Ministry of Infrastructure and the Environment

Railway map ERTMS

Version 3.0 - Memorandum on Alternatives

Content

Management summary

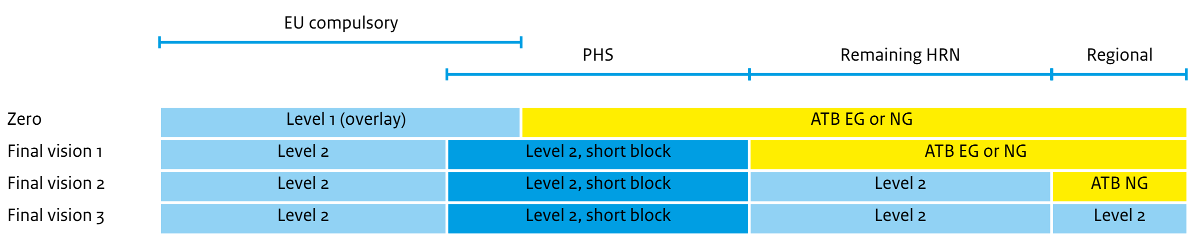
Review including benefits and need

The current train protection system ATB (Dutch: Automatische Trein Beïnvloeding) must be replaced in the coming decades. ERTMS has now expanded (also outside Europe) to become the international standard for train protection. Alongside safety and interoperability, replacement of ATB with the European developed safety and traffic management railway system, ERTMS (European Rail Traffic Management System), also offers potential gains in terms of the other goals from the Long Term Rail Agenda (LTSa) such as capacity, speed and reliability. This primarily concerns the replacement of the (electro) mechanical relay technology by ICT in the basic train protection system. This will enable a system transition that could not otherwise be realised by optimising ATB.

The Temporary Maintenance and Innovation for Rail committee (Kuiken committee), the House of Representatives of the States General, the Cabinet and the railway sector believe that ERTMS offers opportunities for the future. The Cabinet took the in-principle decision to implement ERTMS[1] on 8 June 2012. The subsequent "Building bridges" coalition agreement of 29 October included the concept that ERTMS would be implemented in a phased manner from 2016, using existing budgets. With the Railway map ERTMS version 1.0 (hereafter to be referred to as Railway map 1.0) of 13 February 2013, the Start Decision[2] for the Exploratory Phase was made.

With the presentation of the results from the first part of the investigation in the Exploratory Phase in Railway map 2.0[3], it became clear that ERTMS would contribute towards the goals of the LTSa if its implementation was handled carefully. According to Railway map 2.0, in order to achieve the desired system transition, ERTMS Level 2 is required. ERTMS thus forms an important component in the realisation and the ambitions of the Long Term Rail Agenda: improving the quality of the railways as a transport product so that passengers and freight transporters increasingly regard it as an appealing transport option and use it. Railway map 2.0 also presented the funnelling process used to formulate the three favourable scenarios/final visions. These favourable scenarios have been investigated further compared to the 0 scenario.

Figure 1. Diagram of favourable final visions studied in the Memorandum on Alternatives.



Two additional analyses were also carried out, namely the conceptual Level 2plus on final vision 2 and a mix of Level 1 and Level 2 on final vision 3. This Railway map 3.0 presents the results. The investigations serve as the basis for the Preference Decision, to which this Railway map is an annex.

1 Parliamentary papers II, session 2011-2012, 32707 nr. 16
2 In this case, Railway map ERTMS version 1.0: Parliamentary papers II, session 2012-2013, 29984 nr. 385
3 Parliamentary papers II, session 2013-2014, 33652 nr. 4

Results of studies of favourable scenarios

The investigations that were conducted into the three favourable scenarios and the two additional analyses concern, among other things, analyses with respect to safety, capacity, travel time effects and reliability. Cost estimates and risk analyses were also drawn up for the final visions and migration paths. The effects and costs were then translated into a social cost and benefit analysis (MKBA). The results presented in this Railway map 3.0 form, in accordance with the MIRT[4], the Memorandum on Alternatives and the basis for the cabinet's Preference Decision ERTMS.

The table below provides a summary of the results or the score of the final visions with respect to the goals and the other criteria from the scope of considerations, compared to the 0 scenario.

Table 1: The completed scope of considerations for the three final visions and additional analyses, in combination with the migration path High Frequency Rail Transport Programme (PHS) first. All scores relate to the 0 scenario, with the exception of investment costs.

Scope of considerations	Final visions				Additional analyses	
	0: EU-compulsory	1: PHS	2: Main Railway Network (HRN)	3: NL	2 HRN: L2plus	3 NL: L1/2
Safety	0	+	++	++	++	+
Interoperability	0	0	0/+	++	0/+	+
Capacity	0	+	++	++	++	+
Speed/journey time	0	-2.4%	-2.9%	-2.9%	-2.9%	-2.8%
Reliability (lost hours) (index)	100	97.2	94.8	93.2	94.8	95.9
Investment costs infra + rolling stock in € mln[5]	850	3,600	4,700	5,150	4,150	4,600
Life Cycle Costs, NCW compared with 0 scenario	3,700	1,800	2,250	2,400	2,000	2,250
Profitability of freight transporters[6]	0	-/--	-	0/-	-	0/-
Future robustness	0	0/+	+	+/++	+	+/++
Benefit/Cost-ratio (RC/GE)[7]	0	0.7/1.0	0.7/1.0	0.7/1.0	0.8/1.1	0.7/1. 0
90% reliability interval NCW investment costs in € mln	0	+/- 500	+/- 650	+/- 700	Greater than or equal to L2[8]	Greater than L2
90% reliability interval NCW investment benefits in € mln	0	+/- 410	+/- 510	+/- 530		

NB: For the time being, Level 2plus is a concept that requires further development. The analysis assumed a working concept from 2020. Further considerations have shown that Level 2plus is expected to be available as of 2025 at the earliest.

[4] Long Term Programme Infrastructure, Transport and Space.

[5] Investment costs for the 0 scenario comprise the installation of Level 1 overlay on the EU compulsory corridors. Including the necessary rolling stock for the 0 scenario.

[6] For 100% funding of the installation of ERTMS in rolling stock by operators.

[7] The benefit cost analysis has been conducted for two economic scenarios, i.e. the 'higher' Global Economy and the 'lower' Regional Communities.

[8] The risk analysis looked at the extent to which the risk profile is influenced with respect to the final vision, for the additional analyses. In terms of Level 2plus, there is also planning uncertainty in relation to the availability of the concept.

In terms of refurbishing rolling stock[9], this study assumed the refurbishment of all of the rolling stock would be completed by the end of 2021. This was deemed to be feasible according to the then insights from bodies such as the NS. An exception to this is rolling stock for the commissioning of the European compulsory line Rotterdam to the Belgian border. The basic principle in this regard is that sufficient rolling stock is available in order to travel under ERTMS here from 2020. For regional operators, this means that 50% of rolling stock will be refurbished in final vision 1, and 100% in scenarios/final visions 2 and 3.

For final vision 2 (the entire Main Railway Network – HRN), three migration paths have been envisaged. One migration path comprises a series of corridors, including a time-path, that leads to a final vision. The migration path PHS-first is inserted with the aim of realising advantages and therefore gains for large groups of passengers as quickly as possible. The migration path Replacement-first focuses on a rollout that is as cost-effective as possible as a result of closely adhering to the replacement specification for the current protection system. The path Districts-first starts in quieter areas and aims to minimise any inconvenience from the initial rollout. The score for final vision 2 is provided for the three migration paths in the table below. This involves a comparison of the paths with respect to the average outcome.

Table 2: completed scope of considerations for the 3 migration paths that correspond to final vision 2: HRN

Scope of considerations	Migration path		
	PHS first	Replacement first	Districts first
Safety	0/+	0	0/-
Interoperability	0	0	0
Capacity	0/+	0/+	0
Speed	0/+	+	-
Reliability	0/+	0	0/-
Costs (Lifecycle-costs), NCW in € mln compared to 0 scenario	2,250	2,250	2,150
Future robustness	0	0	0
Benefit/Cost-ratio (RC/GE)	0.7/1.0	0.8/1.0	0.7/1.0
Risks in € mln (effect on balance NCW assuming delay)	-340	-345	-340

Key results of studies into favourable scenarios

On the basis of the study into favourable scenarios, key findings have been formulated. These findings must be regarded in combination with the previous summary table.

ERTMS scores better than ATB on all goals and in final vision 1 (EU-compulsory + PHS) is the comparative best. Safety is improved

The scenarios all score better on the five goals from Railway map 1.0 than the 0 scenario in which ATB is largely maintained. ERTMS thus provides an improvement in safety. A reduction in STS incidents (Signals Passed at Danger) of between 50 and 70% is also expected. Level crossing safety will also improve if the 'Constant Warning Time' concept (currently under development) is applied. As a result, the closure of a level crossing will depend on the speed of the approaching train. The score on project goals improves as the share of the network on which ERTMS is rolled out expands.

9 In addition to rolling stock for the HRN, also regional rolling stock, freight rolling stock, maintenance trains and museum trains

The costs are highest for final vision 1 (EU compulsory + PHS).
In final vision 1, ERTMS is rolled out on the busiest corridors. In order to prevent transfers/ interfaces between protection systems as far as possible, all final visions will include the rail hubs on the outer edges of the area. These rail hubs are also prerequisites in other scenarios but are, in terms of realisation and costs, already allocated to final vision 1. Costs of rolling stock also differ slightly between the final visions. In final vision 1, pretty much all of the rolling stock has to be refurbished.

Costs can be further optimised via more austere points of departure and more effective harmonisation with the replacement task.
By choosing more austere points of departure with respect to replacing cables and detection, a maximum of € 500 million can be saved. This primarily concerns the detection method and the moment of replacement of the old cables. More effective reconciliation with the replacement task could also represent potential and substantial replacement cost savings, as predicted for around 2023, if replacement can be postponed or the current points of departure regarding pace and order are relinquished.

The additional analyses (application of Level 2plus and a mix of Level 2 and Level 1) both demonstrate a potential saving of around € 550 million in investment costs.
The saving that is demonstrated by the analysis for Level 2plus involves no longer having physical requirements for shorter blocks. In the conceptual Level 2plus, these shorter blocks are realised virtually. The rolling stock, however, must be fitted with a Train Integrity Monitor. For the time being, Level 2plus is only a concept and (prompt) implementation is uncertain. The saving for a mix of Level 2 and Level 1 arises as a result of the cheaper Level 1 being applied to track sections that do not need extra capacity. Replacement costs are indeed higher for Level 1 than for Level 2 and the system transition is limited. The effect in Net Cash Value is slightly positive.

Accelerated implementation results in a somewhat higher cost/benefit balance.
The rollout pace in the scenarios studied is based on 12-15 years, depending on the final vision. If the pace is accelerated to 6 years for final vision 2, which is possible with respect to market capacity (suppliers etc), this results in both higher net cash costs and greater benefits. As a result, the balance of benefits and costs increases somewhat positively.

The differences in scores on the 5 goals between the migration paths are limited.
The order and the moment of rollout (in this case the migration path to the final visions) are largely determined by a number of prerequisites for the implementation of ERTMS, i.e. the EU obligations in 2020 and 2030, the choice of rolling stock to be initially fitted with ERTMS and the choice to fit OV-SAAL with ERTMS in 2023. The minimisation of the number of transitions between ERTMS and ATB as well as following the replacement task as closely as possible, also impact upon the migration path.

Knowledge book

Knowledge Book 1.0 was presented in Railway map 2.0. Knowledge Book 1.0 provides an insight into the technical (im)possibilities of ERTMS and the extent to which ERTMS can contribute towards the set goals. Market parties and stakeholders were asked to respond to the Knowledge Book. Their comments concerned, among other things, suggestions for new aspects, honing the current descriptions and removing a number of opinions contained within the Knowledge Book. The comments have been included, as far as possible, in Knowledge Book 2.0 (Annex F). In the context of knowledge development with respect to areas of attention from Railway map 2.0, further studies have also been conducted. The key findings of these are:

ERTMS Level 2 on sidings is possible and comprises two focus areas
Level 2 has not yet been realised on large sidings at home or abroad. It can be realised, however, and there are two particular focus areas, i.e. capacity of GSM-R and further reconciliation between subsystems within the protection system, and operational rules.

Level 2plus or Level 3 on track sections are expected to be proven concepts as of 2025 at the earliest.
There are 2 main focus areas for the further development of ERTMS Level 2 to Level 3. These are guarantees of train integrity and start-up after system failures. In order to resolve these points, further development must take place. In this context, Level 2plus can help facilitate an effective transition from Level 2 to Level 3. Sidings are expected to run under Level 3 later than 2025.

Other subjects

The results of the studies into the effects and social costs and benefits of the favourable scenarios form an important basis for the Preference Decision. There are, however, other aspects that are also important for the Preference Decision and/or require attention in the next phase of the project/programme.

During the Exploratory Phase, therefore, three meetings were held with the most important stakeholders alongside ProRail and NS. In the final round, this concerned the content and progress of the project (including the outcome of the various studies), the elements of the Preference Decision and the interests and wishes of the stakeholders, including the extent of involvement in the subsequent phase of the programme. The stakeholders are exclusively positive about the implementation of ERTMS. They do, however, offer precise advice, recognise specific focus areas and demand that attention is paid to risks and opportunities that correspond to the implementation of ERTMS. The lines of contact that have been set up with stakeholders will be advanced and continued in the Plan Elaboration Phase.

In the Exploratory Phase, contact was also made with other countries that are working on or preparing for the national rollout of ERTMS, including Denmark, Belgium, Switzerland and Italy. The experiences of these countries will be included in the implementation of ERTMS in the Netherlands. These contacts will also be continued into the Plan Elaboration Phase.

Alongside conversations with stakeholders, meetings with market parties have also been held in order to provide them with information regarding the progress of the project and ask for their vision regarding the implementation of ERTMS in the Netherlands. In spring 2013, a second market information round took place during which discussions were held about rolling stock refurbishment, sidings and the ongoing development of Level 2 to Level 3. Now that the Preference Decision has provided further clarity on the scope of the programme, in the coming phase a more detailed market analysis can be carried out and tendering and contracting strategies can be drawn up.

A pilot is currently being carried out with Dual Signalling (ERTMS and ATB) on the Amsterdam-Utrecht line. The pilot is going very well for most of the rolling stock. Problems did arise, however, during the refurbishment of the Sprinter Light Train with ERTMS. Experiences thus far have provided many insights into, for example, how to train personnel, availability, operational reliability, operational rules and risks. The ERTMS-pilot therefore contributes towards gaining further experience with and knowledge about many aspects of ERTMS. A study programme has been set up with practical research questions that have to be answered by the end of the pilot. These will provide useful information, even during the pilot itself.

In terms of the refurbishment of rolling stock owned by the operators, agreements still have to be made about costings and the date on which all of the rolling stock on the Dutch rail network must have been fitted with ERTMS. One of the reasons why the costs for fitting

ERTMS in rolling stock are currently so high is the long and complex procedure for rolling stock acceptance. In the coming phase, methods for simplifying this procedure will be further examined. Once the rolling stock has been refurbished, speeds can exceed 140 km/h on the modified ERTMS track sections that have already been made suitable[10]. This partly substantiates the ambition to travel at 160 km/h on the Dutch rail network.

A project such as ERTMS requires effective project management. During the Exploratory Phase, work took place under the leadership of the Ministry for Infrastructure and the Environment (IenM), in close collaboration with ProRail and NS. In the Plan Elaboration Phase, this organisation structure is set to change. IenM will retain a directorial role. Agreements regarding collaboration between IenM, ProRail and NS (the Railway map parties) will be formalised. In order to retain the scrupulousness and pace of the Exploratory Phase and to support the ministry with specific ERTMS capacity, extra capacity and expertise will be requested via a European tendering procedure. An important success factor in the organisation is the appointment of a system integrator who will coordinate and control the interfaces between (implementation in) track and train. In the Basic Report (Annex D), more attention will be paid to the organisation of the Plan Elaboration Phase. It will also deal with recommendations from reviews and interfaces with other dossiers in more depth.

In the Exploratory Phase, various risk analyses were conducted in order to gain an insight into the various (types of) risks that correspond to the implementation of ERTMS, such as financial, planning, organisational and technical risks. Many risks are managed by further research, the Plan of Approach for the subsequent phase and general risk management. Further inventorying, evaluation and management of these risks will form an integral part of the Plan Elaboration Phase.

A number of components from the last phase of the Exploratory process but also the Exploratory Phase as a whole are also reviewed. A review of the costings for infrastructure and rolling stock has demonstrated that they provide a reliable overview but that they are a little on the conservative side. A review of the research into the effects on journey time, capacity and reliability has indicated that these were drawn up in a plausible manner and that the expected effects are also a little conservative. The MKBA then provided a third review of the effects of ERTMS in terms of social costs and benefits. It must be noted here, however, that both costs and benefits of this complex project could well change during implementation.

In a so-called gate-review, the results of the studies from the entire Exploratory Phase were presented to a group of experts with the aim of ensuring that the project is ready for the next (MIRT) phase. The review team concluded that the requirements for the move to the MIRT phase have been fulfilled: there is sufficient information and adequate insights in order to make a Preference Decision and start the Plan Elaboration Phase for the ERTMS programme. A number of recommendations were also given, e.g. regarding the programme layout and organisation. These recommendations will be monitored and applied when drawing up the plan of approach for the Plan Elaboration Phase.

[10] Train protection is not the only condition for higher speeds; physical infrastructure (switches, radius of curvature, inclines) must also be appropriate.

1 Introduction: a new protection system – benefits and need

This Railway map ERTMS version 3.0. 'Memorandum on Alternatives' (hereafter referred to as Railway map 3.0), presents the studies that have taken place since Railway map ERTMS version 2.0 'State of play regarding research in the Exploratory Phase' (hereafter referred to as Railway map 2.0)[11]. These results built on the results of the previous studies as presented in Railway map 2.0. Railway map 3.0 presents the results of the studies that have been conducted into the favourable scenarios selected in Railway map 2.0 and the results of other expertise development.

Whereas this first chapter focuses on the value of and need for the implementation of ERTMS, chapter 2 will look at funnelling towards and the presentation of the three favourable scenarios and two additional analyses from Railway map 2.0. Chapter 3 will set out and interpret the results of the further studies into these favourable scenarios. Chapter 4 processes the insights into other aspects, which of these will be examined more closely in the next phase and in what manner. Chapter 5 looks at the most significant risks in the Plan Elaboration and Realisation phases and chapter 6 closes with the results of the reviews in and of the ERTMS Exploratory Phase.

1.1 Provocation

As indicated in the Start Decision ERTMS[12], the current protection system[13] functions effectively with respect to the current requirements that are set for capacity and safety, but it is ageing. The current system is based on (electro)mechanical relay technology which was phased out some time ago in other sectors. Over the coming decades, much of the train protection system in the Netherlands must be replaced. There is therefore an opportunity to implement ERTMS, the new standard for train protection which has already been or will be installed at various locations throughout the country.

ERTMS offers advantages when it comes to safety and interoperability compared to the current systems. In addition, ERTMS as an element in the chain of systems that form the Traffic Management System, contributes towards increasing capacity, speed and reliability on the railway network. Many of these advantages can be put down to the introduction of ICT in the basis of the train protection system. This was quantified as far as possible in the Exploratory Phase.

If ERTMS is introduced carefully, it can contribute towards all of these goals and thus forms an important link in realising the ambitions of the Long Term Rail Agenda, i.e. improving the quality of the railways as a transport product so that passengers and freight transporters increasingly regard it as an appealing transport option and use it.

If a decision was taken to continue with the current train protection system ATB, it would not offer the freedom to achieve the desired advances in train protection[14], even with further optimisation.

[11] Parliamentary papers II, session 2013-2014, 33652 nr. 4

[12] In this case Railway map ERTMS version 1.0: Parliamentary papers II, session 2012-2013, 29984 nr. 385

[13] ATB (Dutch: Automatische Trein Beïnvloeding)

[14] See studies in Railway map 2.0

On 16 February 2012, the report of the Temporary Committee on Railway Maintenance and Innovation[15] (Kuiken Committee) was published. The Committee concluded in its report, among other things, that the development of train protection in the Netherlands had come to an impasse and that there were sufficient departure points to make a decision to implement ERTMS. It also concluded that a system transition in train protection would offer the opportunity to realise increased transport on the existing infrastructure, resulting in a lower requirement for additional infrastructure.

In response to the findings of the Committee, the minister of IenM on 8 June 2012 made the in-principle decision to implement ERTMS[16]. The Cabinet Rutte II, in its coalition agreement "Bruggen Slaan" (Building Bridges) of 29 October 2012, specified the goal of a phased implementation of ERTMS from 2016.[17]

On 13 February 2013, with the Railway map ERTMS version 1.0[18], the Start Decision for the Exploratory Phase was made. This includes goals, points of departure, prerequisites and directional choices for the process and studies. In Railway map ERTMS version 2.0, an interim state-of-play was provided regarding the process and the studies from the Exploratory Phase. This Railway map ERTMS version 3.0 includes the results of the last part of the Exploratory Phase.

The necessary decision-making information for the Preference Decision has been gathered according to the MIRT method. This has been adapted to the particular nature of ERTMS, which is not a traditional infrastructure project, but is a replacement project which encompasses additional opportunities and also a significant ICT component.

1.2 Context

ERTMS has been under development since the 1990s, under the supervision of the European Union, with the aim of removing technical barriers for interoperability on the European railway network and, as a result, averting the diminishing competitive force of the railway sector. That is why, in the EU setting, there have also been agreements to fit specific corridors (international/TEN-T) with ERTMS[19] in the long-term (with result obligations for 2015, 2020 and 2030 and an obligation to work towards 2050).

In line with the agreed international corridors, the Betuweroute and the HSL-Zuid were fitted with ERTMS at the time of construction. The track doubling Amsterdam-Utrecht and the Hanzelijn were also fitted with ERTMS at the time of creation; this was achieved in overlay, alongside the current train protection system ATB. Previous experiences with installing ERTMS in our own country have provided many lessons for the further rollout of ERTMS in the Netherlands, e.g. when it comes to tendering, acceptance, release and operation. In the near future, the sidings at Kijfhoek and Zevenaar will also be fitted with ERTMS. This corresponds to raising the interoperability level of the Betuweroute even further.

For a summary of the already realised and previously agreed rollout to 2030 of ERTMS, see figure 2.

[15] Parliamentary papers II, session 2011-2012, 32707 nr. 9

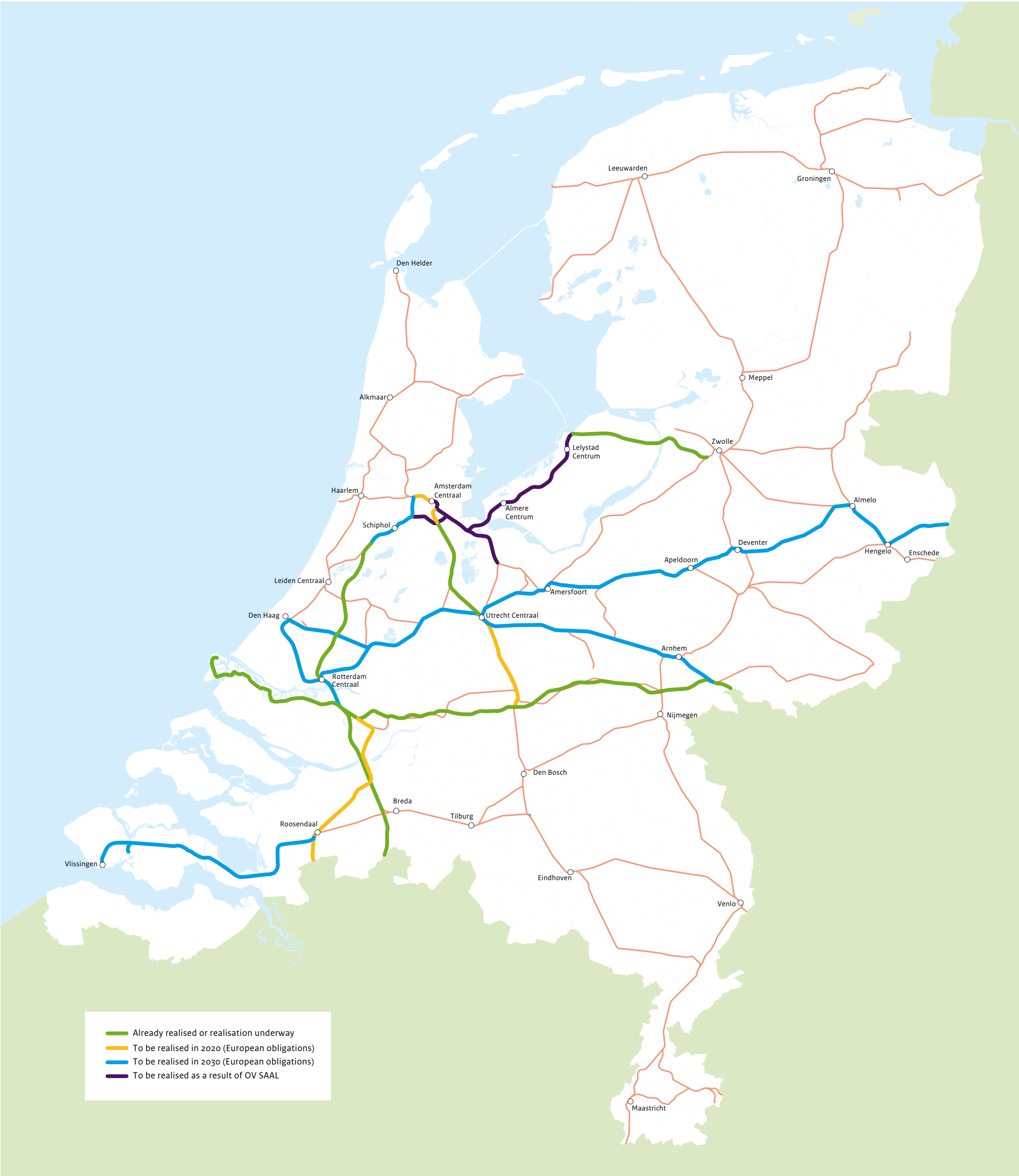
[16] Parliamentary papers II, session 2011-2012, 32707 nr. 16

[17] Parliamentary papers II, session 2012-2013, 33410 nr. 1

[18] Parliamentary papers II, session 2012-2013, 29984 nr. 385

[19] See also annex D in Railway map ERTMS version 2.0

Figure 2. Summary of already realised and previously agreed rollout of ERTMS to 2030



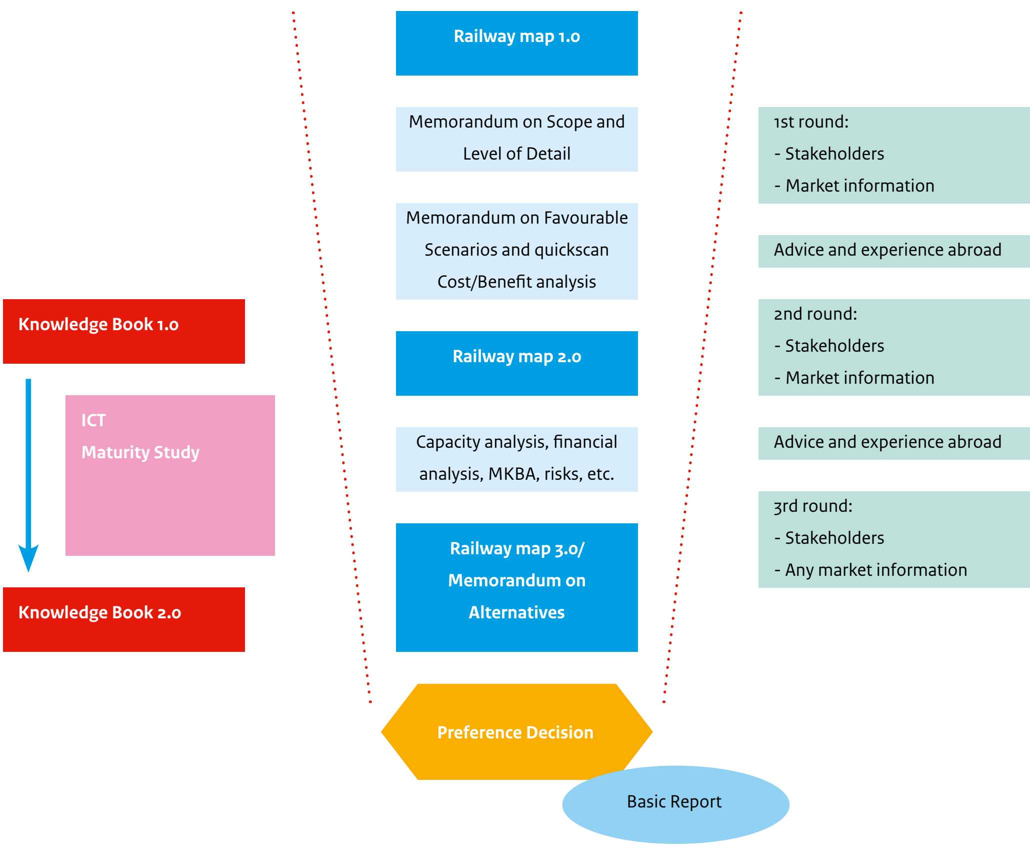
1.3 Building on the exploratory phase of ERTMS

The MIRT system provides substantiation to a phased decision-making process whereby the process moves from outline to detail. This approach will ensure that every decision-making moment will include a consideration of whether there are sufficient grounds for responsibly moving onto the next phase. This will take place via formal go/no-go decisions. Once the Start Decision was made on 13 February 2013[20], the Exploratory Phase for the implementation of ERTMS began working towards the decision-making moment for the Preference Decision.

The MIRT method was developed for planning and infrastructural projects and is thus not applicable to the ERTMS project in every aspect. In contrast, for example, to the traditional road or railway infrastructure projects, the Preference Decision for ERTMS does not contain a precisely defined subject (e.g. a new railway line or bridge) and an Environmental Impact Report (MER) is not required[21]. ERTMS is, in fact, a replacement project with a large ICT component and a long duration period. The working methods of MIRT are therefore supported in this project with research and decision-making phases. In addition, the working methods characteristic to ICT project development (system-engineering), such as the ability to adapt quickly and flexibly to rapid technological developments and the corresponding, changing reality, must be applied.

Figure 3 below, provides a visual overview of the approach of the ERTMS Exploratory Phase.

Figure 3. Summary of already realised and previously agreed rollout of ERTMS to 2030



[20] Parliamentary papers II, session 2012-2013, 29984, nr. 385

[21] The implementation of ERTMS does not fall under the project concept of the environmental impact report guideline and does not fit into category C2 or D2.2 of the environmental impact report directive. That is why an environmental report has not been drawn up for ERTMS.

After the Start Decision in Railway map 1.0, the Exploratory Phase followed two workflows. The first workflow focused on developing expertise (from opinions to facts), resulting in the Knowledge Book 1.0 with Railway map 2.0. This Knowledge Book has now, on the basis of input from sources such as stakeholders and market parties to the published Knowledge Book 1.0, been expanded into Knowledge Book 2.0. This has been added as a separate annex to this Railway map 3.0.

In the other workflow, research was carried out in line with the MIRT rules, into possible implementation scenarios for ERTMS. In accordance with the MIRT rules, a process of outline to detail was adopted with three funnelling stages. First, the playing field of the scenarios was delineated in the Memorandum on Scope and Level of Detail. A selection was then made of the favourable scenarios in the Memorandum of the Favourable Scenarios, using a quickscan MKBA[22]. These first two steps are set out in full in the Railway map 2.0. This Railway map 3.0 sets out the third funnelling step of the MIRT Exploration, the Memorandum on Alternatives, in which the three favourable scenarios and two additional analyses are examined in more detail. The directional choices, points of departure and study directions from Railway map 1.0 are included herein as a basis. The Memorandum on Alternatives is the basis for the Preference Decision.

In addition to the aforementioned workflows, during the Exploration and prior to publication of the Railway maps, harmonisation was sought with the various stakeholders and information meetings were held with various market parties. The results of the latest meetings are further examined in chapter 4 and annexes B and C.

[22] Social Cost/Benefit Analysis

The DMI (DriverMachineInterface) in the train driver's cabin shows how fast the train is moving and how fast it is permitted to move at that location. (Photo: ProRail)

2 The creation of the studied favourable scenarios

In this second chapter, the focus shifts to the process that has been completed since the Start Decision in order to come up with the favourable scenarios. The chapter closes with a presentation of these favourable scenarios, before chapter 3 illustrates the effects on the goals and the costs, benefits and risks of these scenarios.

2.1 Initiation phase/Railway map 1.0

The Railway map version 1.0 of 13 February 2013, formulates five goals that are set for the implementation of ERTMS. A number of directional choices are also made in relation to implementation.

Goals, departure points and directional choices from Railway map 1.0

Goals

The implementation of ERTMS could potentially make an important contribution towards taking the following objectives to a higher plane:

- Safety
- Interoperability
- Capacity
- Speed
- Reliability

Points of departure

- Phased implementation from 2016
- Utilisation of existing budgets
- Minimisation of inconvenience for passengers and freight transporters
- Future-proofing of investments
- Explicit inclusion of system effects within the entire railway system as part of the investigation of the variants and their effects.

Directional choices

- A simple and standardised introduction of ERTMS is the aim
- Start migration with ERTMS in rolling stock
- Dual period is necessary (trains equipped with ATB and ERTMS)
- Preferably install ‘ERTMS only’ infrastructure
- Speed increases to 160 km/hour on certain track sections

2.2 Towards the favourable scenarios/Railway map 2.0

In line with the MIRT system, an outline-to-detail approach was then applied in order to work towards a number of favourable scenarios (see figure 3).
The first step of the funnelling process, the Memorandum on Scope and Level of Detail (hereafter referred to as the NRD) sets out the details of an implementation scenario and the possibilities therein. This highlighted the fact that an implementation scenario is determined by:

1. ‘What’ — What desired functionality/performance or, in this case, operational choices?
2. ‘Where’ — All of the Netherlands or parts of the main railway structure (e.g. specific areas or corridors)?
3. ‘When/How’ — Desired start and end date + rollout pace and order?

The building stones 'what' and 'where' provide the final vision with regard to a scenario; the building stones 'when' and 'how' set the migration path in order to arrive at the final vision.

The NRD, on the basis of theoretically possible scenarios, then selects sixteen practical scenarios, alongside the so-called 0 scenario. This 0 scenario, in which only the decisions about ERTMS that have been made thus far are implemented, serves as a comparison (reference) for the future visions of the implementation scenarios. The sixteen possible scenarios are included in the subsequent funnelling step.

In this second step, the possible scenarios are further elaborated into thirteen focus scenarios:

- two basic scenarios (no ERTMS but investment in the current system and no ERTMS and extra investment in the current system);
- two 0 scenario (ERTMS Level 1 and Level 2 as overlay on the current system on the compulsory corridors so that non cross-border rolling stock does not have to be refurbished with ERTMS);
- nine scenarios for further implementation of ERTMS in the Netherlands.

The major points of the focus scenarios in this phase are then assessed and compared to the goals and prerequisites from Railway map E version 1.0 (safety, interoperability, capacity, speed, reliability) and (an indication of) costs and risks. This takes place on the basis of available information and expert judgement.

The results of this second step are then reported in the Memorandum on the Favourable Scenarios (hereafter referred to as NKS). This selection process was reported in Railway Map 2.0.

2.3 Elaborating the favourable scenarios/Railway map 3.0

More recently, in line with the MIRT and on the basis of conclusions from the NKS, the favourable scenarios[23] have been studied in more detail in terms of effects, costs, benefits and risks.

Alongside these scenarios, the 0 scenario has also been defined for the purposes of the research. This scenario sets out the expectations and the situation posited by the studies, if there is no large-scale rollout of ERTMS. The 0 scenario does fulfil the EU compulsory requirements when it comes to the implementation of ERTMS and the implementation of ERTMS on OV-SAAL. The points of departure are based on the state-of-play at the end of November, regarding policy intentions. Two supplementary analyses were also carried out, i.e. the application of the (currently only conceptual) existing Level 2plus form of ERTMS and an application of a mix of Level 2 on busy corridors and Level 1 on quieter corridors (Level 1/2 mix).

The studies used the most recent traffic forecasts, drawn up in the context of the Long Term Rail Agenda[24]. These growth figures are much lower than, for example, the PHS forecasts.

[23] A scenario is defined as a combination of a final vision and a migration path. The final vision sets a horizon year in which the implementation phase is completed, or when ERTMS is implemented according to the final vision. A migration path encompasses the route to the final vision. This contains an order of track sections and time elements (when). Not all possible combinations for the favourable final visions and favourable scenarios have been studied because the results of the various migration paths on one final vision provide a good indication of the results of these migration paths for the other final visions.

[24] Long Term Rail Agenda part 2 "Network Netherlands – OV on the right tracks", dated 28 March 2014

2.3.1 Favourable final visions

The railway infrastructure, for this study, was divided into four elements (see figure 5). Figure 4 shows the final visions studied. Two additional analyses were also carried out, namely the Level 2plus concept on final vision 2 and a mix of Level 1 and Level 2 on final vision 3.

Figure 4. Summary of final visions and additional analyses in the study

	EU compulsory	PHS	Remaining HRN	Regional
Zero	Level 1 (overlay)	ATB EG or NG		
Final vision 1	Level 2	Level 2, short block	ATB EG or NG	
Final vision 2	Level 2	Level 2, short block	Level 2	ATB NG
Final vision 3	Level 2	Level 2, short block	Level 2	Level 2
Additional analyses	Level 2plus	Level 2plus	Level 2plus	ATB NG
	L1/2 mix	Level 2, short block	L1/2 mix	Level 1

0 scenario: This scenario only assumes the decisions already taken and corresponding obligations in a European setting with respect to ERTMS[25]. Otherwise, the current train protection system ATB will be replaced on a regular basis. In this scenario, the EU compulsory corridors will be created in a cost-effective manner, i.e. with ERTMS Level 1 overlay. The Preference Decisions of PHS, including OV-SAAL, will also form part of the 0 scenario. This complies with the MKBA approach. With respect to OV-SAAL, this incorporates the implementation of ERTMS Level 2 only, with short blocks on the Amsterdam Centraal – Hilversum and Schiphol – Lelystad routes. Signalling optimisation under ATB will be implemented for the other PHS track sections, in accordance with the project overview. There is also a proposal to roll out ATB-Vv to around 50%[26].

Final vision 1 (PHS): This final vision assumes the implementation of ERTMS Level 2 only on the EU compulsory corridors (2020 and 2030) and the PHS corridors with connections to that network. ATB will be maintained on other routes (remaining HRN and regional). The PHS segment corresponds to the greatest capacity needs and the highest passenger flows. Block compression (short blocks) will be applied at many locations within this segment.

Final vision 2 (HRN): In this scenario, ERTMS Level 2 only is implemented across the entire railway network. On the regional track sections, ATB will be maintained. Only at locations where a substantial effect is expected, will block compression be applied; this will particularly apply to PHS track sections and around larger stations.

Final vision 3 (NL): In this scenario, ERTMS Level 2 only is implemented on the entire Main Railway infrastructure, resulting in uniformity and homogeneity within the network. Only at locations where a substantial effect is expected, will block compression be applied. This will particularly apply to PHS track sections and around the larger stations.

Supplementary analyses compared to final visions:

[25] Order (EU) nr. 1315/2013 of the European Parliament and the Council of 11 December 2013 regarding guidelines from the Union for the development of the trans-European transport network and the withdrawal of Resolution nr. 661/2010/EU and Order (EU) Nr. 1316/2013 from the European Parliament and the Council of 11 December 2013 for establishing the financing facility for European connections, for modification of the Order (EU) nr. 913/2010 and withdrawal of Order (EU) nr. 680/2007 and (EU) nr. 67/2010.

[26] In line with state of play for issues when drawing up impact analyses and MKBA.

Figure 5. Division of railway infrastructure in scenario areas

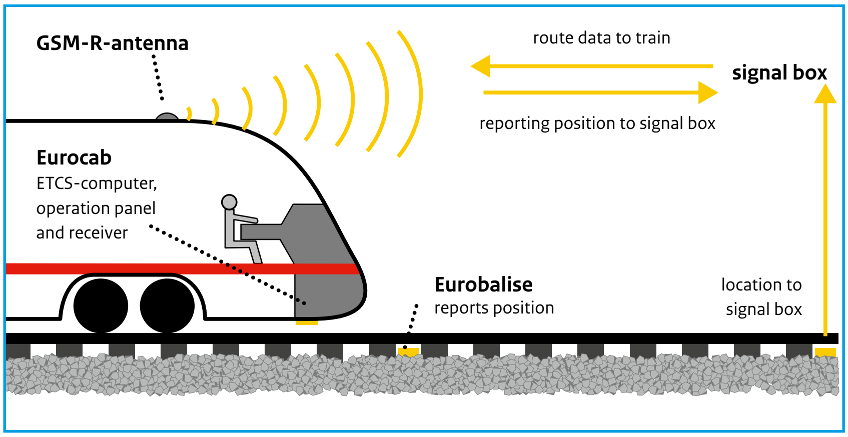
Level 2plus: in this analysis, it is assumed that the so-called Level 2plus will be realised for the entire HRN. Level 2plus currently only exists in a conceptual form. Level 2plus combines virtual blocks of Level 3 for trains that can guarantee their integrity and track-linked blocks for trains that cannot.

Level 1/2 mix: the realisation of Level 1 could lead to lower investment costs than Level 2. In these additional analyses for the entire Netherlands, Level 1 is rolled out instead of Level 2 on track sections where there is no need for extra capacity and, therefore, no need for block compression and on the larger sidings outside PHS (this is to limit the number of transactions between Level 1 and Level 2). This mix corresponds to Belgium's implementation scenario and advice from the Kuiken committee.

Description of ERTMS Level 2, block compression and Level 2plus

In the study, three favourable final visions were nominated with ERTMS Level 2. An additional analysis was also conducted of the ERTMS Level 2plus concept.

Figure 6. The principle of ERTMS Level 2



ERTMS Level 2 does not work with signals, like the current system ATB, but with radio communication. The train driver receives authorisation to drive (to where and at what speed) via GSM-Rail-radio and can read this off in his cabin. The authorisation is given by a Radio Block Center (RBC) message that is passed on via the GSM Rail system to the train. The train, in turn, broadcasts its position and other supplementary information such as speed, via GSM-R to the RBC. In this way, the RBC continuously knows the locations of all trains and their speed and direction. A more comprehensive explanation can be found in the ERTMS Knowledge Book 2.0.

Train detection: short blocks

In order to determine where the train is in a safe manner, ERTMS Level 2 uses track-bound train detection. In essence, the railway network is divided into blocks (from between a few hundred metres to a few kilometres) and there is a physical measurement of whether there is a train in that block. This works the same under ATB as it does under ERTMS Level 2.

Both the location and the length of the blocks under ATB depend on the location of the signals. Given the fact that with ERTMS Level 2 there are no longer any external signals, there is more freedom in terms of both the position of a block and the length thereof. Block shortening (also called block compression) means shortening the length of the blocks. As a result, the protection system can more accurately gauge which parts

of the railway network are free and authorisation can be granted to other trains more meticulously. This offers optimisation opportunities to allow trains to be driven closer to one another and this will lead to capacity gains on the railway network. For further details, see research results from the capacity analysis in chapter 3.

Level 2plus: track-bound detection in combination with detection on the basis of train data
Alongside track detection, Level 2plus also provides the option to apply detection from train information. Thanks to the train message, an RBC constantly knows where a train is located. In ERTMS Level 2plus, the RBC virtually divides the existing blocks into sections and determines whether these sections are free on the basis of information that is provided by the train. As a result, shorter blocks, and therefore optimisations, are possible without the track-bound train detection being modified to create physically shorter blocks. For safety reasons, the position message from trains may only be used with trains that can monitor their integrity. Track-bound train detection will continue to be used to determine which blocks are released for trains that cannot monitor their integrity. The option of closer follow-ups will not therefore be realised for these trains.

Level 2plus is currently just a concept. In the context of the ERTMS Knowledge Book 2.0, further research was carried out into the future developments herein. The results are summarised in chapter 4.

Project Redesign Traffic Control and Disruption Management
The current Redesign of traffic control and disruption management project, which is part of the LTSa, aims to bring about substantial improvements in traffic control and disruption management in the period up to 2017. The provision of information between trains and traffic control system(s) will be greatly improved as a result.

Given that the implementation of ERTMS is not expected to deliver any (significant) added value in terms of information provision to traffic control system(s) compared to the current plans within the Redesign project, the effects of an improved traffic management system are not included in the research into the effects of ERTMS. The project will be managed so that the investments that are made within the Redesign programme are future-proof, or that the future traffic control system(s) is/are ready for ERTMS. Within the ERTMS business case, no costs or benefits will therefore be included with respect to the traffic management system and improved traffic control and disruption management.

2.3.2 Favourable migration paths for infrastructure with prior refurbishment of rolling stock
In the study, three migration paths were examined for the rollout of ERTMS between 2020 and 2035. Each of the three migration paths has a different philosophy in terms of the order in which the infrastructure is equipped with ERTMS. The point of departure for each migration path for the infrastructure is that the rolling stock must first be fully refurbished, before the infrastructure becomes operational under ERTMS, as has already been decided in Railway map 1.0. An exception to this is formed by rolling stock to be used to commission the EU compulsory TEN-T corridor Rotterdam – Belgian border. The departure point in this regard is that sufficient rolling stock is available in order to travel under ERTMS here from 2020. The prompt delivery of the EU compulsory corridors in 2020 and 2030 and OV-SAAL in 2023 is also a departure point.

The three migration paths are:

Path A: PHS first. This path begins with the busiest track sections, namely in the PHS area. This is in order to achieve rapid improvements for the largest majority of passengers and thus also the greatest benefits.

Path B: Replacement first. Here, the replacement specification is followed as closely as possible with the aim of limiting the number of ATB replacements and thus ensuring a cost-effective implementation programme.

Path C: Districts first. By beginning with the districts, the aim is to minimise any inconvenience as a result of 'teething' problems. EU compulsory corridors and OV-SAAL will be an exception to this and will be realised with ERTMS.

The siding at Kijfhoek is now equipped with ATB but, over the coming years, will be refurbished to use ERTMS. (Photo: Keyrail)

3 The effects of the favourable scenarios

ERTMS is primarily a protection system. In addition, ERTMS offers other opportunities. This chapter sets out what the implementation of ERTMS can contribute, in the three favourable scenarios, to the five goals of ERTMS implementation: primarily safety but also interoperability, capacity, speed/journey times and reliability. The costs, benefits and risks associated with the scenarios are also summarised. Alongside the three favourable scenarios which assume Level 2, two additional analyses were also conducted regarding the concept of Level 2plus (under development) and a mix between Level 1 and Level 2. The main points of these additional analyses have been studied. This chapter provides a brief summary of the results.

3.1 Safety

Safety concerns the risks that correspond to people, freight and rolling stock as a result of railway system activity, including the management and maintenance thereof. The quantification of the safety effects goes some way to responding to the de Boer/Hoogland motion[27].

ERTMS is primarily a protection system. In terms of safety, ERTMS affects the probability of collisions between trains and, with extra measures, also the safety of level crossings and track workers. The current protection system has a high degree of safety but also encompasses a number of shortcomings. ERTMS offers additional safety improvements:

- Speed monitoring under 40 km/h;
- Brake-curve monitoring for every speed reduction;
- Automatic application of Temporary Speed Limits (TSB);
- Possibility of better notification at level crossings (so-called Constant Warning Time).

Within ERTMS, speed is monitored even under 40 km/h. This is not the case with the current system ATB-EG, which only monitors speeds over 40 km/h. This safety improvement will have a particular effect at sidings and during work when speeds are often reduced to lower than 40 km/h. As a result, the number of STS incidents will reduce.

ERTMS protects all speed reductions by means of brake-curve monitoring. This involves ERTMS checking the speed of the train before each enforced braking moment, e.g. at a station or before a corner, and ensuring that the train reaches the permitted speed (could also be 0 km/h) at the right moment if the train driver does not brake in time.

ERTMS Level 2 also closely monitors the location of the train. This information can then be used to close level crossings at the right moments, so that the variation in waiting times for road traffic can be reduced. This is known as Constant Warning Time (CWT). This has a positive effect on safety because road-users are less likely to 'slalom' between barriers at closed level crossings. For the time being, CWT is a concept; it must be further examined.

In addition, the implementation of ERTMS Level 2 corresponds to electronic (computer) interlockings. These computers enable hand-held terminals to be used to reserve a section of track for track-workers. Temporary speed restrictions can also be enforced with the use of electronic interlockings and ERTMS Level 2 or higher; this means that track-workers can carry out their work safely.

[27] Parliamentary papers II, session 2013-2014, 33652 nr. 8

The effects of ERTMS implementation on the aforementioned aspects have been determined on the basis of accident databases and (causal) analyses. These results are provided in table 3.

Table 3. Result analyses – safety for passengers, railway personnel and level crossing users. Figures indicate averages per year, analysis on the basis of incident register ILT 2008-2012.

Safety	Average number per year per final vision			
number per year	0: EU	1: PHS	2: HRN	3: NL
STS incidents	158	77	54	53
Safety of train passengers and personnel				
Fatal	0.6	0.3	0.3	0.3
Serious injuries	11.8	7.0	4.8	4.6
Minor injuries	116	56	39	38
Level crossing safety				
Fatal	13.6	13.1	12.6	12.2
Serious injuries	3.8	3.7	3.7	3.6
Minor injuries	13.6	13.4	12.9	12.3

STS incidents. For the 0 scenario, an estimate is made of the expected number of STS incidents per year. In this respect, use is made of the STS registration from the ILT for the period 2008-2012. The analysis considers the effects of ATB-Vv, OV-SAAL and PHS. As a result of brake-curve monitoring, the number of STS incidents will reduce in line with the amount of network where ERTMS has been implemented.

The implementation of ERTMS leads to the number of STS incidents in final vision 1 being halved and a reduction by two-thirds in final visions 2 and 3. The limited difference in numbers of STS incidents between final visions 2 and 3 can be put down to the fact that regional railways, which are fitted with ERTMS in final vision 3, have already been equipped with ATB-New Generation which, in this respect, is almost as effective as ERTMS. STS incidents on regional lines can primarily be reduced in relation to erroneous departures from out-of-action tracks, holding sidings or marshalling yards or in a departure through red situation.

Safety of train passengers and personnel. The effect on the number of victims for the various final visions directly corresponds to the number of STS incidents that are prevented. This explains the variations between final visions 1, 2 and 3.

Level crossing safety. Improvements to safety at level crossings can be achieved by reducing the variation in waiting times at such crossings. Some road-users 'slalom' between or dive under the barriers if a level crossing stays closed for too long. This happens, for example, near stations where some trains stop and others continue through at full speed. Using data regarding the speed of trains that are approaching a level crossing means that a 'Constant Warning Time (CWT)' can be developed with ERTMS Level 2. The variation in waiting times will thus be reduced. CWT also requires the development of supplementary technical systems over and above ERTMS Level 2.

Track-workers. Incident registration for the period 2008-2012 does show incidents involving track-workers, however the study ascertained that none of these would have been mitigated as a result of the implementation of ERTMS.
In 2013, two incidents occurred that might have been mitigated. On these grounds, it can be concluded that ERTMS can contribute towards the safety of track-workers but that there is no real insight into the scope of this contribution.

Additional analyses of Level 2plus and Level 1/2 mix. The Level 2plus concept will have the same effect on the above results as final vision 2 (implementation of ERTMS on HRN). An improvement of waiting times for level crossings is also an option in Level 2plus. With the application of Level 1, this is not the case, given the fact that the train determines its own location and this is not sent back to a track-side location. The reduction in STS incidents and the consequences hereof will be about the same with Level 1 and Level 2. As a result of a lack of computer interlockings in Level 1, hand-held terminals cannot be used for track-workers or enforced speed restrictions.

3.2 Interoperability

Interoperability concerns the possibility of trains moving through various protection systems without a hitch in regions (national) or countries (international). ERTMS is encouraged by the EU in order to expand the interoperability of train traffic between countries.

Within the topic of general interoperability, national and international interoperability can be distinguished. National interoperability concerns the (im)possibility of operating rolling stock, without problems arising as a result of different protection systems, across the entire national railway network. International interoperability involves the (im)possibility of train travel between countries for freight and passengers.

The more (sections) of the railway network infrastructure that has the same technical characteristics, the greater the possibility that a locomotive or train can use it without specific modifications being required. This leads to lower costs and simplifies the provision of (cross-border) railway connections; this will result in the popularity of train travel increasing.

Multiple, different protection systems in one train drive up the costs of installation, personnel, management and maintenance. If more than one protection system is required in the trains, there are lower cost levels and/or greater usage options for the locomotives. As a result, interoperability increases as more train services can be run with ERTMS exclusively.

Table 4. Results of interoperability analysis – national and international[28]

Interoperability	Final visions 0: EU compulsory	1: PHS	2: HRN	3: NL
National				
Percentage of passenger rolling stock HRN with only ERTMS/ ERTMS + STM	0/25%	0/100%	100/0%	100/0%
Percentage of passenger rolling stock regional with ERTMS/ ERTMS + STM	0/0%	0/50%	0/100%	100/0%
Percentage of freight trains with ERTMS/ERTMS + STM	46/31%	54/31%	85/15%	100/0%
International				
Percentage of cross-border freight trains with only ERTMS	79%	82%	90%	100%[29]
Percentage of cross-border passenger trains with only ERTMS	5%	42%	95%	100%
Time saving freight (hours/year) compared to 0 scenario (3,885 hours/year)	-	0	3,885	3,885

National. In the 0 scenario, there has been an assumption that 25% of the national passenger rolling stock is fitted with ERTMS. This is a consequence of the integration of HSL-Zuid with the HRN and the application of ERTMS on the SAAL corridor. In final vision 1, there is mention of 100% refurbishment of rolling stock for the train operator of the HRN and 50% refurbishment of rolling stock for the regional train operator. In final visions 2 and 3, the rolling stock must already be fitted with ERTMS, even if the regional railway lines are not fitted with it. This is the result of the common usage of stations on the HRN and the corresponding track sections. Rolling stock for regional train services and a limited percentage of freight transport (i.e. to locations on regional railway lines) rolling stock also requires an ATB installation. In final vision 3, the whole country is equipped with ERTMS and the need for ATB is eliminated.

International. The 0 scenario talks of an improvement of interoperability in terms of international freight transport. The most important reason for this is that a large part of international freight transport takes place on the EU compulsory corridors. International passenger transport primarily takes place on the HRN and HSL-Zuid. At the border, for some of the freight trains on lines other than the Betuweroute, the locomotive always has to be changed for one that can be driven in that particular country. If ERTMS is implemented, in final visions 2 and 3, the border waiting time that arises because of the protection systems (in the 0 scenario, around 4,000 hours per year) is expected to practically be eliminated.

Additional analyses of Level 2plus and Level 1/2 mix. In terms of the Level 2plus concept, both trains with and without a Train Integrity Monitor (hereafter to be referred to as TIM) can be used on ERTMS track sections. This has no effect on interoperability. ERTMS Level 1 is technically interoperable with respect to additional analyses of Level 1/2 but it is not operationally interoperable. This means that the rolling stock can be used on both levels but that a train driver would have to be familiar with different procedures for the various levels (see also ERTMS Knowledge Book 2.0): for Level 1, for example, a foreign train driver must be familiar with the ATB/NS'54 but this is not the case with Level 2.

[28] The shares of rolling stock for HRN and regional (0, 25, 50 en 100%) regarding points of departure.

[29] Irrespective of the fact that a number of trains used abroad must have an additional protection system, specifically for that country.

3.3 Capacity, Journey times and Reliability

ERTMS also has a positive effect on journey times for trains between stations compared to the current protection system ATB. This is principally caused by delayed braking and an ability to more effectively abide by the maximum speed that is possible on the infrastructure because ERTMS can monitor almost all speeds. This is not the case with ATB-EG because there are so-called speed intervals (40, 60, 80, 130, 140 km/h).

ERTMS Level 2 also has a positive effect on capacity. This is due to the fact that there are no signals in Level 2 alongside the track to determine the moment at which the speed (and/or braking) is monitored. As a result, (detection) blocks in the railway network can be shortened more easily than is the case with ATB. With ATB, block length is dimensioned on the braking distance of trains that brake badly. The use of shorter blocks means that trains can more safely travel nearer to one another and this leads to shorter follow-up times. Shortening the blocks, however, requires extra investment that is included in every scenario. The use of this extra capacity can be targeted at situations where it is specifically required.

The shorter follow-up times can then be used to expand buffers between trains (with higher general reliability and reliability of timetables as a result), reduce the time that trains spend waiting for one another (shorter journey times) and/or allow trains to arrive at stations more quickly one after the other so that the transfer time is reduced (shorter journey times). Moreover, reliability is determined by the number and duration of failures affecting infrastructure and rolling stock elements.

The Vache[30] simulation model is used in order to determine journey and follow-up times. A Static and Speed Profile (SSP) and a projection are used as input. In an SSP, the permitted speed on the infrastructure is determined and a projection involves a design that is made for track-bound detection. The Design Regulation ERTMS Level 2 concept by ProRail is used as the basis for this. The effects of timetable stability (see under reliability) have been calculated using the SIMONE[31] national model; follow-up times were used as input for this. Other reliability effects have been determined on the basis of the available failure analyses.

The analysis of capacity, journey times and reliability comprises research into a number of representative track sections in which around thirty follow-up situations and sixteen journey times were reviewed. These form the basis of the extrapolation for the national network.

3.3.1 Effects on capacity

The effects on capacity can be divided into shorter follow-up times and shorter cross-over times. Cross-over times are train follow-up times that cross one another in opposite directions. Table 5 provides the results.

Table 5. Results of research into follow-up times (excl. platform follow-ups) with ERTMS Level 2 in combination with block compression.

Type	Min.	Weighted avg.	Max.
Follow-up	9%	25%	41%
Cross-over	9%	15%	21%

[30] This is a simulation model which has been specified for run and follow-up times under ERTMS and has been used previously in the study of capacity effects from ERTMS on the Utrecht – 's Hertogenbosch route.

[31] SIMONE is a model that has been developed by ProRail and NS; it enables national timetable regulations to be simulated in relation to timetabling reliability.

The weighted average gives a 25% improvement in train follow-up times and a 15% improvement for cross-over times. This roughly corresponds to a 30 second gain per follow-up between trains (specific cases excluded). The differences in the random sample are largely explained by location-specific features in the infrastructure in combination with the current train protection system. Given that every track section has its own features, the gains are expected to vary within this bandwidth, but always remain positive. If block compression does not take place under ERTMS Level 2, the follow-up and cross-over times as a result of delayed braking will improve slightly compared to the current situation.

3.3.2 Effect on journey times

The effects on journey times are the result of five possible causes, namely run time improvements due to speed intervals and delayed braking, the avoidance of waiting times between trains, higher maximum speeds and narrower transfer interchanges (shorter transfer times at interchanges). In the study, run times were also modelled in combination with ERTMS. The run time reductions are separate to block compression and have been translated into journey times. These gains can also be achieved with the current block divisions and ERTMS. The study also reviewed, within the PHS timetable (including correction for current developments), whether waiting times for trains (called bulges) could be prevented as a result of shorter follow-up times. For the larger hubs (e.g. Utrecht and Zwolle), the effects of shortening the transfer times for passengers were also observed. Tables 6 and 7 provide the results.

Table 6. Results of research into run time gains. These are independent of block compression in percentages compared to runtimes under ATB.

Item	Min.	Avg.	Max.
Gain runtime Intercity	2.0%	2.6%	3.0%
Gain runtime Sprinter	2.3%	3.3%	4.3%

Table 7. Results of journey time gains for passengers compared to the 0 scenario as a result of run time improvements, fewer waiting trains, higher maximum speed and narrower transfer interchanges in millions of hours per year in horizon year 2035.

	Final visions		
Section	1: PHS	2: HRN	3: NL
Journey time gain in relation to run time gain	4.2	5.4	5.5
Journey time gain in relation to bulges	1.9	2.0	2.0
Journey time gain in relation to 160km/u	0.8	0.8	0.8
Journey time gain in relation to narrower interchanges	0.1	0.2	0.2
Total	7.0	8.5	8.6

The average gain per Intercity is 2.6% on runtime. This, for example, equates to 1 minute runtime gain between Utrecht and The Hague. The runtime gains to be achieved depend on location-specific features in the infrastructure in combination with the current train protection system. As a result, there is a varied overview per corridor; this explains the bandwidth shown above.

The gains that apply to passengers are largely caused by runtime gains as a result of delayed braking and improvements in terms of maintaining the maximum speed on the infrastructure. The accumulated runtime gains for passengers reduce in line with a decrease in the number of passengers that benefit as a result. The effect on PHS corridors is thus greater

than on other HRN routes. Preventing bulges only relates to the track sections where block compression is applied and there is an issue of waiting (bulging) trains. Almost all journey times are achieved on the PHS corridors as a result of fewer waiting (bulging) trains. The effect of narrower interchanges as a result of shorter train follow-ups at interchanges is limited by the fact that the number of passengers that make such a transfer is also limited.

The above results only relate to track sections with two or more tracks. Single-track sections will see more limited or no journey time gains. The journey time gains can be used to improve reliability and soundness. The reason for the limited journey time gains is the dependence on the timetables for passing and overtaking facilities. Single-track sections also have the more recent ATB-NG protection system, meaning that the journey time gains with ERTMS are less substantial.

Journey time and capacity gains in the final vision with Level 2plus (additional analysis) will be almost the same as in the final vision with Level 2. An important prerequisite for this is that all trains can guarantee their integrity. If this is not the case, the capacity gains will be lower.

In the additional analysis Level 1/2, journey time gains can be achieved on Level 1 but capacity effects are not expected. Delayed braking can also be applied in Level 1 and the permitted speed through the infrastructure can be monitored more accurately. The track sections on which Level 1 is assumed in this final vision are the track sections on which there are no substantial capacity effects, and none are needed, with Level 2.

3.3.3 Effects on reliability

The reliability of the timetables is determined on the basis of punctuality and the percentage of trains driven. There are three possible issues that impact upon these aspects: failures of infrastructure, failures in rolling stock, and spacing in the operation, such as variations in acceleration and halting times. These cause the number of lost hours that passengers encounter when their trains are delayed or cancelled.

An analysis of the impact of the implementation of ERTMS has been conducted per variable. An analysis has thus been made of the number of failures in infrastructure before and after the implementation of ERTMS. Timetable stability has also been modelled in the national model SIMONE and a disruption analysis has been conducted if trains have ERTMS onboard.

Table 8 shows the effects per variable for the various final visions.

Table 8. Results of effects on reliability in millions of lost hours per year

Reliability	**Final visions**			
	0: EU compulsory	**1: PHS**	**2: HRN**	**3: NL**
Punctuality with cause:				
Infrastructure failures	2.11	2.07	2.04	2.01
Rolling stock failures	0.90	0.91	0.91	0.91
Timetable stability	3.01	2.85	2.80	2.76
Total punctuality (millions lost hours)	**6.03**	**5.83**	**5.73**	**5.68**
Cancellation with cause:				
Infrastructure failures	1.71	1.62	1.52	1.45
Rolling stock failures	0.63	0.70	0.69	0.69
Total cancellation (millions lost hours)	**2.34**	**2.31**	**2.21**	**2.13**
Lost hours (millions) per year	**8.37**	**8.14**	**7.94**	**7.81**
Index (0 scenario = 100)	100	97.2	94.8	93.2

In the final visions 1, 2 and 3, there is mention of an improvement in punctuality compared to the 0 situation, particularly via a combination of further timetable stability, fewer failures in infrastructure and shorter repair times for breakdowns. Historical figures, particularly with ERTMS in freight trains, show that the number of lost hours caused by rolling stock will rise slightly.

The gain in shorter follow-up times between trains can only be achieved once - either in shorter journey times as a result of avoiding bulges and realising narrower transfer interchanges or in improved timetable stability. The current analysis opted for the use of shorter follow-up times for the purposes of avoiding bulge and realising narrower transfer interchanges.

For Level 2plus (additional analysis), reliability is the same as final vision 2 (HRN). The effects of additional gains in capacity on the track sections that do not have block compression in final vision 2, will be limited. Also, the reduced use of train detection (other types too) will have a limited effect on reliability.

For a mix of Level 1 and Level 2, there are different effects on reliability on the track sections where Level 1 is assumed. A number of the improvements that are possible with ERTMS Level 2 cannot be realised with ERTMS Level 1. As a result, the index of the number of lost hours is 95.9 compared to 93.2 in final vision 3.

3.4 Required measures and costs

In order to implement ERTMS, measures and tasks are required:

- purchase and installation of interlockings;
- Radio Block Centers (RBC's);
- balises and track-bound detection;
- purchase of On-Board units;
- installation of cables so that all elements are connected to one another.

Before the infrastructure can be used with ERTMS, the rolling stock must first be fitted with ERTMS by installing ERTMS onboard units.

In the coming decades, a large part of the current protection system must be replaced. The implementation of ERTMS can be carried out more cost-effectively according to how much of the replacement of the current protection system can be avoided or where the replacement can be anticipated by the implementation of ERTMS.

The costs that correspond to the implementation of ERTMS also encompass investments in rolling stock, infrastructure and costs for managing and maintaining infrastructure, reduced by the replacements that become unnecessary as a result of the implementation[32]. On the basis of a design to determine the necessary measures, a probabilistic estimate of the costs in line with the standard system cost estimate (SSK system) has been drawn up for the various final visions and migration paths.

3.4.1 Results

Implementation of ERTMS Level 2 essentially requires the following activities:

- installation of new computer interlockings and RBCs;
- creation of GSM-R redundancy (double construction);
- removal of elements of the current train protection system, such as signals, testing and commissioning.

For track sections that are selected for block compression, the cost profile for restructuring train detection in the track has also been included. The fact that train detection must be replaced if ERTMS is implemented has also been taken into account.

[32] The review period is from 2015 to 2065; this period of 50 years is standard for projects with a large ICT component.

Table 9. Summary of investment, replacement and maintenance costs. Amounts are given in millions of euros, including risk-surcharges and VAT. Price benchmark 2013. Final vision in combination with migration path PHS first.

Costs	Final visions			
	0: EU compulsory	1: PHS	2: HRN	3: NL
Investment Infrastructure + rolling stock	850	3,600	4,700	5,150
Avoided investment/double counting	-	-335	-335	-335
Replacement of infrastructure	4,800	4,150	4,000	3,800
Maintenance infra per year (from 2035)	55	80	95	105
Life Cycle Costs (Net Cash)	3,700	5,500	5,950	6,100
Total costs compared to 0 scenario (Net Cash)		1,800	2,250	2,400

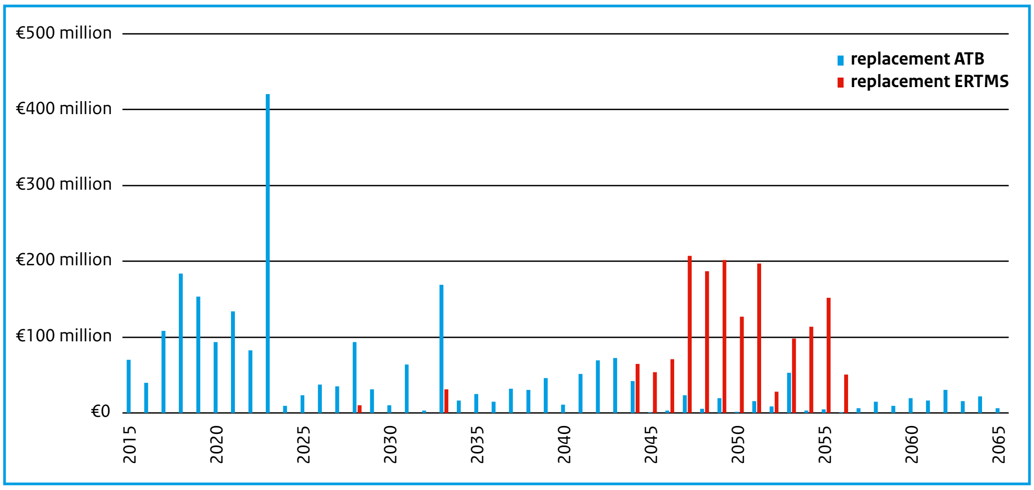
Investment costs infrastructure. The costs in the 0 scenario encompass the costs of installing ERTMS Level 1 (overlay) on the EU compulsory corridors. The costs for the other scenarios comprise the installation of ERTMS Level 2 on the PHS and EU compulsory corridors, on the HRN and the entire network. The variations between the scenarios are principally explained as a result of network length. No additional scale-advantages can be expected between the final visions.

The investment costs comprise removing and installing infrastructure (including cable work and GSM-R), installing interlocking and RBCs, programme costs and a risk provision. The risk provision amounts to 34% on the basis of the risk analysis conducted. VAT of 21% must be applied to the various amounts.

Avoided investment/double counting. Avoided investments are investments in the railway network that have already been green-lighted (and form an implicit element of the 0 scenario) but that are no longer necessary if ERTMS is rolled out. The level of avoided investments is the same for all final visions. This amount encompasses 50% of the planned investment costs in signalling optimisation within the PHS programme, 50% of the measures for capacity expansion of infrastructure within the PHS programme that could be avoided via ERTMS, and costs for installing of ERTMS on the OV-SAAL corridor. Strictly speaking, the latter is not an avoided investment but double-counting amounting to € 225 million.

Replacement costs. This amount includes costs that correspond with the replacement of infrastructure elements (such as signals, cables, B-relays, interlocking, train detection, ATB, etc) for the purposes of train protection. In the coming years, a huge 30-year round of replacements will start for all current, existing protection systems. This will lead to a replacement task concerning the existing technology. The costs of this, but also those that correspond to vital replacement of the newly installed ERTMS systems have been included to the year 2065. In figure 7 these costs are given for final vision 2 (implementation of ERTMS on the HRN) in combination with migration path PHS first.

Figure 7. Replacement costs for ATB (blue) and ERTMS (red) set out over time for final vision 2 HRN, in combination with migration path PHS first. Amounts are given in millions of euros.



The majority of the replacement costs are required before circa 2025. The peak in 2023 is caused by the fact that a relatively high number of installations, according to the current calculation model, come to the end of their useful lives in this year. The precise moment of replacement, however, is hard to determine and it is possible that this peak will be smoothed out in practice. It is expected that many of the outdated installations will have to be replaced in the coming 10 years. None of the migration paths studied eliminate a significant element of this replacement. Once the rollout of ERTMS is underway, more replacement could be avoided as a result of ERTMS implementation.

In the analysis, no account was taken of the possible optimisation of the replacement task. This requires both further investigation into the moment of exact replacement need and a greater insight into the desired rollout pattern for ERTMS. In the next phase, a more thorough examination will be made concerning the actual longest lifespan of the installations to be replaced, or lifespan extension measures that could be taken (e.g. for Rotterdam), but also whether actual replacement could be anticipated by the later implementation of ERTMS (no regret investment). Being smart about the ERTMS rollout order could also lead to possible replacements being avoided. Such measures could thus lead to a reduction in replacement costs.

Maintenance costs. These costs, according to the current insights, are higher for a final vision with ERTMS Level 2 than for the existing protection system. The reason for this is the growing ICT character of railway protection, as this requires additional and more expensive maintenance. These effects are visible for both infrastructure and rolling stock.

Additional analysis final vision Level 2plus. The Level 2plus concept provides for capacity expansion without physical block compression being implemented. The investment costs for final vision 2 will thus be reduced by circa € 550 million. The Life Cycle Costs are around € 300 million (NCW) lower. The maintenance costs are also lower as a result of less track-bound train detection. This also has a cost-saving effect on replacement costs for this track-bound detection up to and including 2065. These savings are made quite late in the day (after 2040).

Additional analysis final vision Level 1/2 mix. The investment costs for this additional analysis amount to around € 550 million less. The track sections where no block compression is assumed, i.e. all regional track sections, and the less busy track sections on the HRN were reviewed. The difference in investment costs for final vision 3 is the result of not

needing RBCs, and requiring simplified interlockings (conventional rather than computer interlockings) on the Level 1 track sections. As a result, maintenance costs also work out cheaper. Replacement costs will, however, rise given that Level 1 is applied as an addition to the existing infrastructure and comprises more track elements than Level 2.

3.5 Costs and returns for operators

The implementation of ERTMS will impact upon the profits of operators. This will depend, on the one hand, on refurbishment costs, the issue of who pays for refurbishment, expected higher maintenance costs and, on the other, reduced operational costs and extra income from passengers. The operational costs are reduced as a result of runtime gains, energy savings and the higher reliability realised with the implementation of ERTMS.

The final visions 1, 2 and 3 assume that the train operator on the HRN will prepare 100% of its rolling stock for ERTMS Level 2. For final visions 2 and 3, the other train operators would also have to prepare their rolling stock for ERTMS (around 170 trains, including 20 museum trains). For final vision 1, this is the case for around 50% of the rolling stock from the other operators. This is due to the fact that several regional operators partially use HRN track sections that will be refurbished for ERTMS Level 2. The investment costs also include expenditure for preparing maintenance equipment. The amounts include VAT and a risk provision of 15%.

The return on investments in onboard-units for the total period (2015-2065) is negative, in line with the current model calculations for all passenger train operators, given that the costs for the benefits and the calculations assume 100% funding by the operators. From 2017, substantial costs will be incurred for the refurbishment of rolling stock, whereas operational costs will only rise substantially after 2025. The annual effect on operations for the concession holder of the HRN (currently NS) is positive from horizon year 2035 but is negative for the regional concession areas. On balance, over the entire 2015-2065 period, it is also negative for the HRN.

The results outlined in this chapter have considered all of the known costs in relation to the refurbishment of rolling stock, such as refurbishment/installation of reserve rolling stock, increased workplace capacity and management and maintenance.

3.5.1 Returns for train operators HRN

With an ERTMS rollout on the scale of the HRN or at a national level (final visions 2 and 3), the effect of ERTMS on operation costs on the HRN become positive in horizon year 2035. This effect is the balance of the following factors:

- Journey time reduction and the higher system speed as a result of the implementation of ERTMS Level 2 lead to a more efficient use of production resources. This has a positive effect on costs with the implementation of ERTMS across the entire HRN;
- Annual depreciation of the necessary investment and maintenance of the ERTMS onboard equipment;
- In the event of implementation of ERTMS across the entire HRN, the ATB system no longer requires maintenance;
- Journey time reductions lead to transport growth. This has an additional positive effect on operations;
- The implementation of ERTMS has a number of supplementary benefits, namely the reduction of energy usage as a result of the more uniform acceleration and braking of trains, and a reduction in costs via a reduction of STS incidents that lead to collisions.

In final vision 1, the annual operational effects in the horizon year 2035 for the HRN are expected to be practically neutral. The most important difference in this is that maintenance of ATB must continue if the end situation involves (some of) the rolling stock still

running with ATB. In addition, the benefits of ERTMS cannot be realised on all routes because these routes are still equipped with ATB. The net-effect is thus neutral.

Assuming 100% funding by the train operator, the return on the investment in onboard-systems across the entire period 2015-2065, despite a positive balance from horizon year 2035, is negative due to the costs exceeding the benefits. If funding is 50%, the return in final visions 2 and 3 for the train operator is positive. Accelerated migration during which the benefits in time are advanced could lead to another overview.

3.5.2 Returns for passenger train operators in decentralised concession areas
Final visions 1 and 2 are unfavourable for passenger train operators in decentralised concession areas. The routes that are used by these operators are not equipped with ERTMS in this scenario, whereas a high number of interchanges that these operators visit will change to ERTMS only in order to more effectively reap the social benefits. This means that these operators must prepare some (an estimated 50%) of their rolling stock for use with ERTMS. There are few benefits gained in terms of this investment.

For these operators, final vision 2 is less favourable than final vision 1. In order to be able to use ERTMS only on HRN interchanges, the operators must equip almost all of their rolling stock with ERTMS onboard systems. They gain few benefits in terms of this investment.

Final vision 3 is expected to be more appealing to regional operators. Just like the situation for train operators on the HRN, the final visions become more appealing the more they are funded by the State. In this final vision, the operators must fully prepare the rolling stock for use with ERTMS and the operators can then gain the benefits of improved safety, capacity and reliability. The fact that the journey time gains of ERTMS on the regional lines are limited compared to the journey time gains on parts of the HRN, means that there is the possibility of generally lower benefits as a result of the more efficient use of rolling stock and the implementation of ERTMS is less favourable for the other passenger train operators than for NS on the HRN. For these reasons, these operators have estimated a neutral result in this scenario.

The 0 scenario has a very limited impact on other passenger train operators in a general sense (for individual passenger train operators this can vary). Operators do not have to invest in ERTMS and have no (or little) benefit from the implementation of ERTMS.

3.5.3 Returns for freight train operators
The effect of implementation of ERTMS on freight train operators can be divided in two: effect on costs, in particular for the installation and maintenance of onboard systems; effect on benefits, in particular via increasing interoperability and safety.

The costs for the installation of ERTMS and maintaining the various onboard systems determine the cost differences between the scenarios. The scenarios whereby freight train operators can remove ATB are favourable because this saves on the corresponding maintenance costs of ATB.
The final vision of increasing interoperability and safety for freight train operators is more positive in final visions 2 and 3 than in the 0 scenario and final vision 1. The large-scale modifications on the Dutch network will create, in combination with the refurbishment of the entire Belgian railway network (2022) and the German TEN-T-corridors, a large and relevant network that can be used under ERTMS. This simplifies the cross-border use of personnel and rolling stock which results in pretty much all waiting time at the border being eliminated (estimated at about 4,000 hours per year) and facilitates more efficient operations. In the 0 scenario and in final vision 1, fewer opportunities are offered.

In paragraph 4.7, there is further discussion of the rolling stock, rolling stock refurbishment and access to the infrastructure.

3.6 Social cost/benefit analysis

The Social cost/benefit analysis (MKBA, see Annex E) provides an insight into the costs and benefits of the project for the Netherlands as a whole. In this context, the effects of two economic scenarios on the various ERTMS scenarios are set out compared to the 0 scenario. The economic scenarios are GE and RC. GE stands for Global Economy and assumes higher growth in passengers and journey time appreciation than the scenario Regional Communities. The updated operators' prognosis that has been elaborated in the context of the Long Term Rail Agenda has also been applied in the calculations. These forecasts are lower than was previously forecast in the context of PHS. Both financial and social benefits are included in the MKBA.

3.6.1 Results of GE scenario

Table 10 gives the results for the final visions in combination with the migration path PHS first.

Table 10. Results of MKBA, figures given in millions of euros, net cash for the GE scenario. The final visions are combined with the migration path PHS first.

MKBA	Final visions		
	1: PHS	2: HRN	3: NL
Benefits			
Journey time gains passengers	1,104	1,289	1,288
Journey time gains freight	21	27	25
Reliability benefits passengers	90	159	200
Gains for operation	212	354	375
Delays for car traffic at level crossings	57	108	136
Indirect effects	191	237	247
External effects	96	115	116
Costs			
Investment costs infra	-1,418	-1,881	-2,035
Investment costs rolling stock	-363	-410	-409
Avoided investments	215	215	215
Management and maintenance infra	-278	-394	-452
Management and maintenance rolling stock	-263	-179	-169
Replacement costs	291	383	455
Balance			
Benefits	1,770	2,290	2,388
Costs	-1,815	-2,266	-2,395
Balance benefits costs	-46	24	-7
Benefit/cost ratio	1.0	1.0	1.0

A description of the effects was provided in the previous chapter. Indirect economic effects are defined as the subsequent impact of direct effects on the economy. When a project leads to an improvement of accessibility, the economy can function more effectively. External effects for this project are effects that occur with respect to the safety of the road user as a result of reduced waiting times at level crossings, and for train passengers and personnel. The result for practically all of the scenarios is an almost neutral benefit/cost ratio.

Journey time benefits. This post includes the journey time benefits as a result of run time gains, fewer waiting trains and narrower interchanges. The effects of delayed braking and continuous speed safety create the majority of journey time benefits. The effect of fewer waiting trains is also substantial. The effect of narrower interchanges (shorter transfer times at interchanges) is limited. The reason for the difference between the final visions lies in the number of passengers (runtime gains) and the focus areas in capacity (practically only for PHS). The journey time benefits for freight trains are also caused by the effects of delayed braking and continuous speed safety.

Gains for operation. This is a post comprising elements from the annual operations of all passenger train operators in the Netherlands, such as extra income and lower costs for energy, rolling stock and personnel. The variations between the final visions are explained by the effect on the number of passengers and the necessary differences in management and maintenance with respect to operators' rolling stock fleets.

3.6.2 Results of RC scenario

The MKBA was also carried out with the low economic growth scenario Regional Communities. In this scenario, the journey times are lower as a result of the lower numbers of passengers that use the trains. The costs remain the same as under the GE-scenario. The benefit/cost ratios for final visions 1, 2 and 3 are pretty much identical for the RC-scenario, i.e. 0.7. Table 11 indicates the results.

Table 11. Results of MKBA, figures given in millions of euros, net cash for the RC scenario. The final visions are combined with the migration path PHS first.

MKBA	Final visions		
	1: PHS	2: HRN	3: NL
Benefits			
Journey time gains passengers	760	884	884
Journey time gains freight	17	22	20
Reliability benefits passengers	62	108	136
Gains for operation	200	329	338
Delays for car traffic at level crossings	39	74	93
Indirect effects	132	163	170
External effects	96	115	116
Costs			
Investment costs infra	-1,418	-1,881	-2,035
Investment costs rolling stock	-363	-410	-409
Avoided investments	215	215	215
Management and maintenance infra	-278	-394	-452
Management and maintenance rolling stock	-263	-179	-169
Replacement costs	291	383	455
Balance			
Benefits	1,305	1,697	1,758
Costs	-1,815	-2,266	-2,395
Balance benefits costs	-510	-568	-637
Benefit/cost ratio	0.7	0.7	0.7

Additional analysis Level 2plus. The benefits remain identical under the ERTMS Level 2plus concept. This is under the assumption that train integrity is guaranteed for all of the rolling stock. If this is not the case, the benefits will reduce as a result of expanding capacity. The costs reduce net cash by € 300 million for final vision 2 HRN. This results in a benefit/cost ratio of 1.1 for the GE-scenario and 0.8 in the RC-scenario. With respect to the implementation of Level 2plus, there are several other uncertainties, such as development costs and risks during rollout and operation.

Additional analysis Level 1/2 mix. Both the benefits and the costs are reduced with the application of Level 1 on track sections where there is no need for capacity compared to final vision 3. The benefits are reduced as these track sections have a lower gain in terms of reliability and because no gains for waiting times (level crossings) are achieved on these track sections. The reduction of benefits (NCW) is proportionate to the reduction of costs (NCW). As a result, the benefit/cost ratio is 0.7 in RC and 1.0 in the GE-scenario.

3.6.3 Effect of OV SAAL on the MKBA results

In line with the usual method for drawing up an MKBA, decisions that have already been made are used as the departure points for the analyses to be carried out. In the cost/benefit ratio for ERTMS explained above, no benefits and costs have been assumed for OV SAAL because this has already been reported in the context of decision-making for OV SAAL. The benefits and costs of OV SAAL are, therefore, already encompassed within the 0 scenario and do not form part of the project alternatives.

Given the decision regarding OV SAAL closely corresponds with the realisation of ERTMS, a brief analysis reviewed the effect on the MKBA results if all of the costs for SAAL (for necessary infrastructure, such as 8-track facilities at Weesp and for ERTMS in rolling stock) and all of the benefits for SAAL are included.

The benefit/cost ratio of the ERTMS final visions changes for the RC-scenario from 0.7 to 1.0 for all final visions and for the GE-scenario from 1.0 to 1.3 for final visions 2 and 3 and to 1.4 for final vision 1.

3.7 Migration paths

Alongside the features of the final visions, the paths taken to reach these areso important. That is why three migration paths have been studied for one final vision, i.e. implementation of ERTMS on HRN. The three migration paths are characterised by various drivers with respect to the implementation of ERTMS, see paragraph 2.3. The results of this study also provide an indication of the significance of the migration paths for other final visions.

3.7.1 Results

The migration paths differ in terms of order (in time) of rollout and, thus, in net cash effects. Table 12 shows the results compared to an ‘average’ migration path. The differences between the migration paths are limited. The variations in score are principally caused by the number of transitions (from ATB to ERTMS) during the migration phase and the number of passengers that use the network section. The obligations that correspond to the EU context (EU compulsory corridors in 2020 and 2030) and the Preference Decision OV SAAL (2023) are fixed components of every migration path that, in combination with the efforts to connect ERTMS areas to one another (and thus prevent transitions), have a significant impact on the rollout.

Table 12. Completed scope of considerations for the 3 migration paths corresponding to final vision 2 (HRN).

Scope of considerations	Migration path		
	PHS first	Replacement first	Landsdelen eerst
Safety	0/+	0	0/-
Interoperability	0	0	0
Capacity	0/+	0/+	0
Speed	0/+	+	-
Reliability	0/+	0	0/-
Costs (Lifecycle-costs), NCW, compared to 0 scenario	2,250	2,250	2,150
Future soundness	0	0	0
Benefit/cost ratio (RC/GE)	0.7/1.0	0.8/1.0	0.7/1.0
Risks (in million €)	-340	-345	-340

Costs. Various peak moments of investment in infrastructure can explain the difference in NCW between the scenarios. The formulated migration paths can only slightly limit the huge replacement task in the first decades. As a result, the difference between migration path 'Replacement first' and the other migration paths is limited.

Risks. The absolute differences in risks in terms of costs and monetarised benefits between the migration paths are minor. The primary risk that has been inventoried and monetarised relates to structural delays of two years at the beginning of the project. These could be caused by problems during the implementation of ERTMS as a result of unacceptable failures due to teething problems. The migration paths show a limited difference in the effects hereof.

3.8 Risk profile scenarios

The national implementation of a new train protection system is a vast and complex task. Manageability of the risks is vital in order to realise goals and prerequisites, both during the implementation phase and within the final situation. As a result, during the Exploratory Phase, two types of risk analysis were conducted on the basis of interviews and brainstorms, i.e. quantitative (risk profiles around scenarios) and qualitative in relation to the wider project. Stakeholder discussions also highlighted more operational and management risks, as indicated in annex C. Chapter 5 provides further information about both types of risk analysis.

The quantitative risk analysis was conducted for the purposes of evaluating the favourable scenarios. Risks are inventoried and quantified herein. The inventoried risks in relation to the estimate of the costs and the corresponding risk profile are included in the estimate of the costs itself. Alongside these risks, there are also risks in relation to planning, benefits and decision uncertainties. Decision uncertainties are risks that could result in the scope of the project changing during implementation.

Table 13 shows the effects of the risks (likelihood x consequence) for the benefits, costs and benefit/cost ratio. In the risk analysis, a distinction has been made between planning uncertainties, uncertainties in relation to benefits and in relation to costs. The results provide an 'average' for all risks; it is possible that there could be a more substantial (negative) effect if several risks occur simultaneously.

Planning uncertainties. These relate to delays/standstills in the beginning of the project and structural delays (particularly caused by infrastructure). Causes in this context could cor-

Table 13. Results of sensitivity analysis risks on MKBA results GE-scenario. Amounts are given in millions of euros.

Risk	Final visions		
	1: PHS	2: HRN	3: NL
Planning uncertainties			
Effect balance benefit/cost NCW	-290	- 340	-350
Effect on benefit/cost ratio	-0.15	-0.14	-0.14
Uncertainties benefits			
Effect benefits NCW	+/- 410	+/- 510	+/- 530
Modified benefit/cost ratio	+/- 0.23	+/- 0.23	+/-0.22
Uncertainties costs			
Effect costs NCW	+/- 500	+/- 650	+/- 700
Modified benefit/cost ratio	+/- 0.21	+/- 0.23	+/- 0.23

respond to teething problems and ineffective organisation and/or collaboration. The effects lead to late delivery and, as a result, a longer net cash value for benefits and (partially) costs.

Benefit uncertainties. These relate specifically to the use of capacity gains for the purposes of journey time gains and/or gains in reliability. There are also uncertainties with regard to the first phase of rollout or teething problems. These uncertainties could lead to no or lower benefits being generated in the initial period. One other uncertainty is the feasibility of capacity gains at large sidings.

Cost uncertainties. The above table indicates the 90% reliability interval of the estimates. This means that there is 90% certainty[33] that the actual costs will fall within the bandwidth (given the current insights and departure points). The chance that actual costs will lie above the interval is 5% and that they will lie below the interval is also 5%. The upper limit of the interval is applied in the sensitivity analysis of the MKBA in relation to costs. The risks that determine the reliability interval also relate to the GSM-R market prices and further lock-ins for various elements, developments in interlockings and RBCs and measures in the context of sound, vibration and energy provision.

Decision uncertainties (not quantified). In the risk analysis, there are two primary risks for this aspect: changing the design and execution choices and a lack of financial coverage and/or insufficient clarity about risk distribution. During the process, parties can create/amend design rules and the costs and/or pace will change as a result. The lack of financial cover and/or insufficient clarity about the risk distribution relates to a political decision. The effect of this has not been quantified.

Additional analyses of Level 2plus and Level 1/2 mix. Level 2plus is a less 'mature' system than Level 2 or Level 1. In order to realise this system, additional development (to Level 2) is required but it does offer further opportunities with respect to reliability and cost reduction. The necessary, additional developments mean that Level 2plus corresponds to further planning uncertainties.
The risk considerations for ERTMS Level 1/2 mix have shown that this alternative relates to more uncertainties in relation to realisation, management and maintenance costs and benefits than ERTMS Level 2. This is specifically the result of having to design, manage and maintain more, different systems, interfaces and transitions.
As indicated, chapter 5 will also discuss the quantitative risk analysis and provide an overview of the most important risks.

[33] In the SSK-2010 indicated as 'fulfilment certainty'.

4 Opportunities, risks and focus areas for the Preference Decision and Plan Elaboration Phase

The results of the studies into the favourable scenarios form an important basis for the Preference Decision. There are, however, other issues that impact upon this decision. In addition, there are aspects of the implementation of ERTMS which must be considered in the coming phase. This chapter discusses these other aspects.

4.1 Input and involvement of stakeholders

An important mainstay in the creation of an ERTMS project is the involvement of stakeholders. The application of ERTMS will lead to changes across the entire railway sector and many different parties therefore have an interest in ERTMS.

Three rounds of discussions and meetings with stakeholders

In 2013, two exploratory rounds of discussions and meetings took place with interested parties (stakeholders). This process encompassed one round in spring, one at the beginning of summer and another round in autumn 2013. The aim of the first round was familiarisation with and an explanation of Railway map 1.0. During the second round, the results of Railway map 2.0 and Knowledge Book 1.0 were presented. The aim of this round was to gauge reactions to both documents and set up the subsequent process regarding the Preference Decision and the Plan Elaboration Phase. The results of these discussions and meetings were, where possible, included within Railway map 2.0 and were presented in full in annex C provided with Railway map 2.0. On the day that Railway map 2.0 was sent out (3 December 2013), Railforum organised a workshop during which Knowledge Book 1.0 was presented and discussed in sessions.

This stakeholder management process continued in the period up to the Preference Decision. At the beginning of 2014 (February to March), discussions took place and meetings were held with various stakeholders regarding the content and progress of the project, the Preference Decision and further collaboration with respect to the relevant stakeholders or stakeholder groups. The agenda points focussed on the interests of the specific stakeholders. The project team paid special attention to the study results when it comes to capacity, because the meetings highlighted that this was the issue that most readily affects the stakeholders. A separate workshop was thus organised regarding the capacity analyses for the decentralised authorities, the operators and ROVER.

After this workshop about the capacity analyses that had been conducted, the following discussions/meetings took place:

- KNV and ERS Railways
- LOCOV (Rover and LSVb)
- FMN parties (Veolia, Arriva, Connexxion en Syntus[34])
- Decentralised authorities (provinces, urban regions and regional cooperative partnerships)
- Unions FNV, CNV and VVMC
- Railway maintenance companies
- Historical Railway transport in the Netherlands (Historisch Railvervoer Nederland)
- Keyrail
- Mitsui

[34] Syntus in this phase is represented via Arriva.

Annex C contains a full overview of the input from stakeholders in relation to the ideas pertaining to the Preference Decision, the Plan Elaboration Phase and collaboration. The input from earlier discussions and meetings has not been included in the overview again but will be used, where relevant, for further elaboration.

Meticulous process

The input of stakeholders has been closely tied into the realisation of the Preference Decision. The stakeholders also play an important role in the further elaboration and the rollout of ERTMS. The input is vital for the quality of studies, the execution of (parts of) the (technically complex) content and integral consideration of the options. Their contribution is also important in terms of promptly inventorying and mitigating risks and highlighting focus areas in order to monitor the progress of ERTMS.

In all discussions there was clear appreciation of the meticulous way in which the ERTMS project deals with the interested parties by preparing and carrying out discussions as a follow-up to earlier contact. The stakeholders are very positive about the implementation of ERTMS and would like to see it realised as rapidly as possible. They have provided advice and identified specific focus areas and demanded that attention is paid to risks and opportunities that correspond to the implementation of ERTMS. The main points of the results of the Exploratory Phase have been discussed with stakeholders. The definitive Preference Decision and the consequences thereof for stakeholders, have not yet been discussed.

The contribution of ERTMS to regional accessibility is important to decentralised authorities, as is the link with already planned investment projects. The effect that ERTMS has on regional concessions is important for the authorities that issue the concessions. The regional operators would like to hold discussions about costs (distribution), the withdrawal of rolling stock, options for pilots, risks and opportunities. Continuing involvement is important for the consumer organisation, particularly when it comes to passenger interests and the consequences of actual ERTMS implementation (also during the refurbishment period). The unions have an interest in collective user discussions during which attention is paid to working conditions and the exchange of experience. The timetabling authority must also be involved herein.

Involvement in Plan Elaboration Phase

The line of contact used for stakeholders will be continued and reinforced. Stakeholder management has so far had an informative and (minor) consultative role as a result of interim updates and the request for focus points. The result is a comprehensive overview of focus areas, risks and advice. In the Plan Elaboration Phase, monitoring these points in the broader ERTMS programme organisation and ensuring feedback is provided to stakeholders will become fundamental elements. Involving stakeholders in the sub-projects, for which Prorail and NS are also responsible, will become an important task in the forerunner phase. It has also been agreed with the stakeholders that they will be structurally involved in the Plan Elaboration Phase, after the Preference Decision, with regard to the topics relevant to them.

In order to substantiate the collaboration, various points have already been defined, see annex C. Once the Preference Decision has been made, a work conference will be held during which the content of the decision and the follow-up process will be explained. In the context of the Major Project Status, six-monthly reports will be provided on the progress of stakeholder involvement.

4.2 Experiences and state of play abroad

The Dutch implementation of ERTMS will include experiences from abroad. In the past, other countries have learned from pioneering work in the Netherlands, with the Betuwe-route and the HSL-Zuid. This leading position has now been taken on by other countries. In some of these countries, the plans for the large-scale rollout of ERTMS and the execution thereof are further advanced than in the Netherlands.

Of these European countries, Luxemburg (ready 2017), Belgium (ready 2022), Switzerland (starting with Level 2 from 2018) and Denmark (ready 2021) have already decided to carry out national implementation of ERTMS. Other countries, such as Norway (ready 2030), Sweden (ready 2030) and the UK (ready 2045) have the same ambitions but are applying a slower pace. Countries such as Germany, France, Spain and Italy are starting in a more limited fashion by initially focussing the implementation of ERTMS on the international compulsory corridors and/or high-speed corridors. Denmark and Belgium, given the respective efforts on Level 2 and a mix of Level 1 and 2, are most relevant for the Netherlands.

During the Exploratory Phase, there was intensive contact with the project and management organisations of Denmark, Belgium, Switzerland and Italy. Numerous working visits have taken place, enabling valuable research information to be shared with the Netherlands. Additionally, foreign consultants with experience in ERTMS projects abroad have been involved in creating or verifying studies.

After the Preference Decision, contacts with other countries will be continued in order to make the best use of one another's learning experiences. The discussions with Belgium and Germany will be continued in order to ensure the ERTMS implementation strategy in the Netherlands connects in as effectively as possible to the implementation strategy in the neighbouring countries. The Anker/Mastwijk[35] motion will also be considered herein.

Below, you can see the state of play of implementation and tendering for ERTMS[36] in countries outside the Netherlands. The European Commission also provides information regarding the latest state of play with regard to implementation of ERTMS in Europe. On 14 February, a working document[37] was published with recent information about topics such as the TEN-T corridors, possible financing constructions and challenges.

Belgium

Since 2002, the Belgian infrastructure manager Infrabel has had a plan for the broad implementation of ERTMS, which was originally exclusively focussed on ERTMS Level 1. The accident near Halle in February 2010 which resulted in 18 deaths led to a parliamentary investigation which, in turn, led to a decision to implement ERTMS more quickly.

On 19 December 2011, Infrabel and SNCB presented their collective Masterplan ETCS to the Belgian parliament. According to this Masterplan, TBL1+will be implemented nationally until 2015; this will rapidly increase safety levels. After this, a mix of ERTMS Level 1 and Level 2 will be rolled out by 2022. This will result in 3,300 km of ERTMS Level 2 on the most important lines, 1,200 km of ERTMS Level 1 and 2,400 km ERTMS Limited Supervision on Secondary lines by 2022. After 2025, only trains that are fitted with ERTMS will be able to use the Belgian railway network. The task of implementing this national rollout is currently out to tender.

[35] Parliamentary papers II, session 2009-2010, 32351 nr. 8

[36] This substantiates the pledge as given in the AO ERTMS/safety of 22-01-2014

[37] http://ec.europa.eu/transport/modes/rail/interoperability/ertms/edp_map_en.htm

Similar to the situation in the Netherlands, Belgium is also having to replace outdated interlocking systems. The Belgian infrastructure manager Infrabel would like to phase out old relay technology within 20 years. The replacement of detection systems is also an issue within the Belgian implementation of ERTMS. Belgium is assuming that electronic interlocking will be necessary for ERTMS Level 2 and that it will be possible to remove the exterior signals. According to Infrabel, traditional relay interlockings will suffice for Level 1. Exterior signals are necessary with Level 1.

As a result of this subdivision, Infrabel has arrived at a total forecast investment sum of circa € 2 billion, around € 0.08 billion of which is for ERTMS infrastructure and € 1.2 billion of which is for interlockings, signals and GSM-R upgrade. This excludes the installation of ERTMS in trains and the acquisition of new trains with ERTMS (circa € 1.7 billion). The justification of this amount is elaborated in the Belgian Masterplan ETCS from 2011.

In January 2012, as part of its Masterplan, Infrabel awarded delivery of ERTMS Level 1, including maintenance for 15 years, to Alstom and Siemens. In order to allocate the task in relation to ERTMS Level 2, a public European tendering process in the form of a negotiation procedure with prior notification, has been commenced. The tender encompasses Design, Build and a partial Maintain components. This tendering process has not yet been finalised.

Denmark

In Denmark in 2006, a decision was made to completely replace the signalling system. An important reason for this was that 50% of the current delays on trains were caused by failures in the signalling system. Moreover, 60% of the system would have to be replaced within 15 years in any case. In the years up to 2006, work took place on a programme of complete modernisation: there was a review of the estimate of costs, organisation, tendering strategy, experience elsewhere, etc. In 2009, the decision was made to move towards the realisation of ERTMS Level 2 across the entire network, costing an estimated € 3.2 billion[38].

In 2012, the contracts were awarded for four large areas: one for the eastern network, one for the western network, one for the refurbishment of rolling stock and one contract for the new system on the S-bane in Copenhagen. The contracts for the national railway network involve the complete design, manufacture and delivery of ERTMS Level 2 components and interlockings combined with track installations and a traffic management system. The maintenance service is, in principle, contracted out for 25 years.

The rolling stock will be refurbished first in order to prevent overlay in the infrastructure as far as possible. In 2017 and 2018, two 'early deployment' lines will be laid, followed by the most important lines in the period up to 2020 and the secondary lines up to 2021.

In the Maturity Study that was sent to the House of Representatives with Railway map 2.0, the researchers concluded that "the tendering phase in Denmark was regarded as a complete success because, as a result, all four tendering areas were realised with a significantly lower price than budgeted and prices per unit were lower than had been offered by the industry up to that point. Despite the high complexity of the tendering process, this phase was also finalised more or less on time." This study provided eight success factors that had been applied in order to successfully complete the tendering round in Denmark. These relate to issues such as the size of the tendering areas, avoiding national requirements, functional specification, a good/realistic risk distribution between parties, and so on.

[38] The estimated costs for replacing train protection with ERTMS amount to € 2.4 billion. With a risk margin of 30%, this comes to € 3.2 billion. This involves integral costs, not just hardware, software and On-Board-Units, but also costs for design, project management, interface management, implementation, safety certification and all other costs that are incurred for the entire safety system modernisation programme.

Luxemburg
Luxemburg has ERTMS Level 1 across the whole country. From 2017, all of the rolling stock must be equipped with ETCS. The passenger train operator's total fleet, over 100 trains, has now been tendered out for a total amount of circa € 30 million.

Switzerland
In Switzerland, ERTMS will be implemented as a result of the replacement task for the national system, improvements in interoperability and the optimisation of timetables via improvements to railway capacity and journey time. The rolling stock will have to be fitted with ECTS Baseline 3 by 2017 at the latest. The railway network will first be equipped with ERTMS Level 1 Limited Supervision overlay and then, from 2018, the network will be refurbished for Level 2 Only. A number of busy lines have already been equipped with ERTMS Level 2, e.g. the Bern-Olten route and the Lötschbergtunnel. In the Lötschberg-tunnel, the capacity is used effectively by combining Level 2 with advanced traffic control and disruption management. The Gotthard-corridor and the Rhonevallei will be fitted with ERTMS Level 2 in the near future. In terms of rolling stock, all 500 trains have already been fitted with ERTMS. As a result of several safety incidents, the federal government ordered the rollout of the original ERTMS programme at an accelerated pace.

Italy
In Italy, ERTMS is operational on most sections of the high-speed route Turin-Milan-Bologne-Florence-Rome-Naples. Around 670 km have been fitted with ERTMS Level 2. At the moment, the focus lies on refurbishing the High-speed corridor Florence-Rome to ERTMS and fulfilling the TEN-T requirements on the freight corridors. ERTMS Level 2 is installed when new lines are being laid. Italy is also starting an ERTMS pilot on a conventional line. The aim of this is to develop specifications, parameters, special functionalities and tests with trains in order to be able to roll out ERTMS in a uniform fashion throughout Italy at a later date.

Germany
In 2013, Germany decided to introduce ERTMS to the country on the Rotterdam-Genoa corridor. The German government chose implementation via a combination of ERTMS Level 1 Limited Supervision and/or ERTMS Level 1 Limited Supervision. As a result of the phasing of the current protection systems (LZB), this system will be replaced by ERTMS Level 2 on various routes in the mid 2020s.

Sweden
The Swedish Transport Plan will be presented for approval to parliament in 2014. This assumes a national rollout of ERTMS in 2030. In Sweden, there are two lines that have been fitted with ERTMS. In 2017, the installation of ERTMS on existing connections between Stockholm and Malmö will commence. In 2014, Sweden will commission a trial track, where the transition ERTMS Sweden 2.3.0d - ERTMS Denmark baseline 3 will be copied. This test location is to prepare for the commissioning of the future ERTMS connection Malmö-Copenhagen (laid from 2017). Sweden has also equipped a quiet, separate route with ERTMS Regional; this is an initial application of ERTMS Level 3.

Norway
In Norway, at the end of 2012, a decision was made to replace the entire signalling system with ERTMS. Just like Denmark, Norway has a protection system that is rapidly becoming outdated: in 2019, over 50% of the system is up for replacement. Moreover, the current system will soon no longer be available. As a result, the number of failures will increase and, in the long-term, the safety level will reduce. In the run up to the national rollout, in 2006 a decision was made to create a pilot; in 2011, the installation of ERTMS in this track was approved and the pilot must be operational in 2014. The first test runs have now taken place successfully. From 2014, a start will be made on the national rollout of ERTMS Level 2;

this will take account of experiences gained during the pilot. In 2030, the entire network must be fully equipped.

United Kingdom

In the UK, ERTMS Level 2 has been operational since March 2011 on the Cambrian line in the west of the country. To the north of London, at the end of 2013, the ETCS National Integration Facility was taken into use; this is a route of 8 miles (12.8 kilometres) where the performance and compatibility of the ERTMS systems from various suppliers can be tested. The lessons learned from the implementation of ERTMS on these lines will be used for the lines that will be equipped with ERTMS in the coming years: the Great Western Main Line (GWML) with Level 2 overlay, part of the East Coast Main line with Level 2 and a number of major lines around London (Thameslink London and Crossrail). As a result of the overlay situation on the GWML, work is taking place with suppliers of the current interlockings. For the other lines and the lines that will be rolled out in the future, the best marketing strategy for ensuring healthy competition is currently being sought. In the UK, there is also a need for capacity, and automated traffic control and disruption management around sidings is being seriously considered.

Spain

In Spain, a large part of the high-speed network has already been equipped with ERTMS Level 1 and Level 2 (1600km) and, in the coming years, other high-speed lines (900 km under contract) will also be equipped. Some of this is currently equipped with Level 2. Spain is interesting because the onboard units from 5 different suppliers are all suitable for the ERTMS infrastructure of 6 different suppliers. Spain has conducted many tests with concepts such as Level 2 and, as a result, has learnt a great deal in relation to testing in a laboratory setting and communication reliability tests.

4.3 Knowledge Book 2.0

In order to ensure a well-informed decision is made about the implementation of ERTMS, it is important that the decision information is based on facts. With any technology that is still under development the facts are often ambiguous and hard to define. In order to achieve a level playing field regarding the technical (im)possibilities of ERTMS and the goals that correspond to the introduction thereof, the Railway map parties have developed an ERTMS Knowledge Book that provides insights into this area.

The ERTMS Knowledge Book 1.0 was published as an annex to Railway map 2.0. In addition, stakeholders and market parties were asked to come up with comments or criticisms of Knowledge Book 1.0 and thus hone and supplement the presented expertise. A workshop was also held in collaboration with Railforum.

In total, around 100 comments were collated. These provided more subjective information regarding the Knowledge Book and suggestions for new topics. Comments concerned, for example, the passages on level crossing safety, the number of market parties that can install ERTMS and ATB and options for increasing capacity. New topics included transitions, law and regulations and energy consumption. The comments also sharpened up the topics already covered. The comments have been included in ERTMS Knowledge Book 2.0 as far as possible; this also contains new topics.

Further analyses have also been conducted with regard to a number of focus areas that were formulated on the basis of Knowledge Book 1.0. These analyses aim to provide further insights into corresponding uncertainties. The analyses comprise, on the one hand, an analysis of the technical aspects and comparable applications in train and metro and, on the other hand, a short market inventory of infrastructure managers and market parties.

Focus area: GSM-R and sidings
The application of Level 2 on sidings is an option but, in practice, has not yet been realised. Comparable applications have been realised in Metro situations. For the successful application of ERTMS on sidings, there are two important focus areas:

- The capacity of the current generation GSM-R for large sidings is approaching the capacity requirement for ERTMS. The application of the new generation mobile communication systems that are under-development could accommodate any capacity problems.
- Further harmonisation of (sub)systems of ERTMS and operational rules are necessary for the application of ERTMS Level 2 on sidings. This particularly concerns specific procedures such as disconnecting and shunting. This could be accommodated by initially starting with smaller sidings and then continuing the development (of expertise) in a step-by-step fashion.

Focus area: Capacity effects
A review has been conducted of what is necessary to realise follow-up times of two minutes with the implementation of ERTMS. The current norms for follow-up times are three minutes (rule of thumb). Analyses have indicated that:

- The application of ERTMS Level 2 on the existing track sections could have a positive effect on follow-up times and, in turn, track section capacity. The actual capacity return depends on specific situations.
- The follow-up time gain from ERTMS Level 2 only (without block compression) with application on existing track sections is insufficient to realise follow-up times of two minutes on the free track.
- The realisation of follow-up times of two minutes on existing free track with ERTMS Level 2 also requires the application of one or more measures from the ProRail Short Follow-ups (Kort Volgen) Toolbox[39]. Block compression is a primary measure but other measures from the Toolbox could also be applied. A (commercial) economic analysis must be conducted to this end.

Focus area: Application of ERTMS Level 3
A review was also conducted of the developments that are underway for ERTMS Level 3, both at home and abroad. Track-bound train detection is no longer required with ERTMS Level 3 and this is expected to have a positive effect on investment costs, reliability and costs of management and maintenance. The analysis provided the following conclusions:

- There are two main focus areas with respect to further development of ERTMS Level 2 and Level 3, these are:
  - guaranteeing train integrity;
  - start-up after system failures.
- In order to resolve these focus areas, further development must take place.
- The current focus of development with respect to ERTMS Level 3 lies on ERTMS regional (ERTMS Level 3 variant for local railway lines with low train intensity).
- Estimates indicate that it will be at least 2025 before the application of Level 3 can be realised on an operational track section. This is even later for sidings under Level 3; the development time for a reliable ERTMS Level 3 application on free track is estimated at 8-10 years,
- Initiatives for this have not yet been implemented and commitments from the parties involved (infra management and operators) are vital in this regard.
- The development of ERTMS Level 3 could be accelerated by developing the initiatives for Level 3, developing solutions for expected issues and making the important design choice with other interested countries.

[39] ProRail has combined the measures to reduce follow-up times under the name 'Kort Volgen Toolbox', see second opinion Kort Volgen for the IenM, dated 12 July 2013. The Kort Volgen Toolbox contains around 40 measures with which follow-up times can be realised.

Focus area: Application of ERTMS Level 2plus
Level 2plus can be regarded as an interim step towards Level 3. It combines train detection with information from the train itself (auto-localisation) and track-bound detection. For the time being, Level 2plus is only a concept; experience is yet to be gained. The analysis examined the feasibility, developments and applicability of Level 2plus and provided the following conclusions:

- ERTMS Level 2plus can offer extra capacity for trains that can guarantee their integrity, without the application of track-bound detection.
- Level 2plus is interoperable; additional operational rules could well be necessary.
- ERTMS Level 2plus is a good method for a controlled transition from ERTMS Level 2 to Level 3.
- During the development of Level 2plus there will be the same focus areas as for the development of Level 3 (train integrity and start-up after system failure).
- For the application of Level 2plus, Level 3 must be developed on track sections. The developments could be combined. ERTMS Level 2plus is expected to become a component of the last step towards the introduction of ERTMS Level 3, which is expected for track sections in 2025 at the earliest.

The analyses have been added to the ERTMS Knowledge Book version 2.0. The Knowledge Book has been provided as an annex to this Railway map ERTMS version 3.0.

Experiences with the Knowledge Book are such that, depending on the results of research and information in the Plan Elaboration, a subsequent version can be drawn up.

4.4 ERTMS Dual Signalling Amsterdam-Utrecht pilot
The implementation of ERTMS means a substantial change compared to the existing system, not only with respect to technology. The necessary expertise and working methods of train drivers, timetable authorities and maintenance teams will all have to change. One of the conditions that correspond to the implementation of ERTMS is that passengers and freight transporters encounter as little inconvenience as possible in relation to the rollout of ERTMS. The pilot is intended to provide learning experiences. In order to gain further experience with ERTMS in practice and to ensure the implementation runs smoother as a result, IenM tasked ProRail and NS in 2012 with collaborating with freight transporters on an 'ERTMS Dual Signalling' pilot on the Amsterdam-Utrecht route.
During the pilot, freight train operators, contractors, NS HiSpeed (with six ICEs) and NS (with ten refurbished SprinterLightTrains(SLTs)) will run under ERTMS on the specific track section. The railway sector can thus use the pilot to investigate experiences of driving under the ERTMS protection system on a busy track section where the current protection system (ATB) is also in use. This situation is referred to as 'Dual Signalling'. Driving a train in a situation where two systems function simultaneously is new for the Netherlands. The routes that will be equipped with ERTMS from 2016 will ultimately be equipped with ERTMS ('only') however, during the migration period, there will be situations with Dual Signalling. That is why it is important to test and gain experiences in this context.

ERTMS and Dual Signalling exams will be taken in the meantime. Freight train operators, contractors and NS HiSpeed will gain a great deal of experience during the pilot. Test trips with the SLTs have confirmed that these trains work effectively under ERTMS. There was an expectation that the refurbishment would have no consequences for driving in ATB. During the use of SLTs, however, a number of unexpected technical problems came to light. These must be resolved before these SLTs can be used in timetables. These learning experiences from the pilot are of huge value in terms of the elaboration of the tendering documents in the Plan Elaboration Phase and the formulation of contractual obligations for suppliers. The ERTMS-pilot thus contributes towards gaining more experience and building up expertise on the many aspects of ERTMS:

- making ERTMS operational;
- the impact of ERTMS and dual signalling (ERTMS and ATB) on accessibility, operational reliability and risks;
- the way in which drivers deal with dual systems in the cabin;
- speed increases;
- refurbishment of rolling stock to ERTMS;
- (simplification) of access to the national network;
- training, training materials and experiences of driving personnel and timetabling managers;
- new operational rules;
- maintenance and failure organisation;
- impact on quality of services for the passenger and freight transporter.

A research programme for the pilot has been set up with practical research questions that must have been answered by the end of the pilot. These will provide useful information for the elaboration and realisation of ERTMS.

4.5 Input from market parties

After the first plenary market information meeting in July 2013 and the individual discussions that followed (reported in Railway map 2.0), a second plenary meeting was held with market parties at the end of October 2013. The market parties were then informed about the results of the studies and scenario analyses from Railway map 2.0. Questions were put to the market parties with regard to the Memorandum on Alternatives (Railway map 3.0). These questions related to the installation in rolling stock, sidings and the ongoing development of Level 2 to Level 2plus or Level 3. This latter corresponds to the fact that suppliers in the first market information round indicated that they have a great deal of confidence in the development of Level 3 and therefore advised the use of Level 2, at least.

The parties responded in writing to the questions. Of these, five were suppliers, four were engineering bureaus and one was a railway contractor.

The most important learning areas from the second market information round are:

Installation into rolling stock:
- Ensure there is standardisation of the installation and homologation process[40] for each rolling stock variant.
- The time that is required for the installation period for rolling stock primarily depends on the size of the rolling stock fleet and the options to temporarily take rolling stock out of action and reduce the industry's capacity.
- Many market parties noted that the market for STM-ATB-EG in the Netherlands is dominated by two suppliers. It would seem difficult, therefore, for a new supplier to build a positive business case, certainly if the time for Dual Signalling is limited, the costs are high, development time is long and the risk of losing the tender is also high.
- The market parties are divided about the need and/or usefulness of providing a universal STM[41].
- There are various estimates of the period required for the installation into rolling stock in terms of installation per rolling stock variant and for the entire Dutch fleet.

[40] Homologation is the entire procedure that is required to be granted access to the railways and within which evidence must be provided that there is fulfilment of the rules and conditions set in the context of EU and national legislation

[41] Specific Transmission Module

Sidings:
- The market parties indicate that Level 1 on sidings corresponds to 'proven technology' and that Level 1 can be integrated with existing interlocking technologies, even on sidings.
- The challenges on sidings for Level 2 lie with the capacity of GSM-R and RBC, in particular.
- A number of parties have indicated that the transfer to GPRS (instead of the current Circuit Switched) in GSM-R on sidings is vital in order to incorporate the larger sidings under Level 2. Other market parties indicated that this is not necessary.
- The issue of shunting creating complexity and error sensitivities in the system has to be resolved.
- In Level 3, complexity is increased as a result of trains providing their locations to track-side systems via auto-localisation instead of track-bound detection. This means that certain modifications must be made in system architecture, including VPT process systems.
- In Level 3, the fact that trains could collide on a siding if their systems are switched off is regarded as a risk. Management measures must be taken in this regard. The accuracy of the odometry is also a point that needs to be investigated.

Ongoing development from Level 2 to Level 3:
- Market parties are not unified as to when they believe Level 2plus and/or Level 3 will be available for the Netherlands.
- To the question regarding the need for developments, the market parties provided a range of responses.
- Laboratory tests and the need for a large sales market are noted as critical success factors.
- The responses to the issue of possible risks also lacked uniformity.

The report of the second market information round can be found in annex B. In the Plan Elaboration Phase, particular attention was paid to the issue of sidings.

4.6 Tendering factors

The two informal market information rounds that were held in the Exploratory Phase were not only intended to inform market parties about the progress of the project, but also to invite them to provide their visions of the development and implementation of ERTMS in the Netherlands, in preparation for the tendering and contracting strategies.

Once the Preference Decision has provided further clarity about the scope of the programme, in the coming phase a more detailed market analysis can be conducted and the tendering and contracting strategy can be elaborated. The cost estimate will also be regularly updated and elaborated in more detail, taking into account the areas to be tendered and cost and technological developments. The core of the tendering strategy, given the features of the market and the ERTMS product, is to create market tension and scale advantages in order to arrive at the best price/quality ratio for the implementation of ERTMS. The elaboration of the tendering and contracting strategy means, among other things, that a decision will have to be made regarding how many tenders will take place, how many and which areas each tendering round will encompass, whether the tendering form will be selected per tender, whether the task will cover Design and Build only or whether Maintenance and Finance will also be included, to what extent the question is specified and how the financial risk coverage will be divided between the client(s) and principal(s). These choices will be made on the basis of a detailed market analysis conducted within the Plan Elaboration Phase.

The implementation of ERTMS concerns not only a change to the railway infrastructure but also a substantial ICT component. This requires flexibility in terms of tendering. The time it takes to implement ERTMS in the Netherlands is expected to be longer than the lifetime of individual ICT components. For this reason alone, new (software) versions must be monitored during the rollout. Technical updates and improvements in the systems that are interesting for the Dutch situation will also be created in that period. Both aspects mean that, at the current time, it is not possible to ascertain exactly which (ICT) technologies will ultimately be implemented. In the tendering and contracting strategy, a choice will be made as to which technologies will be implemented. This will also include the way in which as much flexibility as possible is included within tendering and, ultimately, contracting.

The studies that have been conducted for the purposes of the Memorandum on Alternatives have shown, among other things, that a thorough and intelligent tendering strategy could realise scale advantages and that the risks of vendor lock-in can be mitigated. The reviews of the research also highlight the fact that costs have been estimated conservatively, resulting in opportunities for 'getting more for less'. It is important that these results are further investigated. To this end, in the Plan Elaboration Phase, the experiences of other countries will be further analysed and follow-up research will be conducted into optimising the question, see also paragraph 4.2. Market parties will be consulted about this.

Railway map 2.0 indicated that a number of tendering forms would be further elaborated in order to evaluate their added value. This included the negotiation procedure with notification and a public or non-public tendering procedure with or without the application of integrated contract forms and/or 'best value procurement' elements. These tendering forms connect into an important lesson from Denmark, where tendering with a negotiation phase was the chosen option. This allows the question specification to be clarified and adjusted during the negotiation phase so that interested parties can provide a 'Best And Final Offer'. On the grounds of the new European tendering guideline[42] (which is expected to be implemented as part of the Tendering Act in mid 2016 and which will thus also apply to the tendering process that will take place from then on for ERTMS), there is also an option to opt for innovative partnership. This form also offers a certain degree of freedom in terms of the question specification not being entirely fixed in advance. This new procedure will also be further investigated in the coming phase with respect to added value for ERTMS.

The expertise and know-how that has been accumulated as a result of the Betuweroute, HSL-Zuid, the Hanzelijn and Amsterdam-Utrecht within IenM, ProRail and NS will also be utilised for all aspects of the market strategy. Experiences from abroad will also be put to good use. One of the most important lessons from Denmark, in particular, is that careful preparation whereby market parties are consulted on a regular basis, is very important for successful tendering. During the development of the market strategy, an update to the market scan will therefore be conducted and market consultations will be held.

4.7 Rolling stock

Railway map 1.0 established the departure point that rolling stock must be refurbished first. As a result, operators are faced with costs before benefits, as indicated in paragraph 3.5. There is some uncertainty, therefore, as to whether the concession holder that installs ERTMS will also have the concession at the moment that ERTMS is implemented on the track sections in his concession area. This is why it is vital to make agreements with operators regarding costings for the refurbishment of rolling stock.

[42] Directive 2014/25/EC from the European Parliament and the Council of 26 February 2014 regarding the allocation of tasks in the water and energy sectors, transport and postal services and concerning withdrawal of Directive 2004/17/EC

Besides this, on the basis of meetings with the operators, a latest date must be agreed on which all of the rolling stock that is driven on the Dutch railway network will be fitted with ERTMS. This will also be set out in operator concessions and in regulations.
In terms of rolling stock refurbishment, the most recent baseline 3 is the obvious choice because the European TEN-T subsidies are exclusively available for this version.

With the implementation of ERTMS in infrastructure and rolling stock, speeds of over 140 km/h will become possible at locations where the infrastructure is suitable for this. A House of Representatives aim, stated in various motions, is thus being fulfilled, see also annex A.

So far, there has been talk of complex procedures for rolling stock acceptance. This raises the costs for the installation of ERTMS. European legislation sets out the context for certification but IenM and ILT have numerous options therein for simplifying the current rules for allowing rolling stock to access the Dutch ERTMS infrastructure. A few options are the standardisation of ERTMS in the infrastructure, strictly adhering to the European standards when installing ERTMS in rolling stock and simulating test protocols in a laboratory setting. In the Plan Elaboration Phase, the ILT will further examine this type of option for simplifying rolling stock access within the European requirements and conditions for safety.

4.8 Speed increases to 160 km/h

Since the 1980s, there has been an ambition to drive trains at 160 km/h on the Dutch railways. Since this time, a number of routes have therefore been made suitable for this speed and NS has purchased rolling stock that can achieve it. Speed may be increased from 140 to 160 km/h on 7 routes that have already been made suitable in terms of infrastructure:

1. Amsterdam Bijlmer - Utrecht
2. Weesp - Almere
3. Almere - Lelystad
4. Lelystad - Zwolle (Hanzelijn)
5. Den Haag – Leiden
6. Leiden – Schiphol
7. Boxtel – Eindhoven

The Hanzelijn is one of the examples where increasing the speed would lead to several minutes of journey time gains. Increasing speed on this route and on the Amsterdam – Lelystad route means that the north can be better connected with the cities of the west (the Randstad).

In the summer of 2013, in the context of future soundness, a decision was made that the speed increase to 160 km/h must be implemented[43] with the ERTMS protection system. This means that ERTMS on these routes must be used in both the trains and the infrastructure. In the context of the Amsterdam-Utrecht pilot, ICE rolling stock is already being driven at 160 km/h every now and then. Other routes that are suitable for speeds higher than 140 km/h, leading to journey time gains, include the routes The Hague - Eindhoven (via HSL), Schiphol - The Hague and Amsterdam – Utrecht. The De Boer[44] motion requests that suitable trains for these routes are introduced as quickly as possible. Previously, NS has indicated similar ambitions for the Hanzelijn.[45]

[43] An important advantage of ERTMS is that is has more speed traps than the current protection system on the HRN. As a result, significant time gains can be achieved under 140 km/h. In practice, these time gains will be substantially greater than the time gains that are achieved with 160 km/h.

[44] Parliamentary papers II, session 2013-2014, 22026 nr. 440.

[45] Connecting the Netherlands, Our proposal for the passenger for 2015-2025, dated November 2011.

4.9 Governance and organisation

The governance of the Exploratory Phase for the implementation of ERTMS in the Netherlands lay with the Ministry of Infrastructure and the Environment (IenM). During this Exploratory Phase, under the leadership of the ministry, there was collaboration with ProRail and NS at a directorial level in the ERTMS governance group and at a project leader level in the ERTMS working group, supported by a collaborative structure. The various studies were conducted on behalf of IenM. Besides this, harmonisation with the wider railway sector was also sought in discussions between IenM and stakeholders and information meetings with market parties.

In the Plan Elaboration Phase, this organisational structure will change. IenM will retain the directorial role and the collaboration with ProRail and NS will be further reinforced via a collective programme team under IenM leadership. The agreements regarding this reinforced collaboration will be set out in a collaborative contract/covenant. Agreements will also be made with other stakeholders about their involvement in the follow-up. IenM will also appoint a system integrator who will coordinate and control the interfaces between the various systems (see also the next paragraph). For more information about the governance and organisation in the Plan Elaboration Phase, you are referred to the Basic Report (Annex D).

In order to continue the meticulousness and pace of the Exploratory Phase into the Plan Elaboration Phase, the ministry will provide professional support, via a European tendering process, in this new phase in the areas:

- Process and programme management
- Stakeholder and environment management
- Technical, migration and effects
- Support System Integration and ICT
- Contracting and tendering strategies and Finances
- (EU-)Subsidies

This support can help IenM equip itself with the necessary technical and tendering expertise but also support the programme organisation more generally.

4.10 System integration

An important success factor for the implementation of ERTMS is the extent to which the various systems can communicate with one another, enabling everything to work together effectively. That is why, in the Plan Elaboration Phase, a system integrator will be appointed. The system integrator will coordinate and control the interfaces between track and train, with the goal that the total system works and continues to work.

A system integrator/Chief Information Officer (CIO) will control the state of play of the programme organisation when it comes to issues such as integration and the achievement of the business case.

System integrator

The basic task of the system integrator is coordinating the operation and maintaining the effectiveness of the ERTMS traffic system (the combination of rolling stock and infrastructure). A working ERTMS traffic system is a system that fulfils the requirements when it comes to safety, interoperability, reliability and functionality. A system integrator coordinates; the implementation work is carried out by ProRail and/or the rolling stock owners.

The tasks of the System Integrator during the Plan Elaboration Phase will at least comprise:

- *ERTMS system architecture: top requirements ERTMS transport system*
  Coordination of the creation of ERTMS system architecture. ERTMS system architecture involves requirements for the initial version ERTMS baselines and follow-up versions, radio communication etc. This will take place in consultation with representatives of

ProRail and the rolling stock owners. This ERTMS system architecture is an important document in relation to the tendering process for the implementation of ERTMS. The coordination activities principally focus on issues that involve interfaces between the various involved parties and the performances of the whole chain, a working system. Coordination takes place in consultation with representatives of ProRail and the rolling stock owners.

- *Performance norms in terms of safety, interoperability, capacity, speed and reliability*
  Coordination of the creation of a plan regarding how performance norms can be fulfilled. To this end, use is made of specialist knowledge that is available from the parties involved and in the market (in order to calculate availability). Availability can be increased as a result of the redundancy of components and/or avoidance options.
- *Risk management in terms of system integration*
  Both in terms of expertise and the scope of the risks, the system integrator will make a significant contribution to risk management within his field.
- *Guaranteeing functionality*
  The system integrator will ensure that the parties concerned investigate the consequences of non-redundant components failing and having to fall back on reduced functionality. If the results of this study show that performance is unacceptably reduced, the system integrator will ensure that the parties take the appropriate measures.

This type of minimum task package will be set up by the system integrator in due course for the realisation and the operational phase too.

Possibility of using ERTMS data

The introduction of ERTMS offers opportunities for improving services on and around the railway network. Within ERTMS, structured data (e.g. location and speed) are sent to a track-side location. The information that the trains send in the context of safety can also be used for logistical processes or journey information. For this, a combination of Security and Logistics is required. This does not exclude the use of data from a safety level for the purposes of services but does imply that this can (and must) occur without the ERTMS standard having to be applied. Plan Elaboration will pay further attention to the way in which both aspects can be connected to one another. This relates, in the first instance, to the connection with the Redesign of traffic control and disruption management.

4.11 Related dossiers

The implementation of ERTMS in the Netherlands corresponds to changes for the entire railway network. In the long-term it will impact upon various tasks and company processes. There are already many interfaces with other projects and programmes within the railway sector. Further attention is paid to this in the Basic Report. The most important dossiers with which there are interfaces are:

- the Long Term Rail Agenda;
- speed and journey times (including increasing speed to 160 km/h);
- new transport and management concessions;
- the European fourth track package;
- The Programme for High Frequency Rail Travel;
- the corridors where European obligations mean ERTMS has to be implemented to various deadlines;
- the OV-SAAL corridor;
- (other) dossiers relating to (the replacement of) train protection systems such as:
- cross-border railway lines (also in relation to the Anker/Mastwijk[46] motion);
- other developments and policy desires such as the provision of new traction (3 kV instead of the current 1500V).

[46] Parliamentary papers II, session 2009-2010, 32351 nr. 8

In 2013, the House of Representatives of the States General began an investigation into the way in which large-scale ICT projects are carried out for the state government. The findings are expected to be available towards the end of 2014. This offers the opportunity to make use of possible recommendations in this study during the Plan Elaboration Phase. Moreover, a temporary investigation committee called Fyra has been installed; in the coming months/years, this will conduct research into developments that have led to intended transport on HSL-Zuid not being realised. The findings of this committee will become available in May 2015, according to current plans. Where possible, these findings will be included within the ERTMS programme in due course.

Signals along the railway network are a thing of the past with ERTMS Level 2. (Photo: Jos Braal)

5 Risks

Risk management, in relation to ERTMS, is an integrated element of the work, and is applied for the purposes of managing, estimating costs, planning and the tendering strategy. This chapter sets out the greatest risks and the most important management measures for these risks. More information about risks and risk management can be found in the Basic Report (Annex D).

Paragraph 3.8 has already looked at the risk analysis that was conducted in the context of research into the various favourable scenarios. The aim of this risk analysis was to support consideration of the various scenarios by monetarising the scenario risks. These risks have also been included as justification of the estimate of costs.

The Exploratory Phase, alongside this technical risk analysis, also examined a supplement to this risk analysis with respect to finances, planning and organisation for the Plan Elaboration and Realisation phase. This additional risk analysis was conducted at various moments in the Exploratory Phase and focuses on the process risks for the ERTMS project. Various risk sessions have been used to inventory these risks, which could threaten the planning and costs of the project, and management measures have been developed in order to tackle them.

Below, the most significant risks are indicated for the Plan Elaboration and Realisation phase. The most important management measures for these risks are also given.

1. Difficult system integration (technical and organisational)

The fact that various systems (track, track-side and rolling stock) must be integrated during the implementation of ERTMS means that there is a risk that integration is difficult and the Plan Elaboration Phase is delayed. This applies to both a technical and organisational level (governance) and is due to the fact that the mutual dependency of the various systems is high and, simultaneously, they are difficult to adjust to one another. The systems are therefore subject to change and harmonisation is tricky. Lack of coordination between the various parties could also lead to this risk.

Management measures:
- owners appointed for system integration by IenM; separate roles/responsibilities set for system integration (incl. specifications of systems and regulation of interfaces between parties). Specify authority in the covenant.

2. Insufficient interim decisions in the plan elaboration

A lack of interim decisions being made and the fact that there is too little context specification or decision-making regarding products leads to a difficult decision-making process. The result of this is that the Plan Elaboration Phase is delayed because decisions are postponed. The causes of this include the complexity of the project, the general sense of unease for politicians/managers in relation to railway projects and confusion regarding the necessary level of abstraction for products that require decisions to be made. Difficult decision-making can also create time pressures, to the detriment of quality.

Management measures:
- after the forerunner phase, draw up a detailed internal summary of the phasing of the products, including the link with the directorial group/principals' meeting;

- after the forerunner phase, provide a summary in the Progress Reports of the go/no-go moments with respect to the involvement of the House of Representatives of the States General;
- during the forerunner phase, draw up a further elaboration of stakeholder involvement.

3. Difficult collaboration as a result of new organisational forms in which various parties play an important role.

A risk for the Plan Elaboration Phase is that the collaboration between NS, ProRail and IenM does not run smoothly. This could be the result of new types of collaboration within which every organisation must find its own role. Organisations must therefore undergo a learning process. This learning process could result in miscommunication and delays when harmonising products.

Management measures:
- include in the programme plan, in the further elaboration of the forerunner phase, the collective goal per workflow; define corresponding products and work packages; set up collective plans;
- appoint a project director;
- set up a collective project location.

4. Insufficient quality and availability of personnel

As a result of the specific technical expertise that is required in the Plan Elaboration Phase, there is a risk that good quality personnel will be hard to come by. The right personnel are therefore not always available and this could lead to delays and put pressure on the quality of the products.

Management measures:
- use tendering for external capacity (technical, ICT, management support, including international involvement) for IenM for the duration of the Plan Elaboration Phase.

5. Passenger train operators procrastinate due to uncertainties regarding finance/risk distribution

As a result of uncertainties regarding financing and risk distribution between passenger train operators and IenM, the refurbishment of trains starts too late (or not at all), leading to project delays. One of the reasons for this sustained uncertainty could be uncertainties in relation to whether financing for the refurbishment is regarded by the EU as state support.

Management measures:
- discussions between IenM and operators in order to come up with binding (financial) regulations that are acceptable to all of the parties concerned.

6. Lack of competition; market parties are not challenged sufficiently in the tendering process

The competition between suppliers is insufficient due to choices by IenM, ProRail and NS within the tendering process, with higher costs and project delays as a result. This can be caused by too little attention being paid to the way in which the market is organised and utilised.

Management measures:
- conduct market scan and self-analysis of infrastructure and rolling stock for the purposes of the tendering and contracting strategy (supply and demand).

7. The risk of inconvenience for passengers and shippers during the Realisation phase

In terms of ERTMS, business must run as normal during alterations. This means that inconvenience for passengers and transporters must be kept to a minimum. During the Realisation phase, however, there could be inconvenience if the implementation strategy is not well thought through or is not executed effectively.

Management measures:
- the feasibility of the implementation strategy is tested among stakeholders;
- when elaborating plans, explicit attention is paid to the possible inconvenience for passengers and transporters, as is limiting this issue.

8. Changes to European legislation regarding ERTMS over the course of the project
The ERTMS programme runs for a long time. Over the course of the project, the environment could change as a result of external circumstances, such as changing EU legislation; the project will have to be adapted accordingly.

Management measures:
- monitor and influence the European developments in relation to the ERTMS project.

9. Advancing technological developments lead to project modifications
The ERTMS programme runs for a long time. Over the course of the project, the environment could change as a result of external risks, such as advancing technological developments.

Management measures:
- draw up an impact analysis for the changing project environment.

10. Insufficient GSM-R capacity in the case of failures on the railway network on the busy corridor and the sidings.
The current capacity of GSM-R could be inadequate if it is used more intensively. The result is that the rolling stock-track communication does not fulfil the technical requirements of ERTMS.

Management measures:
- research the facts via a pilot;
- expand capacity by developing the necessary structure.

The Havenspoorlijn uses ERTMS Level 1. (Photo: Keyrail)

6 Reviews of studies and the entire Exploratory Phase

In the run-up to the Preference Decision, a number of components from the last Exploratory phase, but also the entire Exploratory Phase, were reviewed. This chapter provides the results of a review of the cost estimates for infrastructure and rolling stock, a review of the capacity effects and a second opinion of the MKBA. The chapter closes with the results of the review of the entire Exploratory Phase.

6.1 Review of cost estimate for infrastructure and rolling stock

The estimate of costs has been externally checked by a collaboration of three parties. These three parties combine expertise and know-how within the context of ERTMS and cost estimate systems and have international experience with ERTMS cost estimates.

The reviewers of the cost estimate came to the conclusion that the scope of the estimates provided a reliable and complete overview. There was also an observation that the estimates were a little on the conservative side. The costs for non-ERTMS items such as cables, train detection, etc. are realistic, whereas ERTMS-specific elements and the maintenance costs that were included are significantly higher than can be expected on the basis of Danish experiences. The maximum effect hereof is around 15% of the investment costs for infrastructure.

On the basis of the review, there are justified arguments that could result, with respect to the current estimates, in a reduction in investment costs for infrastructure and rolling stock, as well as management and maintenance, but with an identical scope.

6.2 Review of Capacity effects

The effects on journey time, capacity and timetable stability have been checked by a foreign agency that has international experience with ERTMS.

The reviewers concluded that the effects on journey time, capacity and timetable stability, for this stage of the study, have been drawn up in a plausible manner and provide a realistic overview of expected effects. There is also an indication that the expected effects have been estimated somewhat conservatively. This is the result of the departure points that have been applied in the study and estimations, made with expert judgement, of the realisation of these effects in timetables. The reviewers expect that these effects could be greater than is currently forecast.

The review also examined the possible effects of other results if the scope of the study is further expanded. The result of this is that, despite the limited scope of the study, the benefit/cost ratio of the scenarios does not change by over 0.1.

6.3 Second opinion MKBA

The second opinion of the MKBA was conducted by the Centre of Expertise for Mobility Policy. This review only looked at the benefits and the overall MKBA system. The estimate of the costs is not covered by this review.

Among other things, there is a suggestion that ERTMS is a complex and innovative project/programme for which there is no standard approach in terms of calculating effects.

The conclusion of the second opinion on the MKBA is that, in general, the MKBA provides a good interpretation of the effects of ERTMS with respect to social costs and benefits. It

must also be noted, however, that both the benefits and costs of this complex project could change during elaboration and that the second opinion principally deals with the benefit posts.

The KiM indicates that the crucial assumption in the analysis regarding the effect on journey time gains of improved capacity in terms of runtime, must be followed up. A large element of all benefits directly or indirectly depends on the estimated effect on runtime gains. If this effect turns out to be different than predicted, this could have a huge impact upon the results of the analysis. This risk, according to KiM, is not inconceivable because runtime gains are based on an analysis of just 3 track sections. The aforementioned review of capacity effects also points to the risks of such a limited sample but finds the estimated effects plausible; according to the KiM, there are remaining uncertainties with respect to aspects such as costs and indirect effects that, in the presentation of the results, should have been illustrated with bandwidth and expanded sensitivity analyses.

The capacity effects play a significant role in determining the social benefits of the implementation or ERTMS. KiM asked whether this could be achieved in a manner other than via the implementation of ERTMS and found that this is not covered by the MKBA, given its scope.

Furthermore, the differences between the project scenarios could be greater than is currently suggested by the MKBA. Calculations used an average journey time gain per passenger, without any distinction according to motive. This distribution of motives varies, however, per element of the railway network. The impact of this could develop differently for each project alternative.

6.4 Gate-review

A Gate-review was conducted as part of the phase transfer from exploratory to plan elaboration. The aim of this review was to establish the risk profile of the decision, so that it is clear whether the project can transfer to the next phase and, if so, what focus areas must be taken forward from the previous phase. On the basis of experiences with previous large projects, the critical review must take place to ensure that it is ready for the next (MIRT) phase and where specific attention must focus during the Plan Elaboration Phase. The Gate-review is an independent, integral, amicable review[47].

The results of the research, reviews and the decision made during the Exploratory Phase are presented to a group of experts with vast experience of infrastructure and ICT projects. The Gate-review paid specific attention to scope, planning, cash, organisation and quality (including risks).

The review team discovered that there was sufficient information, of an adequate quality, and that there were enough insights in order to make a Preference Decision and start the Plan Elaboration Phase for the ERTMS programme. The review team made a number of recommendations with respect to the project's Plan Elaboration Phase. They also recommended a programme-based approach with a forerunner phase with continuing direction provided by IenM and asked that attention is paid to top risks, a thorough plan of approach and fully integrated agreements with at least NS and ProRail. These recommendations will be followed up.

[47] This involves independent experts working at the Ministry of Waterways and Public Works, ProRail, NS Hispeed, the Municipality of Amsterdam and self-employed experts.

Annexes

Annex A
Summary of motions

ERTMS motions			
Submitters	Date	Content	State of play
Hoogland, De Boer 33652-6	29-01-14	Requests that the government places meticulousness above speed and only makes the preference decision once benefits and need have been proven and there is sufficient clarity regarding costs, benefits and risks; also requests that the government, in the intervening period, begins reporting to the House in the context of the Major Project ERTMS.	The Preference Decision focuses on benefits and need; Railway map 3.0 will provide clarity regarding costs, benefits and risks. The Basic Report will be sent to the House with the Preference Decision and the Railway map 3.0.
De Boer, Hoogland 33652-7	29-01-14	Requests that the government, in the new concession Main Railway Network makes binding agreements with the NS regarding the use of ERTMS rolling stock on the already refurbished sections and sections that are to be refurbished in the coming 10 years, beginning with the Hanzelijn.	The agreements regarding costings for rolling stock are expected to be incorporated into a covenant. This ultimately includes more operators than just the NS. In the (draft) concession for the HRN, there is therefore a reference to the (to be drawn up) agreement.
De Boer, Hoogland 33652-11	29-01-14	Requests that the government, with respect to the scenarios that will be studied in relation to the rollout of ERTMS, conducts checks on the basis of safety improvements, economic added value, including journey time gains for the passengers and capacity expansion on the railway network, and informs the House of the findings.	The Railway map 3.0 covers the safety and economic added value (including journey time gains for the passenger and capacity expansion on the railway network) of the favourable scenarios.
Anker, Mastwijk 32351-8	22-04-10	Requests that the government, in consultation with the border regions, the operators at the locations and neighbouring countries, includes ERTMS in the infrastructure during planned major maintenance to safety on cross-border railway lines, and informs the House about this within six months.	This motion will be included within the Plan Elaboration Phase
Dik-Faber, van Tongeren 22026-426	19-06-13	Requests that the government makes agreements with the NS to enable new intercity rolling stock to be driven at a minimum 200 km/h on the HRN, where the infrastructure is suitable for this, and reports back on this for the purposes of processing the HRN concession.	This motion is concluded in the letter dated 27-09-2013 concerning Alternative for the Fyra V250

Annex B
Report of second market information round

Preface

This document contains the report of the second market information round for ERTMS. On 31 October 2013, a plenary meeting was held. Fourteen market parties attended this. During the meeting, there was a presentation and questions that had previously been sent to market parties were discussed. See annex 1 of this report for the presentation details. This report contains a summary of the answers to the aforementioned questions that the market parties had submitted in November and December 2013.

Summary of written questions

The market parties asked several specific questions with respect to ERTMS and the application thereof. These questions are used as a guiding principle in this summary. The questions relate to three topics:

- Rolling stock installation
- Sidings
- Ongoing development from Level 2 to Level 3

The answers are given by 10 market parties, divided into suppliers (5), engineering bureaus (IB) (4) and railway contractors (1). Not all parties provided an answer to every question.

Rolling stock installation[48]

Questions include:

- How much time is required to refurbish rolling stock for ERTMS?
- To what extent are you of the opinion that the current market for STM-ATB/ERTMS is imperfect?
- Is it useful if a universal STM is available?
- What is required in order to build an STM-ATB/ERTMS?
- How long does it take to build an STM?

Market parties indicate that care must be taken to ensure standardisation of refurbishment and approval process per rolling stock variant. There has been a suggestion to start with the refurbishment of 1 train type and then to use this experience to optimise the process of other train types.
The time that is required for the installation period primarily depends on the size of the rolling stock fleet and the option to temporarily take rolling stock out of service and reduce capacity within the industry. The issue of whether, during the installation period, parallel working will be possible and how many people will be available for this (about 5 people is ideal) is also important.

The installation and total turnaround time for the prototype is estimated, on the basis of experience, at 1 to 2 years for rolling stock that has not been prepared for ERTMS (1 year for the tendering phase and definitive certification). The time that is considered necessary for the physical installation varies significantly on the basis of experiences: suppliers say that this depends on the type of train. One supplier suggests it is 3-4 days per train, another thinks it will be 10 days to 2 weeks and one supplier and one railway contractor believe it will take an average of 4 weeks per train in the event of series production. One IB, on the basis of experience from the past, has suggested 2-3 weeks per unit, one IB estimated that refurbishment of an average of 3 vehicles per week was feasible if parallel installation can

[48] This question was answered by 5 suppliers, 2 engineering bureaus and 1 railway contractor.

take place. All of the above depends very much on workshop capacity, national specifications and the availability of qualified personnel.

The refurbishment time for the entire Dutch fleet by one supplier is estimated to be between 7 and 12 years; one IB believes it will be 7 years. The installation costs are estimated by one IB to be between 50 and 90 k per item.

Many market parties noted that the market for STM-ATB-EG in the Netherlands is dominated by two suppliers. It would seem very difficult for a new supplier to build a positive business case, particularly if the time for dual signalling is limited, the costs are high, the development time is long and the risk of losing a tender is also high. The costs for developing an STM are estimated at around € 5 million. One IB suggests that the price of an STM-ATB-EG has steadily increased over the past few years.

The market for the STM-ATB-NG is not open. There is one player. Several suppliers and one IB suggest that they must be persuaded to work on a universal STM for ATB-NG.

Both suppliers and IBs are divided about the need and/or practicality of having a universal STM. Two suppliers and one IB suggest that a 'decoder' is necessary, from a technical viewpoint, in order to allow more suppliers to establish themselves in the market. One IB suggests that in DK, the universal STM did not lead to another supplier and did not therefore lead to lower pricing. One IB also suggests that, given the signal variations within WTB, the construction of an STM requires a great deal of specific expertise. One railway contractor suggests that there must be investment in an alternative such as universal ETCS-Lite. One supplier suggests that unambiguous specifications must be maintained in the long term and that the government must release the specifications for ATB-NG.

Suppliers provide varying estimates, from one year from design to validation, and then two years for certification and practical testing, to 5 years for the complete process. One supplier suggests an average of 3.5 years. The period could be shortened if there was effective project and risk management and use is made of expertise and experience from similar projects.

Sidings[49]

Questions include:

- What are the challenges for the realisation of Level 1, 2 and 3 on the large sidings?
- What are the conditions for the effective functioning of ERTMS for Level 1, 2 and 3 on sidings?
- Is the determination of position in Level 3 sufficiently accurate for the desired capacity expansion on sidings? What are the conditions for good implementation?
- Can sidings with the current GSM-R function under ERTMS Level2/3 and what investment/ developments are needed in this respect?

The market parties indicate that Level 1 on sidings is 'proven technology'. Experiences have been gained with the Havenspoorlijn. The challenges concern optimisations and more efficient system architecture (internal and external). In Level 1, much cabling work has to be carried out on a siding; every balise must be connected to the interlocking. ERTMS Level 1 can be integrated with the existing technologies, even on sidings. Infill will also ensure more effective functioning of Level 1 and increased capacity.

The challenges on sidings with Level 2 lie particularly in the capacity of GSM-R and RBC. One the one hand, this concerns the number of trains that can be served simultaneously by an RBC and GSM-R, on the other hand, it concerns failure sensitivity and the dependence of communication. A number of market parties indicate that a transfer to GPRS (instead of the

[49] This question was answered by 5 suppliers, 4 IB's and 1 railway contractor.

current Circuit Switched) is vital for large sidings in order to bring them under Level 2. Other market parties indicate that this is not necessary.

Shunting also creates complexity and error sensitivity in the system. This is due to the fact that these processes are often communicated manually by a train driver to the track-side centre. Shunting includes: approach times, starting up, splitting and connecting trains. The system must also be aware of the location of the disconnected elements, including the creation of communication between the disconnected part and the track-side system. A resource for several of these shunting activities could be switchable balises; these are also applied under Level 1.

In Level 3, complexity is increased because the position of trains is communicated to track-side via auto-localisation instead of track-bound train detection. This means that changes must be made to the system architecture, including the VPT process systems. None of these systems are currently suitable to carry out train detection via auto-localisation. Under Level 3, train components without radio communication are, in principle, permitted.

One of the risks that is clear under Level 3, concerns train collisions on sidings involving trains that have their systems turned off. The management measure is therefore to maintain train detection. Other issues include the accuracy of the odometry (a determining factor for capacity on the siding), start-up of train services after an outage of GSM-R and/or RBC and guaranteeing train integrity. Two IBs indicate that the capacity on sidings with Level 2 and 3 will come under pressure if overlap lengths also have to be protected. This is not currently the case.

Ongoing development from Level 2 to Level 3[50]

Questions include:

- When does Level 3 (or Level 2plus) become sufficiently reliable for implementation in the Netherlands? How realistic is this?
- What steps must still be taken to develop Level 3 (or Level 2plus) for large-scale rollout? How long will this take?
- Can important interim steps be designated that could be made available earlier?
- Are there risks that would jeopardise efforts in terms of the availability of Level 3 (or Level 2plus)?

One supplier reports that the moment of availability of Level 2plus and/or Level 3 for the Netherlands depends on the establishment of rules and system requirements, as was the case at the time for HSL-Zuid. One supplier talks of 24-30 months from now, another suggests from 2017 and another talks about 10 years from now. One railway contractor is thinking in terms of 20 years for full development to Level 3. The IBs that responded to this question mention 5 years and between 5 and 10 years. There is also talk of prerequisites such as collective advances by suppliers, the availability of a clear European specification and the availability of a solution for the train integrity problem.

To the questions regarding vital developments, the requirement to equip Level 3 with a formal EU standard was emphasised by one IB and one supplier. Two suppliers stressed that Level 2 and Level 3 could run in parallel. Level 3 is a further development of Level 2. Electric interlockings and RBCs are required, however, and interlockings must be developed so that they can deal with sliding blocks, according to one IB. One railway contractor suggests that a fully developed Hand Held Terminal and the corresponding procedures are vital for track work. One supplier and one IB provide a detailed schedule for arriving at production readiness for Level 2plus or Level 3. Laboratory testing and the need for a large sales market are also mentioned as critical success factors.

50 This question was answered by 5 suppliers, 2 engineering bureaus and 1 railway contractor.

Collaboration is regarded by one supplier as a risk. Without collaboration, development will be slow. The Danish model is considered to be an example that leads to collaboration between suppliers. Another supplier said the same but with respect to the risk of an extended specification phase. There must also be agreement between operators and infra-managers regarding operational concepts, according to one supplier. Finally, the capacity of the GSM-R network is stressed by suppliers and IBs as a risk and one IB suggests that development, standardisation, train integrity and odometry all form risks. The same IB indicates that suppliers may hesitate to continue onto Level 3 as a result of an inadequate sales market and insufficient turnover.

Annex C
Report of second and third round of Stakeholder meetings

This annex shows, in the table below, the input from the stakeholder discussions and meetings per (group of) stakeholders. This is an addition to the points that arose as a result of the first and second rounds of stakeholder discussions that were included in Railway map 2.0.
The points concern the most important advice, risks and focus areas that, according to stakeholders, are significant to the Preference Decision, actual elaboration in the Plan Elaboration Phase and collaboration in the subsequent ERTMS process. It en-compasses the opinions or visions of the relevant stakeholder or stakeholder group; this is not always supported by the ministry.

Stakeholder	Advice, risks and focus areas
FMN parties (Regional operators: Arriva, Veolia and Connexxion)	
VKB Q1 2014	**Advice:** - Ensure a rapid rollout in order to minimise the costs for maintaining two systems simultaneously. - Include in the cost centres, the benefits from: • Cheaper installation of infrastructure if ERTMS is installed directly instead of ATB. • Avoided investments via installation of ERTMS in journey time reductions, such as level crossings • Increased reliability and soundness via reduction of failures on failure-sensitive routes • Improved cross-over times • Improved capacity distribution • Dynamic traffic management **Risks:** - There are some unresolved bottlenecks for the installation of ERTMS: • Sidings • 40 km zones • Braking curves for the rolling stock **Focus area:** Someone has to 'bite the bullet' in terms of ERTMS im-plementation. Reports from the Research Council for safety indicate that IenM, Prorail and NS do not agree about the upgrading method for the existing ATB variants.
Plan elaboration	**Advice:** - ERTMS can be used more efficiently if it is combined with other measures (physical but also procedural) - Take the principle decision that ultimately the entire Dutch railway system will be equipped with ERTMS, then effective justification can always be discussed regarding the order and timing of rollout on the decentralised lines. - Interchanges are not only dependent on ERTMS on the HRN, but also on rapid processing of decentralised trains and lines. - Please also pay attention to regional track sections with capacity problems when calculating scenarios, such as Arnhem – Winterswijk or the Valleilijn. - Clarify what ERTMS means for flexibility of the railway system. - Appoint IenM as system integrator; this will prevent focus on sub-issues. - Include the ERTMS obligation in new concessions (prescribe this) and in any acquisition of new rolling stock, so that this can be accounted for in the new concessions. - Use the expertise of regional operators with respect to rolling stock refurbishment and financing, as well as possible rolling stock take-overs. - Ensure there is a level playing field for concession terms in relation to ERTMS obligations. - Define the role of the concession issuer in the implementation of ERTMS. - Provide rapid insights into (the content of) legislation and regulations regarding (the speed of) rolling stock refurbishment.

	- Let all operators begin refurbishment, temporary partial fleets and conversion once a large part of the technology and refurbishment capacity is available for the refurbishment to ERTMS. - Seek options for an extra production unit for refurbishment in the Netherlands or just across the border; a great deal of experience has already been gained with this. Build any temporary extra switches, bring old (maintenance) sites back into use, create track availability with tents, etc. - Ensure sufficient capacity with ILT in order to get the trains certified after refurbishment. - Involve railway maintenance companies as early as possible in the choices to be made and the implementation of ERTMS. **Risks:** - The unknown impact of Level 2 on interchanges. - Resistance in practice within NS and Prorail to the implementation of ERTMS. - Splitting and combining trains: does the train brought to the front or the disconnected train remain visible in ERTMS? - Does deployed and disconnected rolling stock remain visible in ERTMS even after a while? - A train that breaks down and is at a standstill on the free track and is fully disconnected: visible in ERTMS? - Pushed shunting: what position is measured? - GPS position is too inaccurate, certainly on sidings and tracks next to one another. - Connection of itinerary control and ERTMS display in the cabin? - During short-term connection outage: does ERTMS continue to monitor or retain trains? - Disrupted level crossings: are these highlighted? - Level crossing approached at low speed and speed increased before the level crossing: level crossing closes too late? - Power outage on train: does ERTMS remain active? Is battery power required? Is the last known position retained? Where? - Different (software) versions of ERTMS. - Less operability required to be pulled by another vehicle. - Organisation and guaranteed updates. **Focus areas:** - Level 2 is not yet functional on sidings. - There is the problem of 'in use-entry' on sidings. - The 'island issue' where ERTMS is applied on various, separate locations, so-called islands, must be investigated. - The implementation method for ERTMS in the Netherlands must not lead to a worse competitive position for regional operators compared to NS. - Particularly for single track sections, ERTMS can contribute to the expansion of soundness (quicker cross-overs and so on). - In terms of planning the refurbishment of rolling stock, harmonisation with all operators and Prorail is a must. - Continuing innovation must be stimulated. - The Vehicle register provides an overview of the rolling stock managers and rolling stock. - Implementation must involve new trains as much as possible, because taking existing rolling stock out of operation is tricky and time-consuming. - Refurbishment time/effort depends on the type of rolling stock (including diesel/electric). **Opportunities:** - Speed steps of 5 km/h instead of EG steps 40 60 80 130 140 km/h. - Short follow-ups (within a minute?) at lower speeds for entering and leaving sidings to the free track also in comparison to ATB NG. - Earlier acceleration via speed steps of 5 km/h. - Later and uniform braking via smaller steps of 5 km/h. - Uninterrupted braking without interim unloading. - Narrowing of timetable hub via shorter arrival/follow-up times and departure/follow-up times. - The slow train can leave directly after the IC or arrive at a shorter distance in front of IC. - Notification time at level crossing depends on speed of train; short waiting times. - Work towards one ERTMS software version and Level in the Netherlands. - Operability.
Collaboration	**Advice:** - Collaboration of FMN parties with project organisations via short and direct lines is of vital importance. - Organise an opportunities and risks session in order to gain an insight into the opportunities that can be realised and the risks for which management measures must be created. - Make a fixed meeting agenda with at least: costs (distribution), rolling stock withdrawal, options for pilots, risks and opportunities.

	Focus areas: - Continuity in the collaboration is and will remain important for all parties. - Representation within FMN at various levels and the follow-up with IenM.
LOCOV (Consumer organisations ROVER and LSVb)	
VKB Q1 2014	**Advice:** - Start quickly with the shift towards the transfer to full ERTMS. - With new rolling stock, the basics can already be introduced via an onboard unit (OBU); software updates for ERTMS will come at a later date. - The (capacity) gains from ERTMS lie in the combination with other measures or improvements, such as in timetables. Process innovation and 'new thinking' is necessary within ProRail (and across the whole railway sector) in order to ensure ERTMS works successfully. - Move from MISTRAL to ERTMS quicker in order to prevent 'disinvestments'. - When reserving taxes, mention employment and the other opportunities it creates. **Risks:** - A loss of direction and central guidance by IenM in the process is undesirable. **Focus area:** - Paying attention to the train passenger. Create insight into the consequences of ERTMS for the passenger in terms of the five goals (safety, capacity, reliability, speed and interoperability) and make sure they can be monitored.
Plan elaboration	**Advice:** - Consider the consequences in legislation when the systems change. - Look at replacement or modification projects where (large) investments must be made and ERTMS can be immediately included, e.g. Zwolle. **Risks:** - How can responsibility for incidents be verified? **Focus areas:** - Germany is an important foreign party, seek contact. - Be aware of the relationship with the 4th Track Package (standards, EU certification etc.)
Collaboration	**Advice:** - Regular information provision via LOCOV meetings. - Continuing involvement and reviews of passenger interests and consequences as and when ERTMS is actually implemented (also during refurbishment period).
Decentralised authorities (provinces, regional collaborative partnerships and city regions)	
VKB Q1 2014	**Advice:** - Clarify the studies' level of detail in the Railway map. - Make room for opportunities on regional lines, research in the short term where regional gains can be achieved. - Prioritise the cross-border lines with ATB-EG.
Plan elaboration	**Advice:** - ERTMS can be used more efficiently if it is combined with other measures (physical but also procedural): - Research the consequences of the implementation of 3kV for ERTMS. - Research the consequences for noise norms and develop adequate measures where necessary. - Pay attention to the transfer (during replacement) between levels of ERTMS and the consequences that correspond to the transfer from Level 1 to Level 2, for example. - Ensure there is an integrator that provides independent advice so that the directorial parties can work through the problem when there are issues during the elaboration of ERTMS. **Risks:** - Prevent a multitude of protection systems in the Netherlands and on international lines. **Focus areas:** - ERTMS can be appealing for track sections with capacity expansion ambitions or capacity

	problems, e.g. Zwolle-Groningen and Zwolle-Leeuwarden. - All Decentralised Authorities are very interested in ERTMS: what it costs and what it provides. - Decentralised authorities would like to use the expertise in all sorts of accessibility projects in which they are taking part in order to assess whether ERTMS can provide a solution. This also involves decentralised authorities that do not issue concessions. - Attention must be paid to (tying off) legal issues, particularly involving international connections. - There is a field of tension between preservation and the possible consequences for capacity.
Collaboration	**Advice:** - Draw up a fixed meeting agenda containing at least: technical issues, interoperability, legal consequences, order of implementation. - Involve the board members (at a higher level of abstraction) within the elaboration phase, and also in execution but less frequently. - The work conference is a good moment to provide information to board members. - Involve both concession issuing and non-concession issuing authorities. It varies for the commissioning authority whether they are responsible for income or not; this makes a difference in terms of desires. - Let IenM take the lead in this project because of the multiplicity of interests for all parties in the railway sector. **Risks:** - Waiting too long to study and address the consequences of ERTMS for the railway projects that are under preparation (maintenance and installation of infrastructure, purchase of rolling stock, new concessions). **Focus areas:** - Further discussions are necessary regarding costs, where and when pre-investment is possible, required and desirable. Involve the operators in this context where necessary. - Further discussions required concerning the approaching concession in Limburg.
Unions (FNV, CNV, VVMC)	
VKB Q1 2014	**Advice:** - Most of the new locos are already equipped with ERTMS; they can often accommodate eight protection systems. It is only when a train operator specifies it themselves, that these options are removed from the locos. Work with standards as far as possible. **Risks:** - Level 1 offers a semblance of safety and cannot count on support for a national rollout. ATB is preferred over Level 1 with signals. - ERTMS is a project for the long-term, do not fall into the 'false economy' pitfall. **Focus areas:** - Personnel currently consider social safety a higher priority than ERTMS. - Attention to safety when trains operate with multiple systems; variety versus continuity and predictability.
Planuitwerking	**Advice:** - Attention must be paid to the relationship between man and technology, what impact the system has on the user and how this can be taken into consideration. - There is unanimity regarding the desire to move to ERTMS as quickly as possible. - Keep some space for sharing experiences from the pilots; critical signals can contribute towards a more effective rollout. - During the transfer phase, consider the consequences for safety if trains are operated with multiple systems. - Research whether the project 'European Drivers Desk' can provide valuable information for ERTMS and/or vice versa. - Research whether the project 'Routelint' can provide valuable information for ERTMS and/or vice versa. **Risks:** - In terms of tendering and setting up specifications, the experts from the work floor must be given an early role so that costs can be saved in the longer term. - The moment that ATB definitively goes offline is feared because there will be no fall-back option. - GSM-R must be upgraded because this currently forms the Achilles heel of ERTMS.

	- Modifying legislation and regulations takes too long. - It takes ages to implement modifications in the operational Manual. **Focus areas:** - Safety is the most important issue for the unions. - The attention paid to training and courses must be increased. - The use of one ERTMS glossary and language in use and installation is of huge importance. - The vision of the personnel within their own areas; how do the unions (and rank and file) see the developments within the railway personnel specific areas. - How will we deal with changes to company processes that come about as a result of ERTMS? - Employees are very positive about the Amsterdam-Utrecht pilot. After training/initial test runs, it would seem that even the sceptics have been convinced. - The application of ERTMS must be implemented in combination with the timetabling authority.
Collaboration	**Advice:** - Set up a user forum for the Plan Elaboration Phase, which covers working experience and the exchange of experiences. - Involve the timetabling authority in this user forum. - Investigate a possible connection into the regular User Forum for ProRail and the train drivers. Involve the other operators in this context where necessary. **Focus areas:** - The unions would like to be involved in the user forum.
Freight train operators via KNV	
VKB Q1 2014	**Advice:** - The freight train operators are advocates of the implementation of ERTMS.
Plan elaboration	**Advice:** - It is important that the Dutch system connects into the systems abroad in terms of technology and planning. One European set of specifications is required and must be applied. If all countries implement national exceptions in the specifications, there will still be differences. - The timing of the implementation of the systems is also important. Freight train operators primarily carry out international transport; a similar implementation of ERTMS in neighbouring countries is to be recommended. - During further research in the Plan Elaboration Phase do not only study the main freight routes but also the secondary routes. - Freight train operators would very much like to see detection problems eliminated. **Focus areas:** In general, the freight train sector already has more experience and expertise in relation to ERTMS because it has already been implemented on the Betuweroute and the Havenspoorlijn. - Given the development of the ERTMS system in the coming years, there is a chance that the ERTMS system that was installed first is so different to the one that was installed last that there is limited interoperability. The replacement of GSM-R must also be taken into consideration. - Fewer loco switches will probably be required at the border with Levels 2 and 3. The personnel switch, however, will (partially) continue. - There are a number of conceivable measures for freight transport that could improve the functionality of ERTMS, e.g. 3kV. - Having multiple protection systems onboard is not a good outcome for freight train operators. Investments must be made in systems and personnel. Sometimes, personnel must be used for a route that they very seldom encounter. This does not help the cause of safety. Keeping islands in the Netherlands to a minimum is therefore desirable.
Historisch Railvervoer Nederland	
Plan elaboration	- In terms of historical rolling stock, onboard units for ERTMS must be modified on each train according to the type of rolling stock. - This also applies to rolling stock from railway maintenance companies. - This also has consequences for acceptance and certification. Discussions must be held with the ILT regarding how this can best be organised. A review must also take place of

	the agreements at EU level as a result of the interoperability of the rolling stock. - In Sweden, experience has been gained with the refurbishment of historical rolling stock and the corresponding cost issues. - The current train protection system is also suitable for historical rolling stock. - In the European Railway Agency (ERA) setting, further harmonisation can take place in this regard with corresponding agreements. - Train integrity is important for historical rolling stock too. - An agreement could possibly be made with HRN regarding refurbishment and costings and not with all HRN members individually. - In order to gain an overview of the rolling stock, HRN can check the data from the vehicle register (this is not always complete).
Collaboration	- HRN must be regularly involved in terms of the elements collaboration, installation and costings.
Railway maintenance companies (Strukton, Spitzke, BAM, Volkerrail and Eurailscout)	
Plan elaboration	- This primarily concerns the refurbishment/modification of machinery and, to a lesser extent, the locomotives (these are already partially equipped with ERTMS). - The moment at which ERTMS becomes mandatory for rolling stock, costs for installation/refurbishment and the refurbishment period, are all important issues for the railway maintenance companies. - Be aware of the maintenance areas and intensity of use of rolling stock. - Certification and access rights via the ILT are also a focus area here. - Additional costs for maintenance companies will be transferred via the maintenance contracts. - Be aware of the role of leasing companies when it comes to recouping investments.
Collaboration	- Railway maintenance companies have a great deal of knowledge and can exploit experiences in other countries. - Alongside involvement of a number of railway maintenance companies via the market information meetings, these companies must be sufficiently involved when it comes to refurbishment and costings too.
Mitsui	
Plan elaboration	**Advice** - During the rollout, focus on existing hazardous points in the network; the highest level of benefits can be gained at these locations in the short term with ERTMS. - Involve centres of expertise and universities in order to further elaborate (alongside safety improvements) the positive aspects of ERTMS. - During the rollout of ERTMS, refurbish the rolling stock first so that this can be driven anywhere. - Seek collaboration with Belgium and Germany in order to achieve scale advantages. - Avoid the creation of an ERTMS island in the Netherlands within the EU and work according to EU agreements and standards. - The UK and Switzerland have gained interesting experiences; learn from these. **Risks** - Future-proof investments in a market where supplier developments do not run at the same pace as accessibility requirements (Baseline 3.5). - The time taken for acceptance/certification costs after installation/refurbishment is a determining factor for the operators. Having rolling stock out of service is very costly. - ERTMS is a technology with many risks and which is still very much under development so make sure there are good analysis and management measures. **Focus area** - The development to Baseline 3.5 as standard for ERTMS and the option that the market has for fulfilling this in good time.
Collaboration	- Mitsui has a great deal of knowledge and experience with ERTMS due to the scope of the company it can draw on. Freight locos are or will often already be equipped with ERTMS in order to enable them to be used in various European countries.

KeyRail	
Plan elaboration	**Advice** - Keyrail has indicated that the ERTMS rollout must not be seen as an infra project but as a transport concept. - Keyrail recommends creating a new body that works on tendering and also makes decisions when it comes to money. - It may be wise to retain the traffic control system(s) and drivers onboard for acceptance and temporary amendments to and the creation of protocols, manuals, etc. - Keyrail advises talking to managers of infrastructure rather than installers because the former have more expertise in relation to ERTMS. By talking to managers, potential problems and issues may come to light at an early stage and subsequently can be anticipated early. - Keyrail recommends taking on existing people from IenM, NS and ProRail to work on the ERTMS programme team (which is to be set up) at an independent location (e.g. Zoetermeer or Gouda). This will ensure people think outside their usual habits and there will be a shared feeling of being collectively involved in the project. - It is advisable to not allow the people on the programme team to work full working weeks at the independent location. They must have the space to feedback the state of play within the ERTMS programme team to their parent organisation. - The system integrator is a network organisation and keeps track of what is going on in other countries. He manages the money and makes decisions. The system integrator, according to Keyrail, must be apolitical and yet understand politics and must always be able to argue on the basis of the end product. - Baseline 3 is the only realistic option because it is a shared set of requirements. The disadvantage is that it is not yet entirely fixed and could turn out to be less effective than you would like. - The way in which the traffic control system(s) in Spain deal with the ‘patchwork quilt’ of ERTMS systems (and the connections between the existing systems) could be a good lesson for Dutch traffic control system(s). **Risks** - Bear in mind that OBUs need maintenance. If this does not happen, this will lead to problems in the longer term. Always make prompt agreements about this maintenance. - Combination with GSM-R, for how long will GSM-R be supported? And this system is less suitable. - Beware of implementing a unique form of ERTMS. Steer clear of unique products. **Focus areas** - ERTMS in the track is less maintenance-sensitive compared to ATB because there are fewer vulnerable parts, such as cables. - There is a movement that is striving towards open source ETCS. The latest state of play for this is not entirely clear but this could have a huge impact upon the dynamic in the market and tendering.
Collaboration	- Keyrail is offering to facilitate a pilot for level 2 on sidings on part of the Havenspoorlijn and would like to share expertise and experience with ERTMS from other projects.
Other input from stakeholders (including via the Infrastructure & Environment Consultation Group)	
VKB Q1 2014	**Risks:** - If functionality deviates from the standards, it will be harder for companies to obtain ILT approval to drive. - One design criteria for ERTMS in the Netherlands must be that new technologies are always ‘backwards compatible’. This went completely wrong at Kijfhoek because Level 1 was chosen even though Level 2 had been installed in the locomotives.
Plan elaboration	**Advice:** - Retaining and developing expertise about ERTMS is very important for effective implementation. Involvement on an international level is and will remain very important in this context. - For freight train operators, it is important to know what requirements the rolling stock will have to fulfil and when. - Practical experience must be gained as quickly as possible in order to accumulate the necessary experience (and expertise) that is required in order to implement ERTMS in the Netherlands.

Focus areas:

- One important focus area for the implementation of ERTMS is whether there are sufficient, qualified personnel.
- Optimising the braking characteristics of trains also determines the blocks that can be used and thus impacts upon the capacity and capacity improvements.
- Train integrity is an important technical focus area
- It is important to realise the European obligations.

The Preference Decision, the Railway map 3.0 and the majority of its annexes are translated from their original Dutch versions. The translations are a courtesy to stakeholders, other governments and the market. The original versions in Dutch form the basis for the next phases and decision making. In case of debate on interpretations or translations the original Dutch versions are always the leading documents.

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