



Ministerie van Infrastructuur en Milieu

# ERTMS Railway Map

*Version 1.0 - Start decision*

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# 1 Management summary

In 2012, the Ministry of Infrastructure and the Environment and the railway sector (to date, primarily with ProRail and Netherlands Railways (NS)) worked on the first phase of plan for the introduction of ERTMS (the “initiative phase”). This Railway Map Version 1.0 explains the progress to date and the following process.

The Netherlands has a densely-used railway system. The Long-Term Railway Agenda (LTSA) set the ambition for the improvement of the railways as a transport product with the ultimate objective of ensuring that increasing numbers of passengers and shippers perceive the train as an attractive transport option and make use of the railways. This objective can be achieved only with a further general improvement of the railway system. Safety will be a condition attached to these improvements. The current railway protection system performs well, but is ageing. Consequently, the existing system needs to be replaced: this offers opportunities for the introduction of ERTMS (the ‘European Rail Traffic Management System’). ERTMS is the new European standard for train control, including train protection. ERTMS is a new system which offers safety and interoperability benefits. ERTMS also offers potential capacity, speed and reliability benefits.

Communication problems are an issue on the HSL-Zuid high-speed passenger railway line: the communication between the train, track and traffic control is still insufficiently stable. For this reason a carefully-considered and justifiable decision about the introduction of ERTMS can be reached solely with further studies are carried out during the coming exploratory phase.

This Railway Map version 1.0 constitutes, in accordance with the Multi-Year Programme for Infrastructure, Spatial Planning and Transport (MIRT), the start document for the exploratory phase. This start decision, in accordance with the ‘from outline to detail’ principle, makes a number of directional choices:

- The Government has, with the support of the House of Representatives of the States-General, decided to introduce ERTMS in the Netherlands in phases;
- The planned introduction of ERTMS can enable the Netherlands to make a quantum leap that will endeavour to achieve the following objectives: improvements in railway safety and interoperability and, when feasible, in capacity, speed and reliability;
- The objective is to provide for a simple and standardised introduction of ERTMS;
- The introduction of ERTMS will begin with the rolling stock.

This report specifies four search directions for scenarios for the introduction on the infrastructure (“natural replacement”, “rapid replacement”, “begin with routes with a high capacity (need)”, “begin with routes with a low capacity (need)” and a counterfactual scenario (installation on railway lines to the extent that this follows from European obligations). This report also outlines the further studies to be carried out during the exploratory phase.

At present, ERTMS is primarily installed during the construction of new railway lines. Virtually no experience has been acquired with the installation of large-scale systems in the existing railway network. The objective is to achieve a carefully-considered and controlled introduction that causes no hindrance to passengers and shippers, i.e. “the shop must remain open during the alterations”. For this reason the exploratory phases seeks answers to the following questions about the infrastructure and rolling stock:

1. Objectives: to what extent and/or subject to which conditions can ERTMS make a contribution to the specified objectives/benefits? This includes a study of the development in ERTMS' performance and the risks compared to the current situation with the existing train protection in terms of the objectives of safety, interoperability, capacity, speed and reliability. This study will then, for example, zoom in on issues such as ERTMS on yards and the GSM-R system, etc.;

2. Rollout strategy: the determination of the scope, i.e. where and when can ERTMS be installed on the infrastructure in relation to the objectives and timing of other programmes/projects? Which conversion schedule will be adequate for the rolling stock? In the first instance, consideration is being given to working out the four search directions and the counterfactual scenario in more detail.
3. System selections: which types of system are required where, in part as viewed from the perspective of the entire traffic management chain?
4. Which tendering and contracting strategy (including management and maintenance) is desirable in view of the costs and risks?
5. Use and management processes: what is the influence of ERTMS on the use and management, and which approach should be adopted?
6. What are the estimated costs, including the management and maintenance costs (also in comparison with the current situation), what are the associated risks and the management measures that will be required, and how will the financing be organised?

An exploration will also be made of the opportunities available to seek sophisticated combinations with current and planned programmes and projects that can incorporate ERTMS in the design or implementation. Consideration can then be given to the High Frequency Rail Programme and to public transport in the Amsterdam Airport Schiphol-Amsterdam-Almere-Lelystad corridor (OV-SAAL), as well as explorations of the feasibility of and the need to, for example, increase the capacity or reliability of existing railway lines or increase the speeds on a number of railway lines. A review will also be carried out to assess the extent to which the optimisation of the entire traffic management chain – such as, for example, a redesign and improvement of the rail traffic control and disruption management process – in combination with ERTMS could offer benefits including an improvement of the reliability of the railway system. In other words, ERTMS is closely related to other LTSA programmes and projects.

The introduction of ERTMS will need to be preceded by a carefully-considered study and decision-making process in view of the complexity of the introduction due to the role played by factors such as the replacement of obsolescent systems, the relationships with other components of the traffic management chain and potential links with other programmes, projects, explorations and needs. It will be necessary to avoid the situation in which scheduling and cost ideals cannot be fulfilled. ERTMS will be introduced only once it is certain that the risks associated with the introduction can be controlled to an adequate extent.

This is also the reason why it has been decided that the introduction of ERTMS will begin with an exploratory phase. This phase will provide a clear insight into the studies, data and results that are required. A probabilistic schedule will be drawn up for the exploratory phase. In addition, an inventory of the risks will be made and the measures need to control those risks will be specified. The studies to be carried out will consist of a body of technical, practical, cost and benefit, risk and experiential studies. Most of this information for the specific Dutch situation – an existing densely-used railway network – is not currently available. The studies will generate decision-making information and reduce uncertainties. This process will also extend to an incremental process that can result in the identification of the preference decision: options will be studied and eliminated, with substantiation, during the course of the exploratory phase. During the exploratory phase it will also become clear when decisions on which issues can or cannot be made. This may result in decisions on issues or sub-issues at various times during the exploratory phase: for example, the scope could encompass the entire main railway infrastructure or, conversely, be limited to the introduction of the system for specific railway lines, yards and rolling stock, etc.





*The Hanzelijn railway line is equipped with ERTMS and the current train protection system (dual signalling).*

The Ministry of Infrastructure and the Environment and the sector will engage in a learning process while they gain an insight into the extent that and the manner in which the potential benefits offered by ERTMS may make a contribution to the achievement of a range of objectives for (the various parts) of the Dutch railway network and into the issues that require further study. The introduction of ERTMS can be a success only when the infrastructure manager – ProRail – the various train operators and the other stakeholders contribute the knowledge and information and perform the duties that are compatible with their (institutional) duties. Cooperation between the Ministry of Infrastructure and the Environment and the sector will be essential. External expertise and advice will be called in when this is worthwhile or necessary.



## 2 Background

### European Rail Traffic Management System

Work on the development of ERTMS (the ‘European Rail Traffic Management System’) began in the nineteen-nineties on the European Commission’s initiative. The system was originally intended to break down the technical barriers to interoperability on the European railway network caused by the different train control and protection systems and, ultimately, to reverse the declining competitive strength of the railway sector. As a result, ERTMS is a core element of the European strategy for the revitalisation of the railway sector and the promotion of the freedom of movement of persons and freight. This has resulted in a Council Decision<sup>1</sup> prescribing the installation of ERTMS on specific (international) corridors.

ERTMS results in a further shift from the mechanical or electromechanical train protection systems still frequently in use to largely computer-controlled protection systems. ERTMS uses modern electronic systems and means of communication: it represents a quantum leap. ERTMS offers a means of creating an (even) safer system than the current Dutch train protection system. In addition, it offers opportunities for the improved utilisation of the railway infrastructure in the future.

### Temporary Railway Maintenance and Innovation Committee

The Kuiken Committee<sup>2</sup> published its report on 16 February 2012, with conclusions including the following: the development of train protection systems in the Netherlands has landed in an impasse, there are sufficient points of departure for the decision to introduce ERTMS and that a quantum leap in train protection offers opportunities for increased traffic on the existing infrastructure and, as a result, will reduce the need for the construction of additional infrastructure.

### Government's ambition

On 8 June 2012, the Government reached a decision in principle to introduce ERTMS on a broader scale<sup>3</sup>. This decision states that the railways must be safe. Safety is a condition attached to the ability to guarantee the objectives to be achieved by the railways both now and in the future. This decision in principle constitutes an important step towards a future-proof train protection system. This system extends beyond solely improving safety: it is also expected to make a large contribution to the achievement of the current and future objectives of the railways.

As the Kuiken Committee also concludes, ERTMS creates a number of preconditions that are attached to the ability to achieve improvements in the railway system’s performance.

The Kuiken Committee's findings were in part the reason for a change in direction for ERTMS that took place at the end of 2011. In 2012, work began on a Railway Map (in 2012, still referred to as the Road Map) for ERTMS. This work was carried out under the direction of the Ministry of Infrastructure and the Environment. The Railway Map outlines the logical steps and the programme to be followed for the carefully-considered introduction of ERTMS that is to result in a series of incremental, substantiated choices.

The 'Building Bridges' Coalition Agreement<sup>4</sup> of 29 October 2012 includes the statement that: “The European railway protection system (ERTMS) shall be introduced in phases from 2016, using the existing budgets.”

<sup>1</sup> Council Decision 2012/88/EU. A further explanation of the European context is enclosed in the annexes.

<sup>2</sup> Parliamentary Documents II, 2011-2012 sessions, 32707 No. 9

<sup>3</sup> Parliamentary Documents II, 2011-2012 sessions, 32707 No. 16

<sup>4</sup> Parliamentary Documents II, 2012-2013 sessions, 33410 No. 1

As care is essential, the decision-making shall be carried out in phases with integral go/no-go decision-making points. Each phase shall give consideration to the following steps in the process that are both necessary and justified.

### **Long-Term Railway Agenda (LTSA)**

The Dutch railway system has reached the limits of its capacity feasible with the current working methods. This has been recognised for some time, and this was one of the reasons for the decision to initiate the High Frequency Rail Programme. The limits of the railway system are particularly apparent on days with major disruptions. For this reason the main objective of the Long-Term Railway Agenda is to achieve a general improvement in the quality of the railways as a transport product. An increasing number of passengers and shippers will need to perceive the train as an attractive transport option and make use of the railways. Their needs include more capacity, a more reliable system and a more rapid return to normal services after a disruption. ERTMS can serve as an important means of contributing to these and other LTSA objectives. This will also be an element of the current LTSA studies and the studies relating to the review of programmes and projects<sup>5</sup>.

### **A carefully-considered process**

Train operators using the HSL-Zuid high-speed passenger railway line are still confronted with communication problems relating to ERTMS. The problem is caused by the failure of the data link between the track and train required for the appropriate performance of the ERTMS train protection system. The problem is due to the track infrastructure (Infraspeed's responsibility), the GSM-R link (ProRail's responsibility) and the train equipment (the train operator's responsibility). The problem is also exacerbated by the fact that the Technical Specifications for Interoperability drawn up for the trains and track are not always consistent. All the parties involved are cooperating in a task force for the permanent monitoring of the problems and for the joint resolution of the problems within the shortest possible timeframe. The House of Representatives of the States-General is informed about developments in the 'track and train' problem in six-monthly progress reports. Within this context, a great deal can be learned from the experiences with the Betuweroute freight railway line: a software upgrade carried out in the summer of 2012 has resulted in a great improvement in the system's reliability.

Experience with ERTMS has yet to be acquired in yards, i.e. the tracks around stations. Train protection in yards is more complex than on open lines, in part due to the limitations of GSM-R. For this reason this is one of the issues that will need to be studied further during the exploratory phase to provide the information required for a carefully-considered and justifiable preference decision for the introduction of ERTMS.

No experience with a national rollout of ERTMS has been acquired to date, although states including Belgium, Denmark and Switzerland are working on national introduction schemes. Their experiences and strategies in fields such as testing and backup options shall be examined further during the exploratory phase. Each new system must be tested thoroughly prior to its introduction. Denmark, for example, has specified a 3-year test period prior to the decision whether to proceed to a national rollout. Further studies and factual studies of the aforementioned and other problems will be carried out during the exploratory phase. These and the other studies carried out during the exploratory phase, together with the answer to the question as to the extent to which a solution for the identified problems is feasible, will form input for the preference decision to be taken at the end of the exploratory phase.

### **This document**

This Railway Map version 1.0 constitutes the start document for the exploratory phase. The exploratory phase, which in turn constitutes the next step towards a carefully-considered phased introduction of ERTMS, is completed with the next go/no-go decision-making point, the "preference decision".

<sup>5</sup> See Parliamentary Documents II, 2012-2013 sessions, 29984, No. 334



Section 3 lists the objectives to be achieved with ERTMS. Section 4 reviews the directional choices and search directions for the introduction scenarios identified in this start decision. Section 5 outlines the process and the integral go/no-go decision-making points. Section 6 contains a summary of the approach to the exploratory phase, comprised of the studies that need to be carried out and the development of the scenarios. Section 7 reviews the financing, risks and stakeholder management.

ProRail, as the manager of the main railway infrastructure, and Netherlands Railways (NS), as the train operator on the main railway network, were involved in the preparation of this Railway Map Version 1.0 since the introduction of ERTMS will confront them with the greatest tasks. However, the following phases will also make emphatic use of the knowledge, experiences and ideas of train operators and stakeholders alongside ProRail and Netherlands Railways (NS).



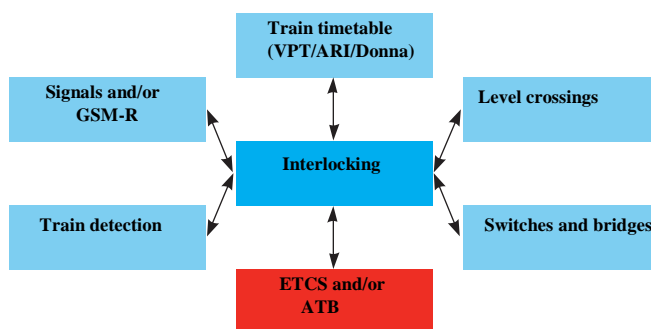
### 3 Objectives to be achieved with ERTMS

This Section reviews the intended objectives to be achieved with the introduction of ERTMS.

#### What is ERTMS?

The European Rail Traffic Management System (ERTMS) constitutes the new standard for train control, including train protection<sup>6</sup>. The Netherlands often uses the ‘ERTMS term’ to refer to the physical railway protection system. The following figure shows that the railway protection system is comprised of a number of components. The heart of ERTMS is formed by the train protection system in the train and on the track, the European Train Control System (ETCS). To make full use of the benefits offered by ERTMS it may be necessary to modify the interlockings, train detection and train management systems, for example the (VPT<sup>7</sup>) system used by the rail traffic controllers.

Figure 1: Train protection components of the railway protection system linked to the train timetable.



#### Why ERTMS?

The protection of the Dutch railway network is of a high level. However, the protection principles and systems date from the first and second halves of the Twentieth Century. The Dutch railway network is now used much more intensively than anticipated in the original design. In addition, the system and its use have become more complex.

As a result, the capacity of the Dutch railway system has reached its limit. The High Frequency Rail Programme was initiated in response to the forecast future growth in the use of the system. The limits of the railway system are particularly apparent on days with major disruptions.

The main objective of the Long-Term Railway Agenda is to improve the quality of the railways as a transport product with the ultimate objective of ensuring that increasing numbers of passengers and shippers perceive the train as an attractive transport option and make use of the railways. There is, in particular, a need for more capacity and increased reliability. ERTMS can serve as an important means of achieving these objectives. An appropriate introduction of ERTMS may also result in the increased flexibility, robustness and capacity of the railway system. However, ERTMS is not an end as such.

<sup>6</sup> ERTMS is not so much a tangible product or system, but rather a specification for the design of systems. The specification of ERTMS is laid down in Council Decision 2012/88/EU, which defines ERTMS as the 'technical specifications for interoperability relating to the control-command and signalling subsystems of the trans-European rail system'.

<sup>7</sup> VPT: Vervoer Per Trein ('Transport by Train')

Nevertheless, on the basis of the current insights it does offer functionality that can make a contribution to the achievement of the Long-Term Railway Agenda's objectives.

A major step forward in the improvement of the performance of the Dutch railway system will be feasible solely when ERTMS is deployed as an element of the complete traffic management system. The implementation of ERTMS can then make a potentially large contribution to substantial improvements in:

- Safety
- Interoperability
- Capacity
- Speed
- Reliability

The extent to which ERTMS will realise these benefits in practice varies between situations and states. Further studies will be required to review the extent to which the presumed benefits can be realised in practice and the extent to which the claimed benefits – and the risks – can be substantiated with facts. Facts are required for the preference decision. The Netherlands has learnt its lessons with the HSL-Zuid high-speed passenger railway line and Betuweroute freight railway line, and has acquired experience with the introduction of ERTMS. This experience is of benefit to states that have decided to introduce the system on a national scale. At present, the Netherlands is no longer in the vanguard. The Dutch ambition and the introduction scenario will in part be dependent on the results from the further studies and the point of departure, and in part on the extent to which the requirements/specifications (which may be based on standardisation and benefits of scale) issued for the tendering process are realistic. This last aspect will also largely determine the costs.

### Safety

The ability to guarantee safety is a condition attached to rail transports of passengers and freight. Train protection systems are used to prevent collisions between trains, train derailments and collisions with road traffic and track workers. This train safety is based on an entirety of technical systems in which train running control ('make sure that trains stop before the danger point') is an essential element. ERTMS includes train running control (braking curve monitoring) which is enabled at all speeds. This is a fundamental difference from the automatic train protection first generation *ATB-EG* system (a more detailed explanation of the technical systems is enclosed in Annex 1).

Although the current train protection system achieves a high level of safety, it also suffers from a number of shortcomings<sup>8</sup>. In the longer term this ATB automatic train protection system and the associated protection equipment will need to be replaced.

Further studies will be required to determine which routes can benefit from a further improvement in safety offered by ERTMS and which period of time will be required to achieve the improvement. Human factors will then also need to be taken into account, both with respect to the current system and to ERTMS, and with respect to the expectations for future trends in these factors.

### Interoperability

The installation of ERTMS on railway lines on each side of the border will make cross-border transports (of freight and passengers) feasible without the need to equip locomotives with a number of train protection systems (which is expensive) or to change train drivers and/or locomotives or, in the event of rolling stock equipped with dual train protection systems, without the need to change to a train driver authorised to operate trains on railways with the protection systems of the various relevant states. Consequently, ERTMS is an important means of promoting (regional) cross-border traffic and is also of importance to the transshipment of freight from the Netherlands to its ultimate destination in Europe.

<sup>8</sup> See also Parliamentary Documents II, 2012-2013 sessions, 29893 No. 137.

Interoperability can be achieved solely when thorough consultations with the states bordering the Netherlands are held to coordinate the introduction strategies. The studies to be carried out during the exploratory phase shall devote attention to this issue, both in terms of the selection of the system and the date specified for the introduction of the system.

### Capacity

As stated in the letters to the House of Representatives of the States-General of 7 September and 13 December 2012<sup>9</sup>, ERTMS offers opportunities for a reduction of the time interval between trains. For this reason the ERTMS studies will include a review of measures for the reduction of time intervals.

Further studies will need to reveal the manner (with links between systems, train timetable models and deployment of rolling stock) in which the introduction of ERTMS can increase the capacity of which routes and within which period of time. The opportunities offered for the improved utilisation of the railway system by the improvement of the traffic control and disruption management system/process (including Automatic Train Operation) will also play an important role. Studies can also be carried out to review the extent to which claims for energy savings and the more efficient deployment of rolling stock can be realised. Complementary measures may also be necessary. Attention will also need to be devoted to the associated costs, benefits and risks.

### Speed

ERTMS supports the safe use of railway lines at speeds between 0 and 500 km per hour. Although – in theory – ERTMS provides for speeds of up to 500 km/hour, this is not realistic for the Dutch main railway infrastructure. A number of railway lines constructed in the Netherlands since the nineteen-eighties are designed for a maximum speed of 160 km/hour (as well as the HSL-Zuid high-speed passenger railway line, which is designed for a maximum speed of 300 km/hour). Trains on the Hanzelijn and Amsterdam-Utrecht railway lines, which are equipped with ERTMS alongside ATB, may travel at a maximum speed of 200 and 160 km/hour respectively.

The current ATB system is based on incremental speed ranges from 40 km/hour and operates to a maximum of 140 km/hour.

Further studies are required to review the relationship between the increased speeds feasible with ERTMS as compared to ATB (both to 140 km/hour and above this speed).

### Reliability

ERTMS can increase reliability, as ERTMS requires fewer railway infrastructure elements.

Further studies are required to gain an insight into how and when ERTMS may be expected to contribute to a general improvement of railway reliability as compared to the current system.

<sup>9</sup> Parliamentary Documents II, 2012-2013 sessions, 32404 No. 58 and No. 62.





*Balise between the rails. ERTMS uses this as a beacon.*



## 4 Directional choices and search directions for introduction scenarios

This Section specifies the points of departure and preconditions attached to the migration to ERTMS. The Section explains ERTMS' position in the traffic management chain, the directional choices made in this start decision and the search directions for introduction scenarios that will be worked out in more detail following the further studies carried out in the exploratory phase.

### Points of departure and preconditions

The Government has decided that ERTMS will be introduced, in phases, in the Netherlands. This decision was in part taken as a result of the Kuiken Committee's report and the potential benefits this system, as a 'dot on the horizon', offers for the railways' performance. Consequently, the ambitions – on the assumption that further studies demonstrate that the risks and costs are controllable and that the cost-benefit ratio is acceptable – extend beyond compliance with the European requirements for the TEN-T Corridors in 2020 and 2030 (see Annex 2). During the coming exploratory phase an assessment will be carried out within the scope of the Railway Map to determine the actual scope available for the selection of the variant and the introduction of the variant on the basis of considerations of the need, value, risks, and costs and benefits.

Points of departure and preconditions have been specified for the exploratory phase (an explanation of the process is enclosed in sections 5 and 6). These update the preconditions laid down in the decision in principle of 8 June 2012, and specify them in more precise terms.

#### *Points of departure*

The migration of ERTMS is governed by the following points of departure:

- The decision in principle has been made to implement ERTMS. ERTMS shall, in accordance with the Coalition Agreement of 29 October 2012, be introduced in phases from 2016;
- The implementation shall be carried out within the existing budgets. The implementation will then be governed by two conditions, firstly that the selection of the variant and the allocation of the funds are cost-effective and, secondly, that the implementation is harmonised with other programmes and projects;
- Passengers and shippers must suffer the least possible hindrance from the rollout of ERTMS. The introduction of ERTMS may not put pressure on the day-to-day quality of railway transport;
- The investments must be future-proof, i.e. the investments must prepare for the future rollout of ERTMS and any investments in replacements of the current train protection system and equipment may be made only when they can be recouped;
- The studies of the variants will explicitly include a review of the system effects on the overall railway operations and infrastructure.

#### *Preconditions*

The migration will be governed by the following preconditions that will need to be met to achieve the objectives:

- The process must be transparent and controllable. Any risks shall be specified explicitly and shall be controlled;
- ERTMS must be sufficiently stable in both technical and operational terms;
- ERTMS must be introduced in a simple and standardised form;
- The cost estimates for the introduction of ERTMS must be sufficiently reliable, the costs must lie within the existing railway budgets and the costs must be in reasonable proportion to the social benefits;

- The work shall be tendered in a manner that promotes market innovation, minimises the total life cycle costs and avoids vendor lock-in<sup>10</sup>;
- The impact on the train operators' returns/business cases must be acceptable or the system must create added value for them.

Studies to be carried out during the exploratory phase will quantify these points of departure and preconditions in more detail.

### Directional choices

Experience with the introduction of ERTMS has been acquired both in the Netherlands and abroad. The Netherlands learnt (major) lessons during the period in which the HSL-Zuid high-speed passenger railway line and Betuweroute freight railway line were delivered. The system installed on the Betuweroute railway line has performed virtually without problems since the summer of 2012. The HSL-Zuid railway line's system still suffers from malfunctions. Test journeys on the Hanzelijn and Amsterdam-Utrecht railway lines have gone smoothly to date. States including Denmark, Belgium and Switzerland are now working on the national introduction of ERTMS.

This start decision has selected the following directional choices for the migration from the current system to ERTMS. These are based on the experience acquired in the Netherlands and elsewhere and shall be used to prepare the various introduction scenarios. The directional choices are:

#### *1: A dual period is necessary*

A large number of people and parties are dependent on railway transport. For this reason the 'shop' will need to remain open during the work, i.e. the normal train services may not be interrupted. During a specific period, in principle temporarily, ERTMS and ATB systems will be in use alongside each other. This dual phase has already begun in the Netherlands: a limited amount of rolling stock is equipped with dual systems (the rolling stock used on the HSL-Zuid high-speed passenger railway line and for freight transport) and some of the infrastructure is equipped with dual systems (the Hanzelijn and Amsterdam-Utrecht railway lines), although the infrastructure systems are not yet in use for the operations. The current ERTMS pilot trial on the Amsterdam-Utrecht railway line constitutes the first step towards the controlled testing and commissioning of the operability on the main railway network. The necessity to retain ATB in the trains, where applicable, will lapse once ERTMS has been rolled out on the infrastructure used by those trains. Following the rollout ATB can be removed from the infrastructure and from rolling stock that is not used on routes that are still equipped solely with ATB.

#### *2: Start the migration with ERTMS in the rolling stock*

The costs of equipping rolling stock with dual systems are significantly lower than the costs incurred in equipping the infrastructure with dual systems. When viewed from the perspective of the total costs, beginning by equipping the rolling stock of all (passenger) operators for the use of ERTMS is the most cost-efficient approach. However, this is governed by the need to select a generally accepted and future-proof version. A quick scan shall be carried out to assess the lead time for and the producibility and funding of the conversion of the rolling stock to ERTMS. It is expected that it will then be possible to use these assessments to reach the initial financing agreements with the train operators. This will need to be followed by a more specific rollout plan and financial plan for the conversion of rolling stock to ERTMS. A business case approach to the conversion programme may then prove useful. The timing of the installation of the equipment in the rolling stock and on the infrastructure will need to be harmonised to ensure that the total costs are as low as possible. It will be logical, in line with the approach adopted by other states, to include a provision in the regulations which prescribes that solely rolling stock equipped with ERTMS will be admitted to the railways after a certain date. A date for the conversion of rolling stock will also need to be stated in the operating concessions.

<sup>10</sup> Vendor lock-in refers to the situation in which a customer becomes dependent on one supplier to an extent that the customer is unable to break with the supplier or switch to another supplier without suffering major (financial) consequences.

### *3: The infrastructure should preferably be equipped with ERTMS only*

When the conversion to ERTMS begins with all or some of the rolling stock then the subsequent conversion of the infrastructure can be restricted to ERTMS whenever possible. This, in principle, is given priority above equipping the railway infrastructure with dual protection systems for reasons including the substantially lower costs (for example, by avoiding double maintenance costs). The interim installation of dual systems on (sections of) corridors remains, by exception, an option (for example, within the context of the Trans European Network Transport (TEN-T) obligations or other corridor policy, where relevant). This has already been adopted for the Amsterdam-Utrecht and Hanzelijn railway lines. A rollout plan for this approach to the infrastructure will be drawn up during the coming period. It will also be necessary to make a number of technical changes. The studies of the scenarios reviewed below and in Section 6 will be required for this plan.

### *4: Increasing the speed*

As increasing the speed of trains will become feasible with ERTMS, increasing the speed to 160 km/hour on specific blocks of track forms one of the pillars of the (detailing of the) Railway Map. Following the inclusion of the phased introduction of ERTMS in the Coalition Agreement, preference will be given to ERTMS as a means of increasing speeds. The plans for the infrastructure routes that have been designed for a maximum speed of 160 km/hour will focus on the utilisation of the benefits. This will, in principle, be based on the use of ERTMS. ERTMS will allow trains on the Hanzelijn railway line and the Amsterdam-Utrecht corridor to travel at maximum speeds of 200 km/hour and 160 km/hour respectively. This, from the perspective of the accessibility of the various regions of the Netherlands, is an important point for attention.

In 2012, the Ministry of Infrastructure and the Environment and ProRail and Netherlands Railways (NS) carried out a study of the technical (train protection) feasibility of increasing the maximum speed on a specific number of railway lines to 160 km/hour and the associated costs. This study has been subjected to an external audit. As the costs and benefits of – and, consequently, the business case for – an increase in speed are influenced by the timing of the introduction of ERTMS on these routes this aspect will be included in the studies of the scenarios carried out during the exploratory phase. This will provide for a carefully-considered and weighted selection when making the preference decision. Consideration shall be given, depending on the period within which ERTMS will be implemented, on the routes offering an opportunity for increasing the speeds, to the use of ATB Code 147<sup>11</sup> prior to the implementation of ERTMS.

### *5: Cross-border railway lines*

ERTMS offers opportunities for cross-border passenger transport, one of the Government's spearheads. ERTMS is currently being installed on a number of sections of railway line to the border (for example, the Betuweroute freight railway line is being extended from Zevenaar to the German border). Belgium is also switching to ERTMS<sup>12</sup>. It will be necessary to review the extent to which the Belgian's temporary TBL-1+ system should be rolled out on the railway lines to the Belgian border prior to the introduction of ERTMS. It will probably be logical to skip the intermediate TBL-1+ phase and switch directly to ERTMS. This issue will be studied in more detail.

### *6: Regional lines*

The regional train operators have, via the *Federatie Mobiliteitsbedrijven Nederland* ('Federation of Netherlands Mobility Companies', FMN), stated that ERTMS will probably yield the greatest benefits on the decentralised electrified railway lines. This will be included in the studies of the scenarios (see below) carried out during the exploratory phase. These studies will also review whether ERTMS could offer benefits on diesel powered railway lines, for example because increases in train frequencies can then be implemented without or with fewer expansions of the infrastructure that will in turn offer savings in costs and lead times for projects of this nature.

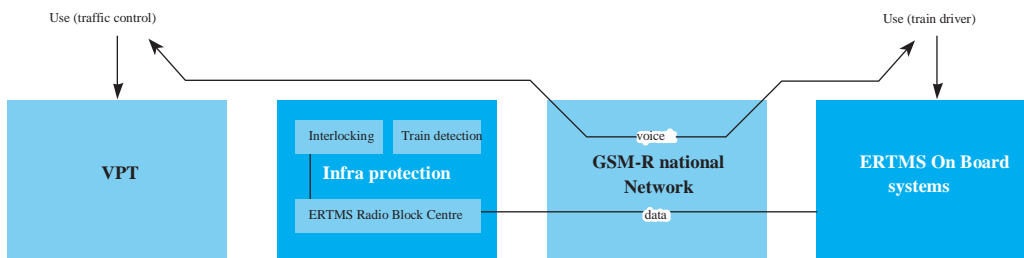
<sup>11</sup> However, it should be noted that in the past the European Commission has criticised the use of ATB Code 147 (see also Parliamentary Documents II, 2008-2009 session, 29984 No. 154)

<sup>12</sup> Infrabel and NMBS submitted their joint proposal for the ETCS Master Plan to the Belgian Parliament on 19 October 2011. Infrabel intends to have equipped the entire Belgian railway network with the European safety system by 2022.

7: System choices

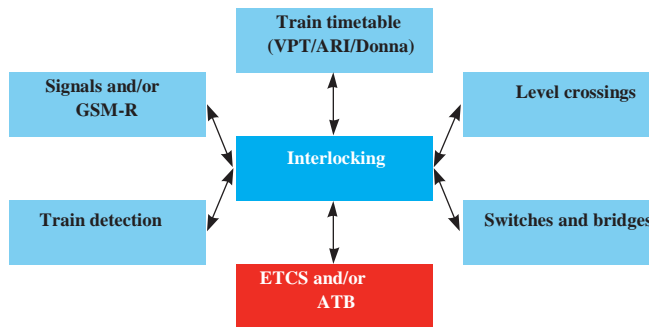
The Netherlands currently uses two basic forms of train protection, namely ATB (the specific Dutch Automatic Train Protection system) and ERTMS. Both systems are based on equipment installed on the infrastructure and in the rolling stock and are part of the traffic management chain in the broadest sense (see the following figure). They, together with the operational processes, determine the behaviour and performance of the railway system.

Figure 2: Traffic management chain



The “Infra protection” block consists of a number of train protection components which are shown in the following diagram and are linked to the train timetables.

Figure 3: Train protection components of the railway protection system linked to the train timetable.



The selection of ‘the system’ is not limited solely to the selection of the ERTMS level or to characteristic elements of the protection system, such as the interlocking and train detection, but also extends to the question whether and, if so, how the traffic controllers' system (VPT) and GSM-R should be modified to achieve the optimum performance of the entire chain in which ERTMS is incorporated. The assessment will also extend to the consequences of any necessary complementary investments and/or opportunities and impediments (from implementation and financial perspectives). Consequently, as stated in Section 3, by definition the introduction of ERTMS extends beyond merely replacing ATB by ETCS. For this reason, the achievement of a performance in some areas which is better than the current generation of (protection) systems will require the optimisation of the system, in particular of the traffic control, protection, GSM-R and rolling stock. One example of the above is the achievement of the maximum utilisation of the railways (capacity) which, in addition, is also dependent on the (complexity of) the infrastructure layout and the logistics process.

The specification of the conditions attached to an optimum system solution is included in the plan of approach to improvements being drawn up jointly by ProRail and Netherlands Railways (NS) within the scope of the Long-Term Railway Agenda. For this reason the introduction of ERTMS can, for example, result in the additional need to upgrade or replace VPT, GSM-R and the train detection and interlocking systems (in the longer term).

### Search directions for ERTMS introduction scenarios for the infrastructure

A number of introduction scenarios are conceivable for the migration to ERTMS. These will need to be compatible with the objectives that could potentially be achieved with ERTMS and with the Coalition Agreement's decision to introduce the system in phases from 2016, within the existing budget and within the capacity available in the market.

A distinction is currently made between four search directions for the introduction scenarios and a counterfactual scenario. These search directions for the scenarios have been identified on the basis of the knowledge of and experience with ERTMS available in the Netherlands and other states, and form the starting point for further studies. It should be noted that these are *search directions*: they are *not* detailed plans.

The counterfactual scenario relates to the further introduction of ERTMS, in addition to the existing railway lines equipped with the system, solely when and where this is required pursuant to European obligations. This relates to the freight corridors from Rotterdam to Germany via the Betuweroute freight railway line (2015) and from Rotterdam to Antwerp (2020). The TEN-T directives are currently being revised: this could result in new obligations<sup>13</sup>.

The four search directions for the introduction scenarios are based on the phased introduction of ERTMS from 2016 as laid down in the Coalition Agreement but differ in terms of the pace of the introduction and the routes that will be addressed first.

- a. The *Natural replacement* scenario follows the ageing of the current protection system. ERTMS will be installed on a railway line once important components of the current protection system have aged to an extent that gives cause to the need for replacement for continued guarantees for the safety and availability of the railway line. This avoids the loss of capital to the maximum possible extent as it makes use of the opportunity offered by the need for replacement. However, as the current systems will not need to be replaced for more than 30 years, this search direction will result in a rollout which lasts several decades and, consequently, will be relatively slow.
- b. The *rapid replacement* search direction is based on the installation of ERTMS on the entire infrastructure as quickly as possible. A scenario of this nature, in which speed could be detrimental to due care, could result in high costs and risks but would lead to the rapid implementation of ERTMS on (a large part of) the Dutch railway network.
- c. The *beginning with routes with a high capacity (need)* search direction is based on a migration to ERTMS which begins with the routes with the most trains and a high capacity need. As a result, the focus is placed on the routes that yield the greatest benefits (such as safety and capacity). This also results in an important relationship with the High Frequency Rail Programme (PHS) and the Amsterdam Airport Schiphol-Amsterdam-Almere-Lelystad corridor (OV-SAAL). Although this may yield the most benefits, the risks (hindrance to customers and producibility) are also high. The installation of ERTMS on the rest of the railway network will follow as determined by the ambitions, budget and necessity.
- d. The *beginning with routes with a low capacity (need)* search direction is based on a migration beginning with the routes with the fewest trains. The routes with the most trains follow at a later date. In this search direction the decentralised railway lines and some of the cross-border railway lines will be the first to come into consideration for the migration. This will be beneficial to interoperability. This will also provide for acquisition of experience with the implementation and operation of the new system. After this phase ERTMS can be implemented on the corridors with most trains.

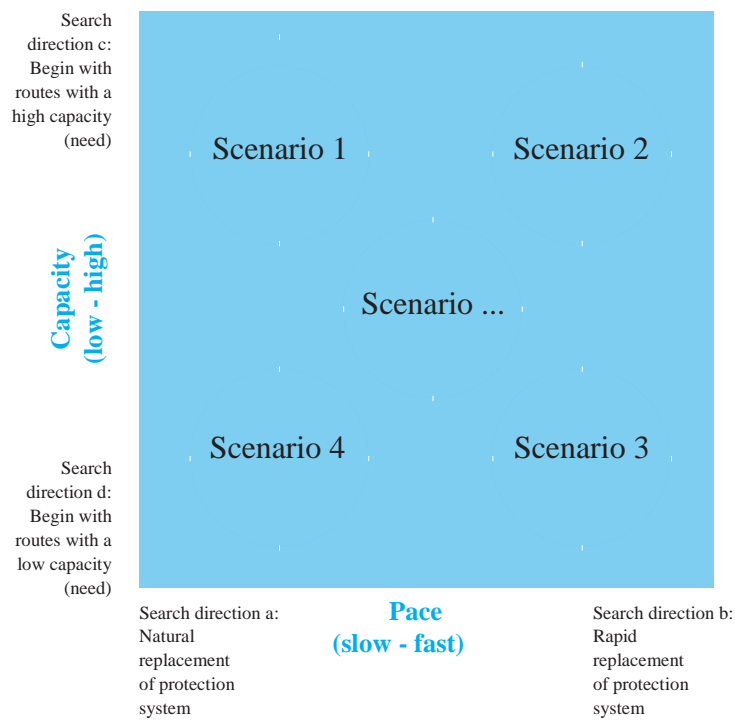
<sup>13</sup> The proposed directives divide the European transport infrastructure into a core network that is to be equipped with ERTMS by 2030 and a comprehensive network that is to be equipped with ERTMS by 2050. The decision-making by the European Parliament is expected in 2013.

The search directions are extremes. Combinations of search directions are also feasible. During the coming period the search directions will be worked out into scenarios and supplemented with the results from studies of the costs, benefits and risks. This development of the scenarios will review the feasibility of developing scenarios which begin with the routes that offer a great potential for improvement (in terms of safety, capacity, reliability and speed) and which offer the best cost-benefit ratio and an acceptable risk profile.

Use will then be made of the efforts, knowledge, expertise and information of independent external bureaus, ProRail, train operators and the Ministry of Infrastructure and the Environment (see Section 6, which summarises more studies). The results from these studies will provide the input for the weighting of the preference decision on the basis of an assessment framework that has yet to be developed.

The following diagram shows these search directions along the axes, and the scenarios that could be developed from the search directions.

*Figure 4: Search directions along the axes, and the scenarios that could be developed from the search directions.*





## Introduction scenarios for the rolling stock

The rolling stock needs to be equipped with what is referred to as an On Board Unit (OBU) for the introduction of ERTMS.

### *Passenger transport*

The following issues are of importance to the introduction scenarios for the rolling stock of passenger operators:

- Conversion to ERTMS, possibly in combination with scheduled overhauls of and modernisation programmes for the existing rolling stock;
- ERTMS on the purchase of new rolling stock;
- Inclusion of the introduction of ERTMS in new railway operating concessions<sup>14</sup>.

Netherlands Railways (NS) is responsible for the majority of the passenger transport in the Netherlands pursuant to the main railway network concession. The remainder of the passenger transport is carried out by passenger operators (affiliated with the *Federatie Mobiliteitsbedrijven Nederland* ('Federation of Netherlands Mobility Companies', FMN) pursuant to concessions granted by decentral authorities. The fleet of rolling stock of the various passenger operators is comprised of a variety of types of trains that will probably each require a specific ERTMS installation.

National introduction scenarios based on the installation of ERTMS solely on the replacement of the passenger operators' rolling stock would not appear to be realistic, as this would result in an extremely long implementation period (to 2040). Scenarios based on an extremely rapid rollout of ERTMS on the rolling stock would result in additional withdrawals from service and overhauls (for example, completed by 2020) that could have a (great) impact on the continuity of the train services and/or costs. A first indication for NS Dutch Railway's rolling stock reveals that all train series coming into consideration for overhauls and/or modernisation could be equipped with ERTMS by about 2025. Additional temporary withdrawals of rolling stock would be required if all Netherlands Railways (NS) rolling stock is to be equipped with ERTMS at an earlier date. Further studies will be carried out to review the extent to which this – alongside the existing temporary withdrawals of rolling stock for overhauls/modernisation – would be feasible without impacting train services as a result of shortages of rolling stock.

Studies to obtain a more detailed insight into the train operators' costs and benefits arising from ERTMS will be carried out during the exploratory phase.

### *Freight transport*

The majority of the freight locomotives calling at the Port of Rotterdam or travelling on the Betuweroute freight railway line are already equipped with ERTMS. Some domestic freight and maintenance rolling stock has yet to be equipped with ERTMS.

The study of the scenarios will devote attention to this issue.

<sup>14</sup> Specific information about the main railway network operating concession 2015 to 2025 is available in Parliamentary Documents II, 2012-2013 sessions, 29984 No. 335, Annex 1 with the schedule of requirements, which states that the new concession is expected to contain requirements for the implementation of ERTMS.



*The Betuwelijn freight railway line is already equipped with ERTMS.*



## 5 Process

The Kuiken Committee set the large-scale introduction of ERTMS on a new course. Work on the preparation of the ERTMS implementation strategy began at the end of 2011, under the direction of the Ministry of Infrastructure and the Environment and in consultation with the sector via a formal consultative structure. Since the end of 2011 specific steps have been taken in advance of the Kuiken Committee's conclusions, which were taken in cooperation with ProRail, as the infrastructure manager, and with Netherlands Railways (NS), as the largest passenger operator.

As great care is required with the decision-making this will be carried out in phases which incorporate integral go/no-go decision-making times. Each phase shall give consideration to the following steps that are both necessary and justifiable. Care is of great importance to the entire process: the implementation will begin only once it is certain that the introduction risks are adequately controlled, the plan is feasible and the costs are in reasonable proportion to the benefits. This Section outlines the process.

### Approach to the process

The approach to the ERTMS process is based on experience with transparent and controlled decision-making in projects funded by the Ministry of Infrastructure and the Environment, for example the Faster & Better philosophy. The rules laid down in the Multi-Year Programme for Infrastructure, Spatial Planning and Transport (MIRT) are observed. These are tailored to the specific nature of the rollout of ERTMS (in terms of the parties involved, the process steps, the relationships with other programmes and projects, renewal issues, the necessary decisions and the financing, etc.). The decision-making, detailing and implementation of ERTMS will take place in phases during the exploratory phase, plan detailing phase and implementation phase, whereby each decision will be a go/no-go decision-making point and in which consideration will be given to the following steps that are necessary and justifiable (see the following figure and the preview in Section 6). A narrowing-down approach will be adopted to the studies and decision-making. All aspects will be developed from outline to detail.

The Government took the initiative for the rollout of ERTMS on reaching the ERTMS decision in principle<sup>15</sup>. The Railway Map version 1.0 constitutes the start document for the exploratory phase. Studies will be carried out during the exploratory phase and the plan for the incremental introduction of ERTMS will be worked out in more detail.

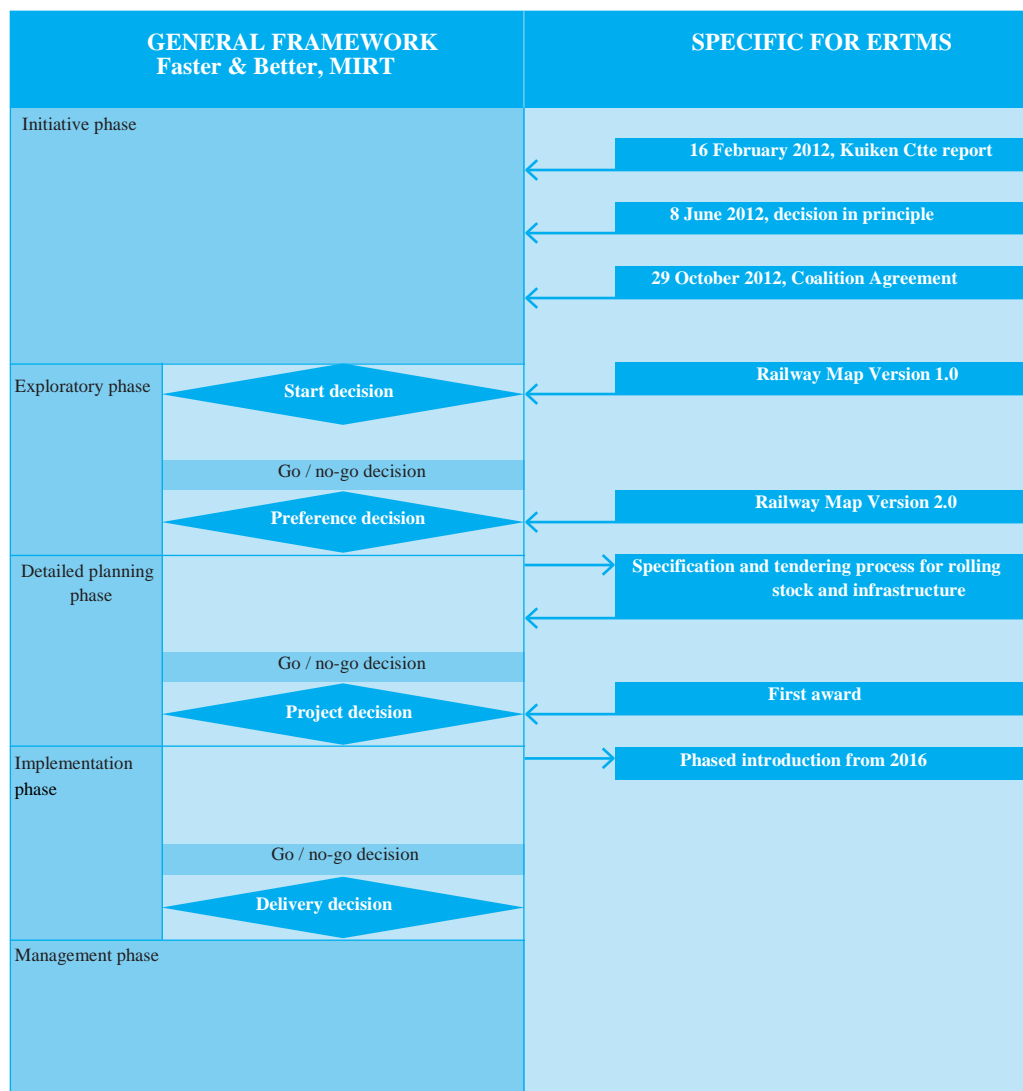
The exploratory phase pivots on a narrowing-down process which begins with a number of option variants and scenarios which are gradually eliminated to arrive at a robust preference decision and one preference scenario. This scenario could also be the counterfactual scenario. For this reason the Railway Map Version 1.0 will be worked out in more detail, in a number of steps, during the exploratory phase (see also Section 6).

The exploratory phase will result in a preference decision on the option variant and the introduction scenario to be followed for the implementation.

The following diagram lists the first indicative points for the decision-making on phased implementation.

<sup>15</sup> Parliamentary Documents II, 2011-2012 sessions, 32707 No. 16

Figure 5: Process for the phased introduction of ERTMS



A probabilistic planning will be drawn up, with bandwidths, during the coming period. The aforementioned studies will also be carried out. These will result in a more refined planning. This will then need to reveal the extent to which the initial planning, as based on the House of Representatives of the States-General letter of 30 November 2012<sup>16</sup> on the coherence between and the step-by step approach to the railway dossiers, is feasible. Information that is not available in time can have an effect on the planning.

#### Division of initiative, roles and duties during the exploratory phase

The initiative and the decision-making authority during the exploratory phase are vested with the national government. The State Secretary of Infrastructure and the Environment is the competent authority for the preference decision-making. Self-evidently, this decision will be made in appropriate consultations with the infrastructure manager, train operators and other stakeholders. The Ministry of Infrastructure and the Environment will act as the client of the external parties that will carry out the studies deemed to be necessary for the exploratory phase. This will introduce external, independent knowledge and experience.

<sup>16</sup> Parliamentary Documents II, 2012-2013 sessions, 29984, No. 334

In view of the duties and responsibilities of ProRail as the infrastructure manager and Netherlands Railways (NS) as the concession holder for the main railway network, joint consultations will be held at top level (4 meetings a year), directors level (monthly) and in a working group (weekly).

The Ministry of Infrastructure and the Environment will hold separate consultations with the other (passenger) operators during the exploratory phase.

The Ministry of Infrastructure and the Environment shall conduct active stakeholder management during the exploratory phase which is tailored to the interests of the various stakeholders. ProRail and Netherlands Railways (NS) shall organise their operations in a manner that ties in closely with the ERTMS programme.

In the longer term (and possibly during the exploratory phase) it may be desirable to set up separate consultative structures between the train operators and the Ministry of Infrastructure and the Environment, between ProRail and the Ministry, and to form an umbrella steering committee comprised of the Ministry, ProRail and the train operators.

The governance structure will be worked out in more detail during the exploratory phase and tailored to the relevant duties, powers and responsibilities.

### **International exchange**

During the initiative phase the Ministry of Infrastructure and the Environment actively sought experiences and lessons learnt outside the Netherlands. The approach to and experience with the implementation of ERTMS in Denmark, Belgium and Switzerland offer particularly interesting reference material for the Netherlands. The Dutch situation differs from the situation in, for example, Denmark and Belgium: these states' existing systems have yet to achieve the level of the Dutch system.

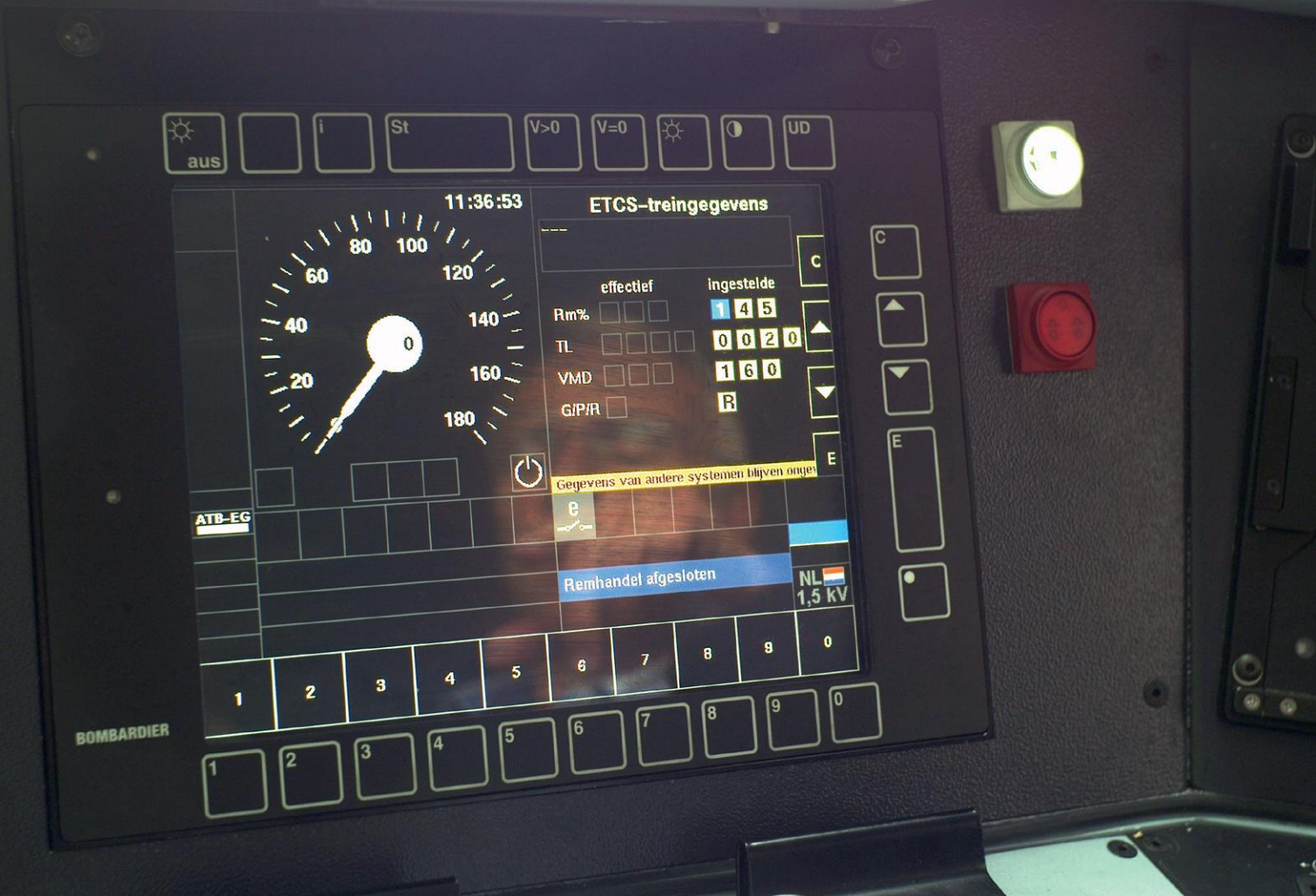
The cooperation with these states is excellent, in part in view of the experiences and lessons learnt by the Netherlands: the states actively exchange expertise with each other. This active approach will be continued during the project.

### **Relationship with other railway programmes and projects**

The introduction of ERTMS will offer general opportunities for improvement. The introduction also coincides with the need for a review of the infrastructure programmes and projects and with the need to modify other systems and the use/management processes (including the traffic control and disruption management process) of both the infrastructure manager and the train operators. ProRail and Netherlands Railways (NS) are preparing a plan of approach to improvements based on the requirements laid down in the Long-Term Railway Agenda that will need to achieve an improved railway product. This plan of approach will make the relationship with the functionality/opportunities and requirements of ERTMS. The Ministry of Infrastructure and the Environment makes the relationship with the review of projects and programmes that will need to take account of the incremental introduction of ERTMS from 2016. This relates, in particular, to the High Frequency Rail Programme (PHS) and the Amsterdam Airport Schiphol-Amsterdam-Almere-Lelystad corridor (OV-SAAL).

During the ERTMS exploratory phase the Ministry of Infrastructure and the Environment will also make the relationship with the new operating concession for the main railway network and the managing concession for the main railway infrastructure, both of which are scheduled to be awarded at the end of 2013. These may include requirements for the implementation of ERTMS. These requirements will be based on the agreements reached within the scope of the Railway Map.

The exploratory phase will also make the substantive relationship with the plans to increase the speed on the railways to 160 km/hour, reduce the time interval between trains, replace aged infrastructure elements such as train protection elements (Mistral) and implement the SPAD reduction plan.



Higher speeds are feasible with ERTMS. The ERTMS pilot trial is testing speeds of up to 160 km/hour.

### ERTMS pilot trial on the Amsterdam-Utrecht route

An ERTMS pilot trial on the Amsterdam-Utrecht route began in 2012. This pilot trial will need to answer questions relating to the following factors: bringing ERTMS into operation; the influence of ERTMS and dual signalling (ERTMS and ATB) on the availability, reliability and risks; the manner in which train drivers work with dual systems in the cab; capacity effects; increasing the speed; converting rolling stock to ERTMS; admission to the national network; training and the experience of train drivers and traffic controllers; the maintenance and breakdown organisation; and the influence on the quality of services provided to passengers.

The majority of the pilot trial will take place in parallel with the exploratory and detailed planning phases of the ERTMS implementation. The pilot trial will provide input for the decision-making and the preparation of a justifiable implementation programme. The relevant knowledge acquired during the course of the pilot trial will be used in the ERTMS exploratory, detailed planning and implementation phases. A large amount of knowledge and the results and data obtained from the pilot trial can be used in the national programme, for example for the training materials/tools and simplified procedures for the admission of rolling stock equipped with ERTMS.



## 6 Approach to the introduction from the exploratory phase to the preference decision

The exploratory phase is the next phase in the process that is to result in a preference decision for the implementation of ERTMS. This phase is characterised by the collection of facts and the acquisition of insights. The contents of the Railway Map will be elaborated from outline to detail in a series of iterations.

The following questions about the infrastructure and rolling stock will then need to be answered:

1. Objectives: to what extent and/or subject to which conditions can ERTMS make a contribution to the specified objectives/benefits? This includes a study of the development in ERTMS' performance and the risks as compared to the current situation with the existing train protection in terms of the objectives of safety, interoperability, capacity, speed and reliability. This will, for example, zoom in on subjects such as ERTMS on yards and GSM-R, etc.;
2. Rollout strategy: the determination of the scope, i.e. where and when can ERTMS be installed on the infrastructure in relation to the objectives and timing of other programmes/projects? Which conversion schedule will be adequate for the rolling stock? In the first instance, consideration is being given to working out the four search directions and the counterfactual scenario in more detail.
3. System selections: which types of system are required at which locations, in part as viewed from the perspective of the entire traffic management chain?
4. Which tendering and contracting strategy (including management and maintenance) is desirable in view of the costs and risks?
5. Use and management processes: what is the influence of ERTMS on the use and management, and which approach should be adopted?
6. What are the estimated costs, including the management and maintenance costs (also in comparison with the current situation), what are the associated risks and the control measures that will be required, and how will the financing be organised?

These questions will be examined in their mutual relationship and in an iterative process. The objective is to obtain and make accessible all the information required to make substantiated choices between subsections of options or scenarios that will in turn yield the decision-making information for an ERTMS preference decision. This phase will also devote explicit attention to elements that require further study or are still unknown, as well as to the measures that will be required to take a step forward. This can include the acquisition of practical experience (in pilot trials). The essence of the exploratory phase is a narrowing down process in which the answers to the questions and the detailing of the scenarios will result in an incremental narrowing-down of the options to a preference decision with one preference scenario.

The implementation of ERTMS in the Netherlands will require work on a railway system that will need to exhibit an appropriate performance both during and after the implementation. The introduction can begin only once it is certain that the risks associated with the introduction can be controlled to an adequate extent. The exploratory phase will include an inventory of the risks and the preparation of measures to control those risks. The lessons learnt during the implementation and operation of ERTMS on the HSL-Zuid high-speed passenger railway line, Betuweroute freight railway line, Hanzelijn railway line, Amsterdam-Utrecht railway line and the ERTMS pilot trial on the last railway line will be taken into account when addressing the risks.

### Results from the exploratory phase

The knowledge and facts will provide the information required for the following decisions on the infrastructure and rolling stock:

- Where: specified by routes throughout the Netherlands, or on sections of the main railway infrastructure;
- What: technical and operational decisions linked to the objectives (including which ERTMS level for the infrastructure, which ERTMS baseline version shall be adopted for the rolling stock, which technical and functional specifications shall be adopted and which modifications of the interlocking, train detection and control systems, etc., will be required);
- When: on which dates (beginning and required finishing times) ERTMS is to be installed in the rolling stock and on the infrastructure;
- How: on the grounds of which tendering and contracting strategy.

This preference decision will provide clarity about:

- The substantiation for the preference scenario;
- The costs and benefits, the consequences of choices, the necessary complementary measures, where relevant, and the risks;
- The substantiation for the investment costs, the costs of management and maintenance (on the basis of the life cycle costs) and the other costs;
- A preview of the planning and the next go/no-go decision-making points, the milestones and products;
- A specification of the division of roles and duties;
- The provisions of assurances for system integration.

During the exploratory phase it will also become clear when decisions on which issues can or cannot be made. This may result in decisions on issues or sub-issues at various times during the exploratory phase: for example, the scope could encompass the entire main railway infrastructure or, conversely, be limited to equipping specific railway lines, yards and rolling stock, etc.

## 7 Financing, risk and stakeholder management

### Financing and cost estimate

ERTMS has been cited as a priority in the Coalition Agreement. The initial allocation of the budget supplementary to the Government's 2013 Budget will take place within the context of the decision-making on the total package of the structural financial target charged to the Infrastructure Fund and the railway priorities as laid down in the Coalition Agreement, namely: Better Utilisation, the introduction of ERTMS and the improvement of level crossings<sup>17</sup>.

The introduction of ERTMS will be financed from the existing budgets. Maximum use will then be made of opportunities for win-win situations, for example within the scope of the review of programmes and projects and, where possible, supplemented with TEN-T subsidies. A cost allocation for the installation of the system in the rolling stock shall be prepared which shall comply with the European regulations and based on the principles of equity. To this end a study will be carried out of the financing options for the On Board Units. The train operators are currently of the opinion that they are not in a position to make a contribution to the costs of ERTMS. Their standpoint is that funding ERTMS is not compatible with their current financial resources and that the government should finance a new system of the nature of ERTMS. The Ministry of Infrastructure and the Environment and the train operators will discuss this issue during the exploratory phase. These discussions will be held on the basis of the prevailing legal framework and the results from further studies.

The scenario studies to be carried out during the exploratory phase will include the preparation of a cost estimate for the total costs incurred in the introduction of ERTMS. Earlier studies have revealed that the costs can depend greatly on the scenario adopted for the introduction. The estimates are, by definition, complex. For this reason they will probably be of a highly probabilistic nature and, consequently, will be specified with a wide bandwidth, an expectation that is in part based on experiences acquired outside the Netherlands. Moreover, the market prices, as demonstrated during the Danish ERTMS tendering procedure, are in a considerable state of flux: cost savings can be achieved by specifying a sufficient degree of standardisation and scale.

### Risks and control measures

Risk management is an integral element of the work. An active approach will be adopted to gaining an insight into the risks, and control measures will be implemented where necessary. These risks relate to the customary time, funds, quality and organisational aspects, as well as to political and administrative risks. Risks are perceived for some of the claimed benefits offered by ERTMS. These will need to be weighed against each other.

Any risks that materialise may exert an influence on the (probabilistic) planning, the costs of the exploration and/or the investments to be made in implementing the ultimate solution. The risk management process will continually take account of the fact that ERTMS serves as a means of achieving the objectives specified in the Long-Term Railway Agenda and that the programme will be carried out in accordance with a carefully-considered phased process with go/no-go decision-making points.

### Stakeholder involvement and support

A large number of players have a greater or lesser interest in the ERTMS exploratory phase. Cooperation with and the support of the parties involved is of great importance to the success of the introduction of ERTMS and to the utilisation of the benefits offered by ERTMS.

<sup>17</sup> Parliamentary Documents II, 2012-2013 session, 33400 A No. 20

The following paragraphs provide a concise analysis of the players in the most important groups of stakeholders.

#### *ProRail*

ProRail, as the infrastructure manager, is responsible for ERTMS as an element of the infrastructure. A modification of the operational processes to accommodate ERTMS will be required for the rail traffic control and disruption management process. ERTMS will also impact the maintenance organisation.

#### *Passenger operators*

The rolling stock of the passenger operators (Netherlands Railways (NS), Veolia, Arriva, Connexion and Syntus) will be equipped with ERTMS on-board equipment. The train drivers will operate trains equipped with ERTMS. They will require training and attention will need to be devoted to the relationship between man, rolling stock and the technology, as well as to the modification of the operational process required on the introduction of ERTMS. ERTMS offers scope for increases in speeds and improvements in the efficiency of energy consumption, control systems and the deployment of rolling stock. International passenger operators will benefit from ERTMS, for example as a result of the interoperability available to them and opportunities for increased speeds.

#### *Freight operators*

The majority of the freight trains admitted to the Netherlands are equipped with on-board ERTMS equipment and many of the freight operators' train drivers are familiar with ERTMS. Freight operators will benefit from the national use of *one* system (ERTMS only) that, moreover, offers them the interoperability they need: most of the freight transported on the railways crosses the border.

#### *Decentral authorities*

The decentral authorities grant the concessions for the decentralised railway lines.

#### *Market parties (ERTMS suppliers, consulting engineers, railway contractors and Notified Bodies)*

The introduction of ERTMS on the Dutch railways offers the various suppliers of ERTMS equipment, consulting engineers, railway contractors and Notified Bodies opportunities to expand their markets and market positions. It also offers them opportunities to acquire expertise they can subsequently put to use outside the Netherlands.

#### *Other stakeholders*

Social organisations attach great importance to the safety of the railways. Centres of expertise can make a valuable contribution to the knowledge required for the programme.

### **Implementing stakeholder management**

An initial stakeholder analysis has already been carried out. Stakeholder management will be worked out in more detail during the exploratory phase and will be differentiated in terms of the relevance and importance of the various stakeholders to the decision-making process on the implementation of ERTMS and the practical detailing of the implementation.

During the exploratory phase the stakeholder management will focus on the acquisition of support for the preference decision. The allocation of the level of interaction with stakeholders will be based on that is referred to as the participation ladder, which ranges from the provision of information to participation. The stakeholder management during the exploratory phase is governed by the principle that a large number of parties are involved in the conceptualisation and a number of parties are involved in the preparations for the decision-making, but that the ultimate decision-making rests with the State Secretary of Infrastructure and the Environment. When feasible, existing consultative structures shall be employed, such as the LOCOV ('National public transport consultation platform') and OIM ('Infrastructure and the Environment consultation platform').

ProRail and the train operators, in particular, will involve their organisations and all their relevant company divisions and staff (train drivers, rail traffic controllers and planners, etc.) at times that are of relevance to the process to ensure that the implementation of ERTMS can be carried out smoothly and that the necessary relationships are made with other operational and management processes.

The contacts with the market players will be maintained in accordance with the market strategy to be drawn up during the exploratory phase on the basis of the tendering regulations. The detailing of this market strategy will also extend to the creation of healthy market tension. All elements of the market and tendering strategies will be formulated using the knowledge and expertise available within the central government, in particular within the Ministry of Infrastructure and the Environment and the Directorate-General for Public Works and Water Management, and the experience acquired by Switzerland, Denmark and Belgium.

# Annexes

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## Annex 1

### Technical glossary

This Annex contains a description of a number of relevant technical terms. A summary of the overall theoretical framework of railway command-control, signalling and train protection systems is enclosed in Section 2 of *Deelonderzoek I Innovatie op het spoor en mogelijkheden van ERTMS in Nederland* ('Innovation on the railway and possibilities for ERTMS in the Netherlands, Sub-study I'), carried out by Delft University of Technology within the context of the Parliamentary Inquiry into railway maintenance and innovation<sup>18</sup>.

#### Introduction to train protection

Train detection and train protection are terms with different meanings. The Dutch railway system was equipped with signals before the Second World War and the location of trains was known (train detection). After the 1962 Harmelen train accident, this was supplemented with a train running control system which intervenes when trains travel faster than permitted by the local signal aspect.

#### The Dutch automatic train protection system (ATB)

The automatic train protection system - first generation (ATB-EG) was the first version of the ATB train protection system, which was introduced in the Netherlands from the nineteen-sixties. ATB-EG passes information to the trains in the form of a continuous signal which is transmitted via the rails. A current is passed through the rails which is switched on and off at a specific frequency. A total of 5 frequencies are employed (what are referred to as the 'ATB codes'). Each code specifies a maximum permitted speed<sup>19</sup> that is in agreement with the local signal aspect<sup>20</sup>. The train driver of a train travelling faster than the maximum permitted speed receives a warning signal in his cab. At the time it was introduced ATB-EG was quite unique. If the train driver does not respond to the ATB-EG warning signal by braking, then the system applies the brakes and automatically brings the train to a standstill. Although ATB-EG then checks that the train is braking it does not check that the brakes have been applied sufficiently to bring the train to a standstill before the danger point. ATB-EG does not intervene at speeds below 40 km/hour. The majority of the main railway network is equipped with ATB-EG.

While ATB-EG uses a simple analogue signal which is conveyed to the rolling stock via the track, the newer ATB-NG (Next Generation, introduced from the nineteen-eighties) is based on information in the form of a digital message that is transmitted to the train by beacons installed between the rails. ATB-NG is based on braking curve monitoring<sup>21</sup> and also monitors train speeds below 40 km/hour. The majority of the Dutch ATB-NG system has been installed on the regional railway lines, the last railway lines to be equipped with a train protection system. The functionality of ATB-NG equipment installed in trains travelling on blocks of track equipped with ATB EG is identical to that of ATB-EG, as a result of which trains equipped with ATB-NG are protected on railway lines equipped with ATB-EG. However, the converse is not the case: the speed of trains equipped with ATB-EG travelling on railway lines equipped with ATB-NG is limited to a maximum of 40 km/hour, the maximum speed permitted in the absence of an ATB-EG code.

<sup>18</sup> Parliamentary Document 32 707, No. 11. *Deelonderzoek I. Innovatie op het spoor en mogelijkheden van ERTMS in Nederland*. Delft University of Technology, Parliamentary Inquiry into railway maintenance and innovation.

<sup>19</sup> The maximum speeds specified for ATB codes (in pulses per minute) <no code>, 220, 180, 147, 120, 96 are 40, 60, 80, 80, 130 and 140 km/hour respectively.

<sup>20</sup> The signal aspect consists of the signal and the speed limit signs.

<sup>21</sup> Braking curve monitoring is employed by ERTMS and ATB-NG, as well as by other train protection systems. Pursuant to this principle the actual speed of the train is compared to the maximum permitted speed at the location. If the train is travelling faster than the maximum permitted speed the system generates a warning alarm and then, in the absence of a response to the warning, applies the brakes on the basis of the braking characteristics of the specific train. In contrast to ATB-EG, which merely checks that the train driver is braking, systems based on braking curve monitoring apply the brakes to the extent required to make sure that the train *will* generally come to a standstill before the danger point.

ATB Improved Version (ATB-Vv) was developed in 2005, after a train collision on 21 May 2004. This version is designed for blocks of track equipped ATB-EG and, in contrast to ATB-EG, *does* monitor trains running at speeds lower than 40 km/hour. The objective of this system was to reduce the number of incidents of signals passed at danger (SPADs). When both the signal and the rolling stock is equipped with ATB-Vv the system will generally brake the train sufficiently to ensure that it comes to a standstill before the danger point. The system intervenes when a train approaches a signal set at danger at too-high a speed and/or is at risk of passing the signal set at danger. However, the ATB-Vv system is not fail-safe: for example, heavy freight trains can still pass a signal set at danger as the dimensioning of ATB-Vv is based on lighter trains and applies the brakes accordingly. Heavier trains may not then be stopped in time. ATB-Vv units that are switched off or defective do not result in the automatic transmission of a message warning of the situation and ProRail and/or the train operator may not immediately realise that the unit is inoperable. In these situations trains equipped with ATB-Vv may still pass signals set at danger. The rollout of ATB-Vv began in 2005.

ATB in its current form began to be installed in the Netherlands in the nineteen-sixties and will ultimately need to be replaced. This is particularly applicable to the first generation system (ATB-EG), which at the time was installed in the greater Randstad conurbation. The regions outside this area are equipped with a relatively modern version (ATB-NG). It should be noted that the need for replacement is particularly applicable to a number of crucial components, for example the interlockings and train detection.

Figure 6: Map of the current train protection systems



## Description of ERTMS

The European Commission has been endeavouring to increase the interoperability of railway traffic for many years. The objective is to enhance the internal rail transport market. This initiative is of particular importance to cross-border freight and passenger transport, as the need to change locomotives at the border costs a relatively large amount of time. In addition, locomotives that may travel solely to or from a national border result in the loss of capital. The idea of developing a European train protection system arose in the nineteen-eighties. The developments that followed resulted in the specifications for ERTMS (European Rail Traffic Management System).

ERTMS is the set of specifications, agreed on a European scale, for on-board systems and the messages exchanged between traffic control and the trains. Some eight suppliers have developed systems on the basis of these specifications. The systems based on the ERTMS specifications consist of a cab system and an infrastructure system that issues the movement authority to the train driver. Within this context 'authority' is understood as permission to proceed at a specific speed to a predetermined point: it is comparable to the colour of signals alongside the track used by non-ERTMS systems. The train driver of a train travelling using ERTMS sees the local maximum permitted speed displayed on a screen in the cab. This maximum speed cannot be exceeded, as the train monitors the speed using what is referred to as a 'braking curve monitoring algorithm' running on the on board computer (EVC) that is linked directly to the brakes. This system replaces ATB-EG's continuous signal transmitted to the train via the rails. In addition, signals alongside the track are no longer required by ERTMS level 2 and 3, as the train driver receives his movement authority via a radio message.

ERTMS covers the risk, in analogy with ATB-NG, of the train driver breaking the speed limit or failing to brake sufficiently to bring the train to a standstill before the danger point (except when the train skates further on slippery rails). The safety level of ERTMS is higher than that of the combination of ATB-EG and ATB-Vv, as the failure of ERTMS (on board or in the train) *does* automatically result in the train braking to a standstill. Trains equipped with ATB-EG can pass a signal set at danger at a speed of 40 km/hour unless they are equipped with ATB-Vv, although the failure of an ATB-Vv unit (or a unit that is switched off) is not detected and the train will not always be brought to a standstill.

A distinction is made between three ERTMS levels, namely level 1, level 2 and level 3.

ERTMS is not new to the Netherlands. About 10% of the Dutch railway network and 20% of the trains admitted to the Dutch railway network are already equipped with ERTMS.

### *ERTMS level 1*

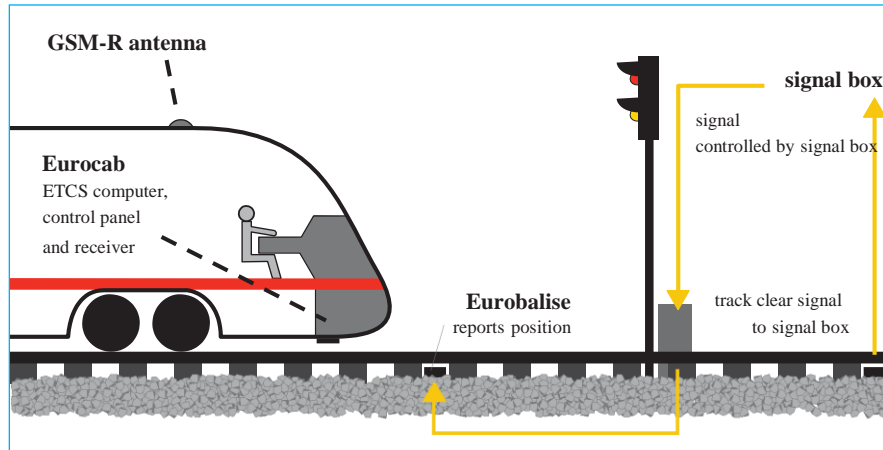
ERTMS level 1 is an ERTMS variant that can be implemented with existing train protection systems since the interlocking does not need to be replaced. The train protection system, in contrast to ATB codes transmitted via the rails, works with beacons between the rails. These are called Eurobalises. These Eurobalises transmit digital messages from the track to passing trains. ETCS<sup>22</sup> level 1 equipment in the train's cab receives, processes and displays the necessary information to the train driver on a screen. The ETCS equipment also uses these messages to calibrate the train's position. The existing signals alongside the railway line are retained and what are referred to as Lineside Electronic Units (LEU) are installed alongside the railway track which interpret the signal set by the signal box (green, yellow or red) in terms of a digital message which is transmitted to the Eurobalises via cables. With level 1 the signals alongside the railway line must be retained.

Solely rolling stock equipped with ETCS systems may make use of infrastructure equipped with ERTMS only.

The functionality of ERTMS level 1 is identical to that of ATB-NG.

<sup>22</sup> European Train Control System: the cab signalling and train protection system used by ERTMS.

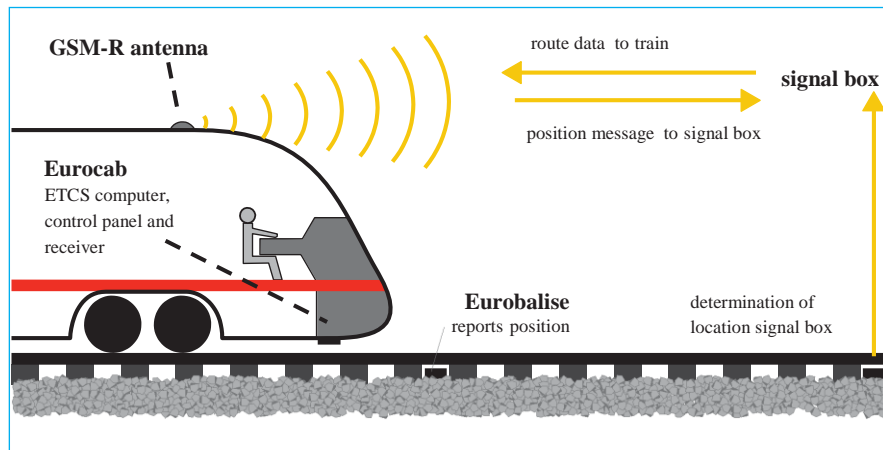
Figure 7: the principle of ERTMS level 1



### ERTMS level 2

With *ERTMS level 2 only* the movement authority (to which point and at which speed) is transmitted to the train by GSM-R radio rather than via the Eurobalises as used in level 1. For this reason the signals alongside the railway line are no longer necessary with level 2. The movement authority is generated centrally in the Radio Block Center (RBC) and an ERTMS message is transmitted to the relevant train via the GSM-R system. Level 2 does not use Eurobalises to issue movement authority: instead, these are used to enable the train to calibrate its position. Solely rolling stock equipped with ETCS systems may make use of infrastructure equipped with ERTMS only.

Figure 8: the principle of ERTMS level 2



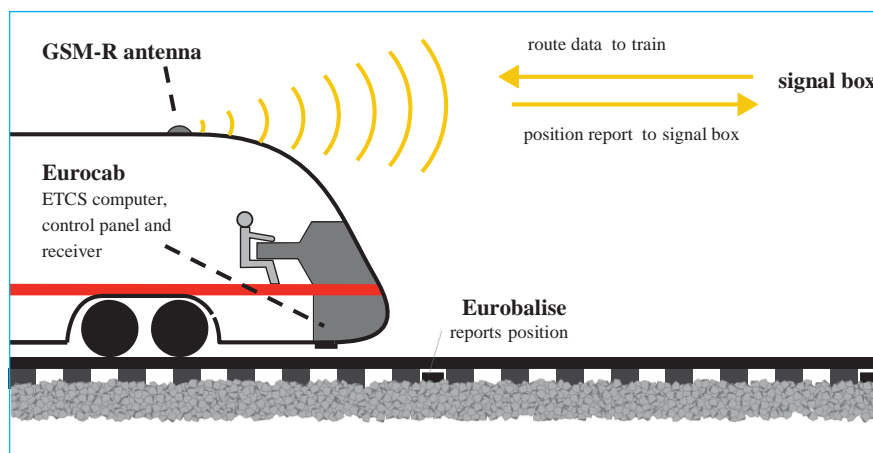
### ERTMS level 3

ERTMS level 3 goes one step further than ERTMS level 2, as the train detection on the track is no longer used in the *level 3 only* variant. This is because each ERTMS level 2 or level 3 train transmits its position via GSM-R (auto-localisation): level 3 uses this position, via the interlocking, to assign blocks to trains<sup>23</sup>. However, a condition attached to level 3 is that the integrity of the train is guaranteed (it is not possible for a carriage to break free without this being detected by the train protection system and being transmitted to traffic control, which will then no longer assign the relevant infrastructure to other trains).

<sup>23</sup> Sweden and Kazakhstan use ERTMS level 3 without a train integrity check. This is also referred to as "ERTMS regional", as this concept is highly suited to simple routes with low train frequencies on which the risk of trains losing carriages can be controlled, for example by operational procedures to be followed by the train driver.

An overlay version of level 3 does not, by definition, exist as the train detection on the track will be retained.

Figure 9: the principle of ERTMS level 3



ERTMS level 3 is still in development.

### Overlay

ERTMS overlay refers to a dual train protection system installed on the infrastructure. Trains may then, for example, use both ATB-EG and ERTMS that are installed on the same infrastructure (two systems on the tracks).

### Baseline 3

ERTMS systems are delivered by a number of suppliers as they are based on specifications agreed on a European scale. These specifications have been issued in several versions. The first versions contained errors that were identified on the initial introduction of the system and gave cause to amendments. The first formally adopted baseline is referred to as '2.3.0 d'. This version serves as the basis for the majority of the current infrastructure and on-board systems. Further improvements and supplements to 2.3.0 d, in particular for the on-board functions, have been introduced in baseline 3. Trains equipped with an ETCS version which complies with baseline 3 can, in principle, travel on infrastructure equipped with 2.3.0 d (downward compatibility).

The Netherlands has acquired experience with ERTMS level 2 on the Betuweroute freight railway line and the HSL-Zuid high-speed passenger railway line. Level 2 is also installed as an overlay system alongside ATB on the Hanzelijn and Amsterdam-Utrecht railway lines, where it is currently being tested. Level 1 has been installed as a back-up system on the HSL-Zuid high-speed passenger railway line and is in use on the Havenspoorlijn freight railway line.

## Annex 2

# European ERTMS obligations and opportunities offered by ERTMS

European legislation lays down a number of obligations on the Netherlands for the introduction of ERTMS:

- Council Decision 2012/88/EU imposes the obligation to install ERTMS on freight corridors 1 (Rotterdam to Germany via the Betuweroute freight railway line) and 2 (Rotterdam to Antwerp);
- The obligations for Kijfhoek and Zevenaar will be fulfilled in 2015. The system must also be installed on the Amsterdam – Meteren railway line (connecting to the Betuweroute freight railway line) and Rotterdam – Belgian border railway lines by 2020.

The TEN-T directives are currently being revised. The European Transport Council reached agreement on these revisions on 22 March 2012. The proposed directives divide the European transport infrastructure into:

- A core network that is to be equipped with ERTMS by 2030; and
- A comprehensive network that is to be equipped with ERTMS by 2050.
- The decision-making by the European Parliament is expected in 2013.

Pursuant to Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area (recast), there is an option to designate railway corridors to give incentives to equip trains with an ETCS version that complies with the requirements laid down in Council Decision 2012/88/EU. Such differentiation shall not result in any overall change in revenue for the infrastructure manager.

## Annex 3

### Main lessons learnt abroad and in the Netherlands

#### Denmark

In January 2009, the Danish Parliament decided on the total replacement of the Danish signalling infrastructure by 2021. Denmark has opted for the national rollout of ERTMS level 2. This programme will focus on the achievement of economies of scale and on the creation of a competitive market situation that will result in the best possible price and quality. This has resulted in the conclusion of 5 contracts with market parties in 2012. These contracts contain a large number of incentives for the suppliers. The prices in the contracts are significantly lower than the benchmarks used for the original cost estimates.

#### Belgium

The Belgian infrastructure manager, Infrabel, adopted the Master Plan ETCS 2010-2025 in 2011, which provides for the installation of the system on the Belgian railway network. The results from the tendering of the integral infrastructure contract with level 2 on busy railway lines and level 1 on the other railway lines are expected within the near future.

#### Netherlands

The Netherlands has also learnt lessons. The Betuweroute freight railway line, high-speed passenger line (HSL), and the Hanzelijn and Amsterdam-Utrecht railway lines are already equipped with ERTMS. A dual-signalling pilot trial is being carried out on the Amsterdam-Utrecht railway line which began in 2012 and will continue until 2014. This pilot trial will yield a great deal of practical experience and knowledge that can be used during the phased introduction.

The first test journeys on the Hanzelijn and Amsterdam-Utrecht railway lines have been completed with success as viewed from a technical perspective.

The general impression is that standardisation will be of value to the introduction of ERTMS. This is reflected in several of the following points.

##### *a. Tendering and contracting*

The Danish procedure, in particular, demonstrates that a carefully-considered tendering and contracting strategy can reduce costs. Sophisticated choices in the scale, uniformity and form of contract and the life cycle approach offer opportunities for optimisation.

In accordance with the Final Report of the Parliamentary Inquiry into Railway Maintenance and Innovation, cost savings can be expected from an increase in the scale of the implementation and tendering of ERTMS. The systems for the Dutch infrastructure that have been equipped with ERTMS to date were procured in separated tendering procedures. In addition, vendor lock-in has occurred.

The Ministry of Infrastructure and the Environment and the Directorate-General for Public Works and Water Management, in particular, has acquired a great deal of tendering and contracting expertise in the past years. This expertise shall be employed whenever possible.

The planned tendering and contracting strategy shall take account of the aforementioned lessons learnt.

##### *b. Specification and design*

To allow the market to do its work properly and achieve the best possible quality-price ratio, the specifications shall contain the maximum possible functional specifications. The tendering specifications will then need to be standardised for as far as is possible.



*c. Project completion*

Experience has revealed that it is difficult to complete turn-key projects within time and within budget. This can be controlled by including the appropriate provisions in the contracts, provisions which also encompass the interaction between the infrastructure and train sides of the programme.

*d. Approval and admission*

To date, the admission of rolling stock to infrastructure equipped with ERTMS has been organised by block and route. When many of the routes have been equipped with ERTMS then individual admission procedures will be required for the rolling stock to be used on a large number of these routes. Arrangements for the national admission of rolling stock will save a great deal of time and money. In addition, the ERTMS products have ripened over the years to an extent that would appear to offer scope for great improvements in the certification and testing efficiency.

*e. Operation/use*

ERTMS will result in modifications of the operation and use as compared to the current train protection system. Personnel including rail traffic controllers, train drivers and maintenance personnel will need to learn how to work with the new system. In addition, an optimum deployment of ERTMS will offer opportunities for the simplification of the overall operation and use of the railway system. This will require training and the amendment of the manuals for train drivers and rail traffic controllers.

*f. Foreign and national experiences, general*

ERTMS is currently being introduced at many locations in Europe and elsewhere in the world. A great deal can be learnt from the approach adopted by other European states. The approach to and experience with the implementation of ERTMS in Denmark, Belgium and Switzerland offer particularly interesting reference material for the Netherlands.



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