (see safety case). The performance test can take place if:

- the railway and stations are freely available;
- suitably qualified tram drivers are available;
- the process can be monitored and guided by central traffic control.

This step will be completed on behalf of the principal under the responsibility of the manager in cooperation with railway undertakings HTM and RET. In addition, management duties relating to safe travel, access to the railway and traffic control come into effect in this step. Operational management subject to the RandstadRail Service Regulations is in force from this point in time, which means that work along railways or at stations may only be performed if the railway section or station in question has been taken out of operation. The resources provided for in the project for communication with the vehicles and personnel along the railway must be available.

### *Step 4 Trial operation based on the timetable for regular services*

The fourth step comprises trial operation based on the timetable for regular services but without passengers. This step must give drivers, traffic controllers and operations personnel the opportunity to become familiar with the new infrastructure and systems. Its purpose is to realise the conditions necessary for operations, such as, for example, familiarity on the part of the drivers with visual-based driving, safety, management and maintenance, emergency response organisation and so on. This period is used primarily to harmonise the respective operations and management/maintenance organisations of RET and HTM. The requirement is three consecutive days of operations without technical failures under nominal load, including disruptions. The trial operation is the responsibility of railway undertakings RET and HTM.

### *Step 5 Approval for operations*

The infrastructure will be approved if the trial operation is completed without as yet to be defined delays/disruptions. Approval for operations (passenger transport by HTM and RET) can be granted after successful completion of the trial operation. In formal terms, this approval will be granted by the principal (the Haaglanden Urban District). Regular operational management, including maintenance, will also be transferred to the managers by the principal. The municipality of The Hague (PoRR) may only work after the manager has granted permission. Because legal transfer has not yet been effected, the municipality of The Hague (PoRR) remains formally responsible for the quality and technical condition of the infrastructure. The Haaglanden Urban District issued separate

instructions to HTM Infra for this management and maintenance phase.

#### *Step 6 Final delivery*

Final delivery of the systems supplied will take place during the initial period of operations (resolution of remaining points, as-built documentation, e.g. technical descriptions, drawings, manuals, legal transfer – including permits, obligations and guarantee provisions – and financial settlement). Insofar as they are covered by the guarantee, the supplier of the system is responsible for remaining points, teething problems and so on.

The project leaders of the municipality of The Hague (PoRR) are responsible for this phase.

Actual delivery will be made by the Project Bureau (the contractor) to the Haaglanden Urban District (the principal). The Haaglanden Urban District will have the technical assessments carried out on its behalf by HTM Infra and will itself see to the legal and financial settlement.

After actual delivery has been effected by the municipality of The Hague (PoRR) to the Haaglanden Urban District, the Haaglanden Urban District will immediately transfer full management and maintenance responsibility to HTM. Only then will HTM formally be the manager and first point of contact, also in relation to external parties.

NB. The municipality of The Hague (PoRR) must remain available and accessible in the first weeks following delivery. The time of discharge will depend on performance in the first weeks of RandstadRail operations.

#### *Transfer protocols*

Delivery protocols have been included in the specifications for step 1 (delivery of subsystems). This is usually a delivery made by the supplier/contractor to the Project Bureau. The project leader for systems or subsystems will have to involve the operational manager (HTM/RET) in this delivery process in order to enable the transfer from the Project Bureau to the maintenance organisation to take place on a one-to-one basis.

The maintenance department of HTM/RET Infra will contribute to the requirements for the transfer protocols governing step 2 (integration test). The transport companies will formulate transfer requirements for steps 3 (performance test) and 4 (trial operation). These will include requirements governing test results as shown in Appendix 3. These will be signed for approval.