Second Opinion on ERTMS prognose eindstand

October 24, 2023

Contents

Glossary

European Rail Traffic Management System (ERTMS)
The European Rail Traffic Management System is the European standard for management and interoperation of signalling for railways.

Final financial forecast [Prognose Eindstand (PE)]
The re-evaluation of the Final Financial Forecast [Prognose Eindstand (PE)] for the ERTMS programme. This re-evaluation was conducted in 2022 and can be found in the document 'Herijking financiële Prognose Eindstand programma ERTMS – per ultimo 2022'.

Programme Decision
The Dutch government [het kabinet] took the decision to install ERTMS on Dutch railways in 2019. The Programme Decision [Programmabeslissing] consists of a basic investment to replace ATB with ERTMS by 2030.

Programme Directorate (PD)
The Programme Directorate is the overarching organisation managing the implementation of ERTMS in the Netherlands.

Implementing Organisation (IO)
The Implementing Organisations (IOs) are the organisations responsible for executing the works assigned by the Programme Directorate (PD) to implement ERTMS. These organisations are the rail network manager ProRail, the national carrier NS, rolling stock owners, regional passenger carriers, freight carriers, rail contractors, and parties with historic rolling stock.

8 lines in scope
The original 7 lines with addition of the Northern lines and the conversion of Hanzelijn to Level 2 Baseline 3 only.

Abbreviations

The following Dutch abbreviations are used in this report. Where necessary, the English explanation is given in here brackets.

ATB
Automatische Treinbeïnvloeding (Automatic Train Control)

ATO
Automatic Train Operation

BOV
Beheer, Onderhoud en Vervanging (Management, Maintenance and Replacement)

CCS
Control Command and Signalling

ESC
ETCS System Compatibility

ETCS
European Train Control System

GSM-R
Global System for Mobile Communications

IenW
Ministerie van Infrastructuur en Waterstaat (Ministry of Infrastructure and Water Management)

IEP
Implementatie ERTMS ProRail (ProRail's ERTMS Implementation)

MIRT
Meerjarenprogramma Infrastructuur, Ruimte en Transport (Multi-year Infrastructure, Spatial Planning and Transport programme)

MT
Management Team

OCD
Operational Concept Description document

(P)RAMS
(Performance and) Reliability, Availability, Maintainability and Safety

SEU
Signalling Equivalent Unit

TEN-T
Trans-European Transport Network

TSI
Technical Specification for Interoperability

Yellow fleet
All contractors' equipment is collectively known as the 'yellow fleet', as the vehicles used by contractors are mostly painted yellow.

1. Management summary

The Second Opinion Committee (hereafter: expert committee) has conducted a high-level review of the Dutch ERTMS Programme, based on document reviews and interviews, to develop the findings given in this report. Based on the data made available, the expert committee has identified areas for potential refinement to the Programme to enhance the likelihood of delivering the desired benefits within an agreed timescale and budget. In addition, the review provides a comparison of how the Dutch ERTMS Programme compares to similar benchmark programmes across Europe, concerning costs and the overall management approach. Throughout the process, the Authorities, Programme Directorate (PD) and the Implementing Organisations (IOs) have been very professional, supportive and transparent in sharing information and opinions, which helped make this second opinion better informed and more applicable.

After three months of interviews and document reviews, the expert committee finds that the Programme is unlikely to achieve its objectives within the timescales currently proposed (end of 2031). Implementing changes suggested herein, in governance, coupled with changes in Programme schedule and risk management, overall technical and integration leadership, as well as scope and cost control will improve the probability of success. However, this is unlikely to achieve the planned timescales, with an additional minimum risk of 2 years based on international benchmark data.

Following its review of the scope and budgets, outlined in the Final Financial Forecast (Prognose Eindstand), the expert committee concludes that the budget requested is comprehensive (with some exceptions identified), it accounts for the anticipated risks and is credible (based on benchmark countries). However, when compared to similar benchmark projects across Europe, the budget appears to be significantly higher.

The expert committee has been unable to conclude whether the Programme will be able to deliver the scope against the Prognose Eindstand, as adequate historic cost, schedule and performance data are not available; the committee concludes from this, that the Programme must implement improved and comprehensive cost and performance management to better manage the outcomes.

Governance and Programme Management

The expert committee finds that the Programme can benefit from improved governance; while a governance structure exists, the current structure and setup lacks clarity regarding overall and delegated authority and responsibility to deliver the desired outputs. The recommendation is to reassess the structure and implement changes centred around ownership of the common objectives and plans, with specific Terms of Reference for each level of governance and control (i.e. Steering Committee, MT Executive Committee, PD, round-table meetings and IOs).

To create a more effective governance structure, the expert committee recommends changes to the authorities and responsibilities of the Programme, by giving the PD the authority and responsibility to act over the IOs in the interests of delivering the overall objectives. This authority and responsibility may be 'policed/augmented' by the MT Executive Committee, which will be composed of similarly responsible representatives from the respective IOs, all of whom will have jointly embraced the overall integrated schedule, costs and associated outcomes against a fixed scope. The Steering Committee will continue to operate as the highest Programme body and owner of the objectives, benefits and total budget. In other words, any proposed changes to the

outcomes, either reduced benefits, changes in scope, increased costs or delays will require the Steering Committee's endorsement before being enacted. Each of the IOs will continue to have responsibility for their respective scope (assigned by the PD) within the agreed costs and schedule. Under the proposed regime, any changes to scope, cost or schedule would require the approval of the PD (if within their programme remit) or the Steering Committee if it cannot be mitigated by the PD.

The Schedule

The expert committee has assessed the Programme Management arrangements and recommends that the PD must respond to the change in authority and responsibility, by proactively managing the delivery in terms of Scope, Integration, Schedule, Risk and Cost. This needs to be enabled through improved (quantitative, KPI and fact based) and more regular (at least monthly) reporting, and stronger schedule control by issuing a credible and fully integrated schedule.

With respect to Risk Management, the expert committee recommends that this is further improved by including risks at the IO level that have a potential to impact the overall programme, with reporting linked to the improved monthly reporting regime.

The committee has assessed the schedule, based on international benchmarks the Dutch ERTMS programme is planning to achieve productivity rates that are up to 3 times those achieved in more mature programmes elsewhere. In addition, delivering the planned volume in a short period will put unrealistic demands on industry resources, and could potentially cause significant disruption to railway operations.

Technical Management and Coordination

For the programme to deliver its technical objectives, it is essential that the PD leads from a position of 'informed client' and assumes the responsibility of integrating the delivery. The expert committee has noted the recent changes made within the PD to address the need for more effective management of integration-related issues (Requirements Management, Migration, Testing & Commissioning), however this is still at too high a level and the expert committee recommends this be developed further to a lower level of detail and to include seconded members of the IOs (and key contractors) into the formal groups (rather than the current round-table meetings). The effect of seconding employees will be to import knowledge into the PD, while maintaining the links to the IOs, thereby increasing the collaborative environment. These integrated teams must have a clear success-oriented purpose with defined outputs linked to the programme schedule and objectives. The expert committee also recommends a similar approach be taken with Operations and System Safety management.

The expert committee also recommends that the IOs take a similar and collaborative (with PD) approach in these areas to ensure a fully integrated delivery.

There are a number of areas where the expert committee recommends that additional work is undertaken, these include operational integration, configuration management and software control.

Programme Costs and Benchmarks

The expert committee finds that the cost estimates are comprehensive and address the required scope, the estimates also have an adequate level of risk and contingency.

When compared to international benchmarks, the expert committee finds that the Infrastructure and Signalling costs are more than double the international benchmarks for a similar Signalling Equivalent Unit (SEU), whereas the onboard costs are about 25% higher.

The ability of the project to deliver within the budget has not been assessed as such historic data is not available. The expert committee considers this an indication that the programme would benefit from monthly overall cost and performance KPIs.

There are a few areas where the programme would benefit from further assessment of costs, namely, the cost of the telecommunications system, costs of the Programme Directorate and the potential cost escalation due to schedule slippage past the current P85 completion of December 2031.

2. Introduction and main characteristics of ERTMS in the Netherlands

Introduction

This chapter introduces the ERTMS context in the Netherlands in two parts. First of all, the background and reasons for requesting this second opinion are presented, then the main characteristics of the ERTMS programme are described.

Background to this second opinion on the ERTMS programme

In 2022, the planning and cost estimates, otherwise known as the final financial forecast [Prognose Eindstand (PE)], for the ERTMS programme in the Netherlands were re-evaluated. This revealed that the ERTMS programme requires considerably more funding to realise the objectives than originally agreed. The final financial forecast showed that with an unchanged approach, the costs incurred through to 2030 would be approximately EUR 994 million higher (at 2022 price levels) than the programme budget available during this period (with the PE retaining to the original scope).

With regards to planning, the 18th progress report[1] shows that in August 2022 the Steering Committee had agreed a revised project plan. The full programme scope was originally planned to be completed by 2030. However, the revised plan, version 7.0, shows a completion date in 2031. Reasons for this delay include the government's decision to include the Northern Lines[2], the changed approach for the Hanzelijn[3] test section, as well as incorporating axle counters to the scope on the other six lines of the programme. The significant interdependence of the various projects within the ERTMS programme means that such developments have severe consequences for the other projects within the programme.

Based on the re-evaluation of the cost estimates, the programme director suggested the ERTMS Steering Committee obtain a second opinion on the final latest plans and final financial forecast [Prognose Eindstand] for the ERTMS programme in the Netherlands. The kick-off meeting with the expert committee was held at the end of April 2023. The scope and objective of the second opinion is discussed in chapter 3.

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[1] https://open.overheid.nl/documenten/ronl-1bfc93b7a511af14e2e97e3c120117d0f814ff7b/pdf (in Dutch)
[2] In Groningen and Friesland
[3] Lelystad–Zwolle

Background to the ERTMS programme

ERTMS

ERTMS stands for 'European Rail Traffic Management System'. It is a control, command, signalling and communication system for railway operations. It is a digital system for railway management and safety control. It was adopted by the European Union as one of the cornerstones of an interoperable European railway network. ERTMS consists of a trackside system and a system onboard the train. Both trackside and train systems must be equipped with the ETCS and GSM-R hardware and software to enable the communication between the trackside, the train and the traffic control centres.

- ETCS (European Train Control System) is a cab-signalling system with standard trackside equipment. It replaces the legacy analogue automatic train protection system (ATP) and ensures that trains have continuous speed control and do not exceed safe track speeds and distances. In addition, it provides relevant information to support train drivers in their tasks.
- GSM-R (Global System for Mobile Communications – Railway) is a dedicated wireless communication system for voice and data services supporting railway operations. It provides voice communication for train drivers and signallers and provides data communication for ETCS.

ERTMS consists of trackside and onboard systems. Trackside and train must be equipped with the ETCS and GSM-R hardware and software to enable the communication between trackside, train and traffic control centres.

The European Union Agency for Railways (ERA) has published the Technical Specifications for Interoperability. These include amendments to the Control Command and Signalling (TSI CSS) part, covering ETCS and GSM-R, as well as to the Operation and Traffic Management (TSI OPE) part, which applies to the operation and traffic management subsystem.

ERTMS in The Netherlands

The current analogue automatic train safety system, ATB (Automatische Treinbeïnvloeding), was designed in the 1950s and is possibly holding back further development of the Dutch railway system. A leap to a digital train safety system is necessary. This will enhance the competitive position of international rail transport compared to other modes of transport and will make passenger and freight transport by rail more sustainable.

The objective is to replace the existing analogue safety system (ATB) with a digital safety system (ERTMS) to improve safety, interoperability, capacity, speed, and reliability, and to comply with European obligations[4]. In doing so, the ERTMS implementation contributes to the five policy goals of the government's long-term rail agenda [Lange Termijn Spooragenda].

By implementing ERTMS, the Netherlands will also contribute to the European TEN-T regulation goals. This regulation aims to establish and develop an integrated Trans-European Transport Network (TEN-T). As part of this, in 2016, member states agreed to the revised European implementation plan. This plan includes implementing ERTMS along nine TEN-T corridors by 2030, three of which start/end in the Netherlands.

The scope under this government decision encompasses a detailed implementation plan with a focus on the first step of this roll out, for the period until 2030, laying the foundation for the

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[4] The existing ERTMS lines in the Netherlands were mostly greenfield – HSL, Betuweroute, Hanzelijn, and AMS-Utrecht as a part of quadrupling tracks.

nationwide deployment of ERTMS. ERTMS will be implemented while the rail system remains in continuous operation (a brownfield situation). This significantly increases the complexity compared to building new tracks with ERTMS. To minimise disruptions, ERTMS will be introduced in controlled stages, known as migration steps.

The Dutch railway sector has been working on a national implementation strategy for ETCS level 2 for approximately 10 years. The government decision made in 2019 is to implement ERTMS nationwide, including all stations, but the scope up to 2030 is smaller with a specific MIRT budget allocated. So unlike Denmark or Norway, where all signalling and traffic management systems in the entire national network are to be replaced, the current scope of the Dutch ERTMS Programme (and the subject of this report) is limited to eight sections of track, ETCS, some TMS upgrades, and only a partial replacement of the interlocking systems equipment. Larger stations will not be converted to ETCS. Much of the freight transport rolling stock is already equipped with ETCS, baseline 2, and needs to be upgraded to the chosen baseline standard. Network-wide implementation is currently anticipated by 2050, as was agreed upon in the decision for a national roll-out (part of the programme decision in 2019). The current programme is an initial investment for the national roll-out.

The government decision to officially install ERTMS on Dutch railways was made in 2019. At that time, the cost estimate and financial coverage for the initial programme decision were in balance. The final financial forecast drawn up in 2022 indicates that the cost estimate has increased significantly (more on this in chapter 4, theme 4). Cost increases are mainly attributable to:

- higher than previously estimated costs for items within the original scope of the programme;
- additional scope, such as including the Northern Lines, which was covered by an additional budget.

Currently, multiple system contracts have been signed, which includes a contract to retrofit approximately 175 intercity trains before 2027. Many activities are ongoing, especially to adapt interlocking and rolling stock equipment, and other trackside and onboard systems. The current planning foresees the start of commercial operation of all tracks could be later than what was originally planned. For example, OV SAAL[5] East and OV SAAL West were planned to be in commercial operation by 2029 at the latest (bandwidth 2027 – 2029), now, master plan version 7.0 shows that commercial operation could take until 2031 (bandwidth 2029 – 2031). The baseline for the latest planning is the master planning 7.0.

Programme structure

The ERTMS implementation is managed by the ERTMS Programme Directorate (PD), which is an independent part of ProRail and therefore separate from ProRail as infrastructure manager. The PD works together with the Implementing Organisations (IOs), which, for example are responsible for the retrofitting of infrastructure and rolling stock. The PD consists of 10 business units each covering different parts of the ERTMS programme. The Steering Committee is responsible for high-level governance and decision-making, while the day-to-day programme management is carried out by the ERTMS Management Team. More on the current programme structure can be found in chapter 4, theme 1.

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[5] Schiphol-Amsterdam-Almere-Lelystad

Scope

In the scope document (version 6.2), the Programme Directorate used five perspectives to describe the minimum required scope to maintain the functional transport system after replacing ATB with ERTMS. These five perspectives are: geographical, material (rolling stock), technical, user-related, and processes. Next to the seven line sections covered by the scope document (ver. 6.2) the Prognose Eindstand includes, among other activities, also Northern Lines.

Several track sections are already equipped with ERTMS in the Netherlands. Havenspoorlijn[6] is level 1, HSL-Zuid[7] and Betuweroute[8] are level 2, and Amsterdam–Utrecht and Hanzelijn[9], are both dual signalling fitted. Some of these track sections will be used for training purposes and knowledge retention, due to start in the second half of 2023.

Approximately 700 units of rolling stock are eligible for retrofitting. In addition, approximately 700 units of rolling stock already have ERTMS installed. However, these units are equipped with an older version of ETCS and require an update to the onboard systems to be compatible with the newly deployed track sections. Existing rolling stock will be upgraded to ETCS, Baseline 3 Release 2, (hereafter referred to as Baseline 3) which is the ERTMS Programme's Baseline choice.

The scope covers training more than 15,000 employees who will be using ERTMS in their work. This includes train drivers and train dispatchers. Additionally, there are thousands of maintenance and operational staff responsible for ensuring that the technology functions properly on the tracks and trains. The ERTMS implementation will affect these operatives to varying degrees.

Migration Strategy

On 31 August 2018, the Programme Directorate established the migration strategy (version 6.0) which describes the changes to the operational transport system when ERTMS is implemented. The migration plan (version 1.4) builds on the migration strategy and has 17 migration steps. The ERTMS Programme Directorate, responsible operators, and infrastructure manager collaborate in each migration step. A complete overview of the migration steps and their planning is shown in Appendix C. Together, these migration steps form the main milestones of the ERTMS Programme.

The management processes and systems required will be prepared in steps 1 and 2. To quickly resolve ERTMS malfunctions, carriers and operators must exchange information and collaborate more closely than they do now. And for this reason, processes need to be reorganised and systems modified.

Steps 3, 4 and 7 are related to upgrades/updates and retrofits of existing trains. Existing trains will be retrofitted with ERTMS and put back on the track, where they will operate under the existing ATB safety system. Converting these trains to ERTMS will provide information which can then be used to test how well the systems function and whether the Dutch railway sector can effectively handle this information.

After technical adaptation, two existing track sections with ERTMS in the Netherlands will be used to gain experience, this is migration steps 5 and 6. Train drivers will gain operational ERTMS experience on these track sections.

Only when all requirements, as specified in the migration steps, are met will ERTMS be put into operation. Examples of such requirements are the infrastructure being ready and the trains

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[6] Port of Rotterdam area
[7] Netherlands part of high-speed line from Amsterdam to Antwerp
[8] High-speed line from Port of Rotterdam to German boarder
[9] Lelystad–Zwolle

retrofitted. A test track section will be configured, a trial period has been allocated to test ERTMS functionality. The test track is designed to test and prove that ERTMS level 2, baseline 3 is functioning correctly, together with the systems onboard the trains running on the test track. In migration step 8, tests will be conducted to check that the Thales system is functioning properly with existing systems. If any issues arise during this phase, the system must be modified. Furthermore, the migration strategy requires the ability to roll back to ATB until the line is fully commissioned.

In migration steps 9 to 17, ERTMS will be implemented on the appointed track sections and Northern Lines. Removing elements which have become redundant, such as cables, is now included in steps 9 to 17 so a separate step for this is no longer required.

Sources

The following sources were used for chapter 2:

Source name	Sender	Document date
ERTMS programme plan for phase 2.0 realisation	PD ERTMS	10-04-2019
ERTMS progress report 18 (as baseline)	Ministry of Infrastructure and Water Management	03-04-2023
ERTMS progress reports 1 – 17 (as reference)	Ministry of Infrastructure and Water Management	30-06-2014 to 26-10-2023
ERTMS website (www.ertms.nl)	Public website	
Interviews (see appendix B)		
Letter to parliament regarding the 18th ERTMS progress report	State secretary for Infrastructure and Water Management	03-04-2023
Migration plan 1.4	PD ERTMS	13-04-2023
Migration strategy 6.0	PD ERTMS	31-08-2018
Planning 7.0	PD ERTMS	05-08-2022
Scope document 6.2	PD ERTMS	07-12-2020

3. Research questions, analytical framework and methodology

Composition of the expert committee

This research was conducted by a committee of six international experts, with ERTMS experience in the UK, Denmark, Norway, Belgium and Australia.
The Second Opinion Committee expert committee) consisted of:

- Pradeep Vasudev (London, WSP) – chair
- Thilde Restofte Pedersen (Copenhagen, Nordic Signals Consulting)
- Chris Binns (London, Crossrail International)
- Bogdan Godziejewski (Arnhem, Mott MacDonald)
- Jost Lüking (Baden (CH), R+R Burger und Partner AG)
- Ron Bailes (London, Railway Operations Group).

Research questions

The ERTMS programme Steering Committee asked the expert committee to answer the following six questions:

1. *Given the implementation strategy, will our approach lead to a transport system in which technical and operational aspects, including processes and human factors, are sufficiently taken into account? What risks does our approach expose? And have we taken sufficient measures to mitigate these risks?*
2. *How does our approach compare to ERTMS implementations elsewhere? Would a different approach be more suitable to the situation in the Netherlands? What risks does a different approach entail?*
3. *Is the project scope fully covered by the Final Financial Forecast? Does the forecast take the risks identified sufficiently into account? What do you specifically think of the unforeseen percentages used? Is the Final Financial Forecast complete and realistic?*
4. *Will we be able to deliver on schedule? What risks are involved? And what are the consequential cost risks of not delivering on schedule?*
5. *Taking specific circumstances in the Netherlands into account, are the expected ERTMS implementation costs in line with the costs in other countries? If not, which programme components contribute the greatest differences? Can these be expressed as approximate percentages? Can you explain these deviations?*
6. *What cost-saving opportunities do you see? Do these opportunities entail additional risks?*

The expert committee's analytical framework

Of the six questions posed by the Steering Committee, four are related to costs. However, to provide an overall second opinion on the Dutch ERTMS Programme, the expert committee considered they needed a broader view of the Dutch ERTMS Programme.

The expert committee therefore developed an analytical framework for the second opinion. In principle, the analytical framework is based on the expert committee's assumptions, which in turn are based on their experience of successful ERTMS implementations.

As a starting point, the expert committee formulated a central research question. The expert committee then conducted an analysis of the Dutch ERTMS programme based on this central research question. This put the experts in a better position to answer the six individual research questions posed by the ERTMS Steering Committee.

The central research question the expert committee formulated for the second opinion is as follows:

> *Can the Dutch ERTMS programme be delivered within the defined scope, time and budget? And is the present framework for managing the ERTMS implementation sufficient to achieve the objectives set by the government?*

Definitions:

Scope: as defined by the programme decision made in 2019 plus additions reflected in Prognose Eindstand

Timing: as defined by the programme planning version 7.0

Costs: Final Financial Forecast provided (Prognose Eindstand)

The expert committee has identified four themes, arising from this central research question, as being key to the second opinion:
1. programme governance and management;
2. technical management and scope;
3. system integration and integration management;
4. programme costs and forecast.

Having identified these four themes, the expert committee was then able to develop an analytical framework for the second opinion. This analytical framework is mainly based on the expert committee's experience of other ERTMS implementations and their assumptions of what is needed to successfully implement ERTMS. These assumptions are documented per theme. The expert committee could then assess whether and to what extent these assumptions apply to the Dutch ERTMS programme.

The expert committee's assumptions

The expert committee has applied its assumptions to the Dutch ERTMS programme by breaking down the assumptions into several sub-questions.

Assumption	Questions
The programme governance structures provide an adequate framework for actively managing the ERTMS programme and the government's objectives.	1. Is management, authority and decision-making being executed in structures established to achieve the government's objectives?
	2. Are the programme controls complete, structured, managed and used?
	3. Is the organisational model appropriate for an ERTMS programme?
	4. Is the planning feasible?
The technical management secures the various technical systems used by the Implementing Organisations and is capable of delivering systems that can fulfil the government's objectives.	1. Has the scope been properly understood and agreed by all stakeholders?
	2. Are the overall programme objectives flowing down as clear requirements to the Implementing Organisations?
	3. Is the procurement of the ERTMS system design, delivery, installation and integration being managed proactively?
	4. Is enough consideration being given to the degraded modes of operations and recovery from incidents?
	5. Is the PD managing and owning the final ERTMS product?
The integration management ensures that the many different capabilities match and interact to deliver an appropriate solution in reference to the government's objectives.	1. Is there enough focus on operational readiness?
	2. Does the migration plan have enough detail?
	3. Is there enough time allowed in the migration plan for any disruptions or slippage that may arise?
	4. Is the PD pulling together the knowledge and resources of the Implementing Organisations?
	5. Are design details being checked regularly and routinely against the (overall) programme requirements?
	1. Is the PE forecast complete and are all the necessary items (= 'must costs') included?

Assumption	Questions
The final financial forecast is covering the programme costs.	2. How is the programme financed?
	3. Does the PE forecast cover all items sufficiently?
	4. Are risks sufficiently accounted for?
	5. Are the costs of Dutch ERTMS programme aligned with those of peer programmes/projects in other countries?
	6. Are there any cost-saving opportunities?

Methodology

To test and validate their assumptions, the expert committee used a mixed methods research approach, combining elements of quantitative and qualitative research. The following research methods were included in the methodology to answer the questions and to test their assumptions:

- Participating in a 2-day workshop introducing the expert committee to the approach to the ERTMS roll-out in the Netherlands (15-05-2023 and 16-05-2023);
- Studying the documentation, see appendix A for a full list of the documents (May – June – July 2023);
- Conducting 28 interviews (refer to appendix B for a full list of interviews) (May – June – July 2023);
- Holding validation sessions on the findings with the ERTMS PD and all interviewees (06-07-2023);
- Presenting the findings to the Steering Committee (11-07-2023);
- Having the report reviewed by experts from within and around the programme (August 2023).

This methodology has resulted in the findings as they are presented in the following chapters of this report.

Second Opinion Committee's approach to the report

The expert committee has drawn up a second opinion of the Final Financial Forecast [Prognose Eindstand] based on information provided by the Program Directorate, the Implementing Organisations and the Ministry of Transport. The expert committee has analysed this information in the light of the broad experience of its members with ERTMS implementation across several countries. This report aims to provide the ERTMS Steering Committee with valuable insights based on that experience. These insights are therefore based on the information provided to the committee, and the experts' interpretation grounded in their experience.

4. Expert committee's assessment of the themes

To draw up this second opinion, the expert committee developed an analytical framework as a reference for its audit. As mentioned in chapter 3, the analytical research framework describes several aspects that the committee expected to find, presented here in four themes:

- Theme 1: Programme governance and management
- Theme 2: Technical management and scope
- Theme 3: System integration and integration management
- Theme 4: Programme costs and forecast

This chapter discusses the themes in the order mentioned above. Each theme starts off with a **framework** explaining the focus of the analysis, followed by relevant **background** information to the theme. Then, the committee's **findings** are presented, and the chapter closes with the **conclusions**. The recommendations are not included in this chapter, these are presented in chapter 7.

Theme 1: Programme governance and management

Framework

In this theme, the expert committee accounts for its findings and recommendations in relation to the governance and management of the Dutch ERTMS programme.

This theme analyses whether technical management has been properly included in the ERTMS programme by looking at the following topics:

1. Is management, authority and decision-making being executed in structures established to achieve the government's objectives?
2. Are the programme controls complete, structured, managed and used?
3. Is the organisational model appropriate for an ERTMS programme?
4. Is the planning feasible?

The Dutch ERTMS implementation is a programme – and to frame the governance and management thinking applied in the second opinion, it is important for the committee to share the view of a programme and its characteristics.

The expert committee views a programme as a collection of multiple inter-related projects and initiatives that need to be managed and coordinated together to achieve the strategic objectives and outcomes of the programme. A programme is characterised by achieving long-term strategic goals, which impact the current state of affairs of business operations and therefore introduce the need for the business to transform significantly. Programmes usually involve ongoing activities, changes, and adaptations over time. A programme can be distinguished from a project in the sense

that a programme delivers a solution, while projects deliver specific capabilities which contribute to the solution and which would not lead to the outcome by themselves.

The focus of the analysis in this second opinion was to establish a clear picture of key elements of the Dutch ERTMS programme governance and management.

For the governance of the programme the committee has been looking at the role and accountability of the governing bodies, how oversight and decision-making takes place, as well as the assurance of the realisation of political objectives by the programme implementation. To gain an impression of the tactical and operational programme governance, the committee focused on the overarching structures of the day-to-day management: Are programme management disciplines exercised? And How do Programme Directorate and Implementing Organisations work together?

Findings

From the materials provided by ProRail and the Dutch ERTMS Programme Directorate, as well as the interviews and workshops conducted, the expert committee has summarised the main findings relating to steering the Dutch ERTMS Programme under the themes **programme governance** and **programme management**. These will be addressed separately.

Programme governance

Programme governance concerns the programme's structural organisational model, the relationship between the governing bodies and the processes around decision-making within the programme and towards its sponsors and owners.

The steering committee

The ERTMS Programme is largely structured as a collaborative effort of the entire railway sector. The Steering Committee is responsible for governance and decision-making at the transportation level.

The Steering Committee consists of executives of the participating parties and is chaired by the Ministry of Infrastructure and Water Management (IenW). The Steering Committee meets four times a year, or more often if necessary. Agenda items consist of strategic, tactical and operational topics raised by the Steering Committee chair and other committee members on an ad hoc basis. Risks experienced by stakeholders and a few recurring items including the six-monthly reporting to Parliament are added to the agenda as necessary.

Based on interviews and the documents obtained, the expert committee finds that the Steering Committee is not wired, organised, or meeting frequently enough to be in tune with what is going in the programme. At this meeting frequency, it cannot properly meet the steering needs for the stage the programme has now entered. When a programme is in the delivery phase, the need for frequent and decisive management is acute. The current Steering Committee meeting frequency is too low, and when meetings are held, they are too short to cover all relevant topics. As the agenda topics are a mix of strategic, tactical and operational issues as well as risks experienced by the stakeholders, it seems that the meetings are somewhat unfocused.

Furthermore, the information provided for the meetings is based on outdated and retrospective reporting. When a programme is in delivery mode, reality is moving quickly. This means accounts of developments and how these developments impact on the programme must be as recent as possible. A steering committee working with incurrent information is greatly limited in its ability to

make decisions and actually steer the programme. The programme needs steering at a strategic and tactical level, so provisions for deviations to maintain progress and momentum can be made. The current steering committee setup does not allow for this.

Programme Directorate, Implementing Organisations and ability to deliver

The Dutch ERTMS Programme is managed by the ERTMS Programme Directorate. The Programme Directorate has been established to direct the implementation of ERTMS. The Programme Directorate, under the leadership of the programme director, is placed within ProRail. This is done in a semi-detached form, where the Programme Directorate is not integrated into ProRail's regular organisational structure. The Programme Directorate reports directly to the Board of Directors of ProRail and IenW.

The expert committee has also looked into the role and authority of the Programme Directorate by interviewing people within the Programme Directorate, the Implementing Organisations, and other stakeholders. In general, the ERTMS Programme Directorate perceives itself as a facilitator and coordinator of various programme activities, not as a manager of the ERTMS solution which will deliver on the capabilities to secure the government's five objectives. This bears significant impact on the potential for the Programme Directorate to effectively steer and manage the programme delivery. Note: this observation is not a reflection of the individuals who fulfil specific roles, but rather an observation of the perceived responsibilities.

The day-to-day programme management body is the ERTMS management team (MT). This consists of the Programme Directorate managers, infrastructure manager representatives, operators and the Ministry. The MT is led by the Programme Director, who also heads the entire Programme Directorate. The MT meets once every two weeks. The expert committee understands that the MT is not given any collective programme progress updates or assessments at these meetings, other than the reports going to the Steering Committee and Parliament. This means that the MT does not have a more frequent formal and collective assessment of the programme's progress, risks and issues regarding the programme's scope, deliverables, costs and plan to act upon.

To support the ERTMS MT in managing the programme, round-table meetings are organised at programme level to discuss options and prepare decisions. These round-table meetings are attended by representatives from the various Implementation Organisations and the Programme Directorate. Topics discussed include migration strategy, safety, system integration, schedule, and risks. The expert committee acknowledges the need and use of these round-table meetings or working groups across the programme and Implementing Organisations, and the structure is recognisable from other programme settings. However, during the interviews it became apparent that the round-table meetings are not viewed or experienced by the Programme Directorate or Implementing Organisations as tactical bodies, where risks and issues are discussed, acted upon and decisions prepared. The expert committee's impression is that the round tables are mostly used to share some, but not all relevant information. This significantly impacts the ability of the MT to manage the programme.

The Programme Directorate is divided into 10 units involving around 70 people. The business units cover different aspects of the Dutch ERTMS Programme including design, project office, migration, planning, communication, reporting and stakeholder management. Through conducting interviews and studying the documents provided, the expert committee realised that the IOs manage their projects somewhat detached from the Programme Directorate's control. This is partially due to how the reporting structure currently works, whereby reporting only goes upstream and is only given on issues that the IOs consider relevant to the programme. However, there is not at present an

efficient mechanism for referring back down the escalation path to manage the consequence at the point of the issue's occur. Neither is there a mechanism for sharing knowledge between IOs. In addition, there may be programme level issues that can only be resolved by the IOs and therefore this two-way reporting is important. As a result, the IOs are continuing to do what they are doing in isolation, disconnected from what the programme needs them to do.

The needs of the digital railway differ from those of the conventional railway. The expert committee has therefore been looking closely at the management of the IEP[10] programme. The IEP programme is key to managing ProRail's ERTMS infrastructure deliverables to the ERTMS programme. The expert committee observes that the IEP structure is based on a traditional approach to infrastructure projects and not yet sufficiently oriented to the large IT technological changes which are needed to realise the objectives of introducing ERTMS. One of the consequences of ERTMS is that change management of railway systems needs to be strengthened, as the digital signalling and train control systems are very sensitive to changes in the physical and IT infrastructure. It is clearly a challenge to all infrastructure managers to manage the railway configuration while implementing lengthy (in time) and intrusive systems such as ERTMS. This requires very different and rigorous structures, and integration efforts also inside ProRail. Until now, the IEP programme has been above ProRail business units – much in the same way as the Programme Directorate is to the Implementing Organisations. The expert committee has been informed that changes to this model are currently being implemented to accommodate the different needs when managing technology projects.

The expert committee commends ProRail on creating the IEP programme to oversee the various activities of the business units, because this shows that ProRail understands the need for a stronger hold on change management in a digitised railway, where IEP must play a significant role. However, the expert committee observes that the IEP programme does not have enough authority to influence the business units' priorities. This is significant because all these activities can, in principle, affect the IEP programme's ability to provide the ProRail deliverables to the ERTMS Programme.

Furthermore, the expert committee has observed that ProRail is using parts of the railway infrastructure maintenance budget (BOV/EOV) to fund its deliverables to the ERTMS programme. When parts of the scope are financed from the BOV/EOV budget, ProRail is not solely responsible for these scope parts. The scope is supervised by the Programme Directorate and the financing of BOV/EOV is supervised by the Ministry through their supervision on the BOV/EOV budget. The responsible Director of Rail from the Ministry is also a member in the steering committee ERTMS. This is financially confusing and complicated from a management and governance perspective. Combining different infrastructure renewals with different funding sources under one project can make sense in a dense railway upgrade plan, but the complexity needs to be met with procedures and process which match this complexity.

Another point the committee would like to make is that safety integration, which is currently in the hands of ProRail, needs a more central approach at Programme Directorate level. The Programme Directorate's role in the overall systems integration also needs to be better defined. Proactive management of Safety Approvals and interoperability certifications at the programme level with discreet IO inputs and approvals would better suit the needs of the programme.

To strengthen the accountability processes in the Dutch ERTMS Programme, the projects within the IOs need to become increasingly responsive to the Programme Directorate. In the absence of the single entity owning overall responsibility, the integration of the solution, and the associated

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[10] ProRail's ERTMS Implementation [Implementatie ERTMS ProRail]

implementation plan, is at risk. As the overall responsibility and accountability for the political objectives at programme level is lacking, this creates a significant risk of the ERTMS solution not fulfilling its purpose and delivering the capabilities needed to realise the expected and envisioned benefits of ERTMS.

The Programme Directorate must therefore play a larger role in the supplier technical solution management and integration of the IOs across the programme. It is the expert committee's clear perception that the Programme Directorate must actively seek to transition from the current conceptual stage to the delivery stage. This requires a deeper level of involvement, which can be achieved by revising the governance mechanisms within the Programme Directorate and between the IOs and the Steering Committee.

Programme Management

Programme management focuses on the structural facets of the programme and the day-to-day-management of the scope, resources and time schedule. This includes discipline management, organisational setup, and capacity. For discipline management, the ERTMS Programme planning and reporting has especially caught the eye of the expert committee, as this is directly linked to the ability to manage the programme and the outcome, i.e. the government's objectives within budget, time schedule and scope.

Planning

The implementation plan has three levels:
1. migration strategy
2. programme plan
3. project plans.

This section concentrates on the migration strategy and the programme plan.

The current Dutch ERTMS Programme migration strategy is defined in 17 migration steps. The expert committee views the migration strategy as a conceptualisation of the overall programme approach – which is a good way of grasping the flow of the programme at a high level. However, the migration strategy must be turned into something with more 'nuts and bolts', as this will reveal what is actually needed to drive the implementation at a more practical level. The expert committee currently observes that the migration strategy is still driving the planning, where the plan is very high level and deterministic, and the migration steps are not divided into actionable deliverables on a more line-by-line, project-by-project, and discipline-by-discipline basis.

As detailed in the Systems Integration section (theme 3), the migration steps are currently at a concept level and need to be developed to a lot more intricate and comprehensive detail. This will enable holistic management at railway level and will also activate delivery management as the implementation railway is divided into measurable deliverables. However, as things stand today, there is not enough detail to do that.

Moreover, the way the migration steps are defined increases the risk of overrunning the schedule. Delays to the first few migration steps (train upgrades, installing trackside equipment etc.) will automatically push the whole schedule out. As a direct consequence of this, the delivery of several lines is currently planned in a very short period at the end of the programme plan. To illustrate how the roll-out pace normally picks up during a programme life cycle, the figure below shows the pace of the ERTMS, level 2, baseline 3 implementation in Denmark and Belgium.

This figure compares the roll-out rate in track km as planned in the Netherlands to the actual ERTMS Level 2 roll outs in Belgium and Denmark. The first year in this figure is the year when the first ERTMS Level 2 BL3 went into commercial operation. Note that the envisaged speed of roll out

in the Netherlands is much higher than the actual rate achieved in Denmark and Belgium. Also note that pace of commissioning ERTMS Level 2 expressed in track km in other countries (Germany) is similar to that in Denmark and Belgium.
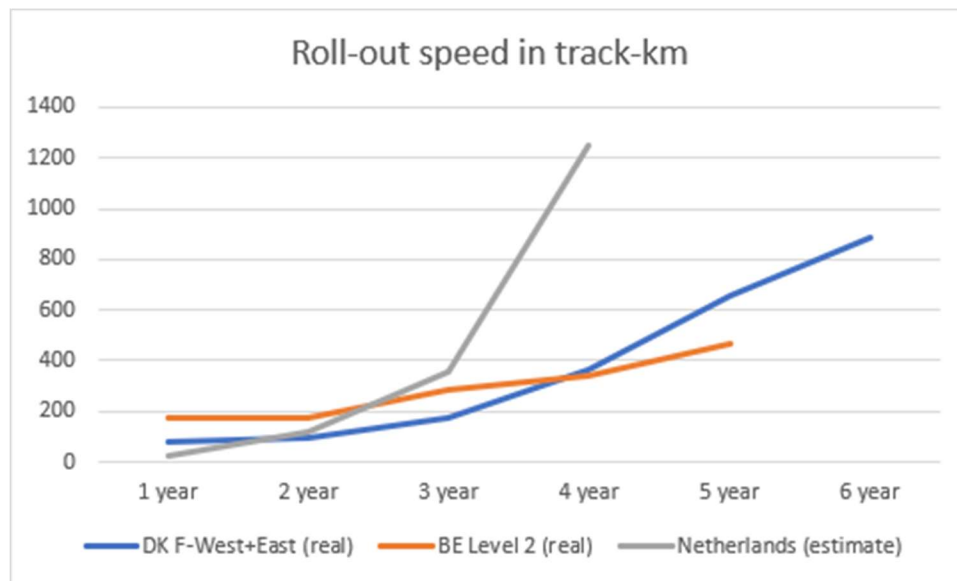

Figure 1: Roll-out speed in track km (year 1 is when the first line went in to commercial operation)[11][12]

The expert committee wishes to state that normally the roll-out pace picks up during a programme, as the effects of the learning curve kick in. The figure shows how this happened in Denmark and Belgium. However, the expert committee does not envisage this happening, given the delivery structure of the Dutch programme, where different engineering companies are designing in parallel and different contractors are installing. The expert committee does not see that the learning curve will increase in such a pace, that planned delivery rates will be achieved as per master plan 7.0.

There is little evidence of development of an integrated programme schedule across the IOs, nor detailed management and control of this integrated schedule. The Programme Directorate's current approach seems limited to monitoring and reporting on the migration plan, rather than managing and controlling the plan. It is therefore highly likely that, without optimisation and adjustment, the overall schedule will drift further and further out. For example, there appear to be few or no firebreaks between IO schedules. Also, it became apparent during the interviews, that the IOs were critical about the understanding of any impact slippage may have on other activities, and hence the impact on the overall programme.

Moreover, as the migration strategy and programme plan stands, there is an overarching risk that the PD and IOs are not aware of capacity constraints in critical functions and disciplines, such as design, testing (Railcenter test facilities in Amersfoort), and installation resources. Also, the sheer requirements for when, where and how much equipment and infrastructure may be out of service does not appear to be taken into account at present. Consequently, the expert committee finds that the plan does not sufficiently include test activities, safety and interoperability activities for equipment and infrastructure. It is well-known that these activities always constrain plans considerably. More specifically, the expert committee finds that equipment and infrastructure management as well as the safety and interoperability certification process are underestimated and unmanaged at programme level. This poses a serious risk to the programme's ability to deliver.

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[11] Usually reports talk about route km – take note that this figure is in track km.
[12] The 4 year rollout period is on the basis of the deterministic planning.

The Programme Directorate organisation needs to track all the dependencies between companies to make sure that the railway is running in a safe way, and that all related open points are considered, mitigated and closed.

The expert committee believes the approach taken with the integrated programme schedule is correct. However, a more detailed schedule is necessary. The programme schedule needs to be integrated at more levels with the IOs to get the right feedback, allowing the Programme Directorate to improve its management of the programme plan and reduce risks such as schedule overrun. Currently, by the time the Programme Directorate realises there is a delay, there is an imminent risk that most of the embedded float/firebreak has already been eroded. Managing this risk requires an increased level of detail and transparency between all parties.

The current programme plan is ambiguous and unconvincing, with bandwidths indicating uncertainty. This lack of clarity among stakeholders and IOs, results in a lack of trust of the plan, and the resulting programme plan does not therefore enjoy the necessary stakeholder buy-in. To transition the programme from a conceptual to a delivery mode, the key priority should be to set a realistic plan, as it is impossible to steer a programme towards a deadline that is not universally perceived as even the slightest bit achievable.

The deterministic programme plan is currently set to be complete in 2029 according to the programme decision planning, and in 2030 according to the deterministic planning 7.0. This has been assessed by the programme to have a 1% probability of success; the P85 (85% probability of success) plan extends this plan by two years to 2031. During the interviews, it became evident that the IOs are operating based on the P85 schedule rather than the deterministic schedule, however there is still perceived doubt about its deliverability. The second opinion committee observes that the P85 schedule is 'back-end loaded', indicating a high level of parallel working in 2030/31, whereby all 8 lines complete their delivery in 2031. This poses several issues in relation to deliverability. It places high demands on resources (people, possessions, material, training, assurance etc.), does not address a learning curve to be able to achieve such a high delivery rate and places a risk on the continued operation of the network during delivery. The expert committee therefore considers the plan unrealistic. The schedule does not adequately consider the practicalities of delivering on such a busy network, nor the demands this will place on the industry to deliver. As a result, the expert committee recommends the schedule be reassessed to consider these points and a deterministic schedule be drawn up that will properly address these issues, and provide a more evenly loaded programme.

Reporting

The PD's reporting to the Steering Committee and above it, currently in place, is infrequent with a low 'beat-rate' of progress letters only and reports twice a year each. The reporting frequency within the programme is currently only three to six months, as there is no progress programme outside the reporting to the Ministry and Parliament. The IOs report more frequently to the Programme Directorate, but this is not followed up by joint programme status reporting, in which the Programme Directorate assesses the collective IOs progress. It is the expert committee's clear assessment that in a programme of this size and complexity, a reporting frequency of anything less than once a month will cause issues for exercising efficient programme management. As such, the current reporting frequency of three or six months is too low. Furthermore, there is a clear need for a higher reporting frequency, as the information in the reports tends to have become old news upon arrival. At the current rate, the IOs will take decisions in isolation, as the Programme Directorate will not have the proper information to make timely interventions.

Again, this highlights the risk of inefficient or directly counterproductive decision-making, resulting in increased costs and project overrun. The expert committee also recommends considering

whether the current reporting method is still appropriate. From a content standpoint, the current reporting is largely qualitative and so does not help determine whether the progress made was acceptable. As things currently stand, different reports about the same project or topic could arise from different parts of the ERTMS programme. Quantifying relevant parts of the reporting will increase the validity and factual basis of the reports. This will also align opinions regarding the pressure points and bottlenecks in the programme's progress, and how to deal with these.

The expert committee believes more quantitative reporting with adequate KPIs and dashboards is necessary to establish the reporting as a tool for programme management which can be actively used for steering the programme. As of today, the reporting is not used as a management tool. It is primarily a one-way reporting regime from the IOs up to the Programme Directorate and further to the Steering Committee and the Ministry/Parliament. The current reporting does not allow for tactical management. As a result, information is assembled into a report, which is then sent out. Often, events are seemingly reported 'after the facts', which does not allow the Programme Directorate nor the Steering Committee and the Ministry/Parliament to manage or help the IOs. Moreover, the reporting is not used to produce a common narrative on the status of the programme, and thereby serving as the one and only story about progress, risks and issues. Rather, reporting should assist the Programme Directorate in managing communication about the programme. This is crucial to create a strong impression of the programme and not spread confusion about how the programme is doing. Reporting as it is structured today, is therefore not fulfilling the important role of being a first-degree management tool.

Other programme disciplines and control

Referring to the observation of the Programme Directorate being more of a facilitator than manager, it is also evident to the expert committee that the Programme Directorate is challenged in controlling other typical programme delivery areas besides reporting and planning. The lack of controls includes scope, change/configuration control, safety & interoperability, supplier management, risk management, issue management and finances. The Programme Directorate must strengthen its technical, operational, and managerial resources. It needs more programme-experienced expert resources to manage the programme disciplines. This is a very complex and ambitious programme and requires people able to lead from a position of knowledge and expertise on multiple fronts: technical, scheduling, integration, operational and programmatically.

The expert committee also believes it is important that the Programme Directorate keeps an eye on the IOs suppliers. It should also monitor production status and progress of certain deliverables crucial to the planning. An improved understanding of suppliers' progress would help inform the Programme Directorate. The expert committee also suggests a shift to a more intervention-based approach to risk management. A closer link between risk management and issue management will allow the Programme Directorate to filter risks, so it can give priority to mitigating the most pertinent risks if relevant aspects of the programme start slipping.

The initiative to establish programme disciplines such as testing & commissioning, system integration and migration are considered positive, but these disciplines need strengthening and reinforcing to deliver the outcomes needed for the programme. This is also pertinent for risk management. A new risk management plan has recently been implemented in the programme. Related to this, and based on the interviews conducted, the expert committee perceives that the risk culture is changing and empowering employees to speak up about risks related to the programme and projects. However, enforcing the programmatic responsibility and approach would benefit the programme risk management. The expert committee also believes that alignment between the PD and IOs regarding their roles within risk management is affected by the PD's

reluctance to intervene. This is causing limited visibility into the risks of the IOs on the programme level.

Stakeholder management and perception

The expert committee also observed that regional and freight operators see obstacles and are dissatisfied with the programme as they do not perceive that the ERTMS system will benefit them.

Most initiatives the expert committee has come across in interviews have been initiatives between ProRail and NS. There was little mention of initiatives established with regional and freight operators in mind. While the expert committee acknowledges that some initiatives involve other operators, it is also clear to the expert committee that something needs to be done to pull the regional and freight operators closer into the programme, and to make them feel part of the programme and its success. The expert committee acknowledges that freight operators request full funding for the changes they need to make, such as to their locomotives and driver training. It is clear to the expert committee that a funding discussion will need to take place at some point, and that this is also a topic for debate at government level. As things stand now and due to the limited involvement of regional and freight operators, the expert committee observes resistance to the ERTMS programme. The freight operators do not perceive enough benefit from the programme to be motivated. Instead, they believe the ERTMS deployment will mean additional costs without any return in terms of improved journey times or more track slots. To motivate the freight operators, the expert committee recommends taking an approach that aligns with their business case.

Conclusion

Based on the information available, the expert committee concludes that the current programme governance and management, including the steering committee setup as it stands today, is not fully effective in serving the needs for efficient programme management.

Programme Governance

The Steering Committee was established to engage decision makers at the highest levels of the Ministry with stakeholders, all the way to the Implementing Organisations. Currently, the Steering Committee mainly operates as a receiver of reports and manager of stakeholders.

There is a need for *actual* steering of the programme. The current programme governance and steering committee setup does not fulfil this need. As a result, the governance needs revision, and the steering committee needs to change in composition, mandate, and authority. Alternatively, an additional layer or another version of the MT can help the programme steer effectively and make tactical decisions at the rate necessary, as well as prepare modifications to the strategy based on the developments and progress made during delivery. This could then leave the Steering Committee as a means of informing senior stakeholders, making high-level strategic decisions and being responsible for maintaining and following up on the government's overall objectives.

The Programme Directorate is not managing the implementation of ERTMS as a programme and the expert committee perceives that, at present, the Programme Directorate does not have the power or authority to do so. Instead, the overall programme organisation currently consists of a portfolio of projects, with a programme overlay but without the necessary authority. As a result, the implementing organisations (IOs) are currently managing their own projects somewhat detached from the Programme Directorate's control. The Programme Directorate needs a stronger mandate to change its role from 'facilitator' to 'manager' of the ERTMS roll out so it can lead the programme successfully.

Programme Management

Several of the programme management disciplines necessary to implement ERTMS are in place at the programme level *in principle*. *In principle* because the Programme Directorate's and Implementing Organisations approach seems to shy away from owning the whole programme and making the effort which is absolutely necessary to manage a solution.

This lack of efficient controls and tying together the different deliverables to a solution is visible. When looking at the present management structures as they are not sufficient for a programme of this size and complexity. Furthermore, communications to feed reporting, monitoring and controls is too infrequent and primarily one-way, In other words, it only reports isolated historic progress rather than a continuous and common narrative of developments, progress, risks, issues and mitigations, to serve as a proactive tactical management mechanism.

The reason for the lack of efficient controls might be, to a certain extent, connected to the migration strategy and the corresponding implementation plan still being very conceptual. Even the most recent planning for the ERTMS roll out, version 7.0, has not really been transformed into a deliverables plan. Based on comparisons of the Dutch ERTMS, level 2, implementation planning to the rolling out of ERTMS in other European countries, the expert committee considers the envisaged roll-out planning in the Netherlands is very challenged and virtually unrealistic.

Sources

These sources were used for theme 1 (programme governance and management):

Name of source	Sender	Date of document
ERTMS progress report 18 (as baseline)	Ministry of Infrastructure and Water Management	03-04-2023
ERTMS progress reports 1 – 17 (as reference)	Ministry of Infrastructure and Water Management	30-06-2014 to 26-10-2023
Letter to parliament regarding the 18th ERTMS progress report	State secretary for Infrastructure and Water Management	03-04-2023
Migration plan 1.4	PD ERTMS	13-04-2023
Migration strategy 6.0	PD ERTMS	31-08-2018
Multiple interviews: see appendix B	Multiple sources	May – June – July 2023
Planning version 7.0	PD ERTMS	05-08-2022
Programme plan for ERTMS implementation phase 2.0	PD ERTMS	10-04-2019
Rail map 4.0	PD ERTMS	03-05-2019
Scope document 6.2	PD ERTMS	07-12-2020
Steering Committee meeting documents (agendas, minutes, memos and decision lists) from meetings between December 21st, 2021 until March 9th, 2023)	ERTMS Steering Committee	2021 – 2023
Website ERTMS (www.ertms.nl)	Public website	

Theme 2: Technical management and scope

Framework

In this theme the Second Opinion Committee (expert committee) provides an assessment of the technical management and scope of the programme.

The analysis focuses on how the Programme Directorate secures the different technical deliverables of the Implementing Organisations, so that the Programme Directorate can deliver the systems that can fulfil the government's objectives.

This theme analyses whether technical management has been properly included in the ERTMS programme by looking at the following topics:

1. Has the scope been fixed and equally understood by all stakeholders?
2. Are the overall ERTMS programme objectives flowing down as clear requirements to the Implementing Organisations?
3. Is procurement of the ERTMS system design, delivery, installation and integration being managed proactively?
4. Is enough consideration being given to degraded modes of operations and recovery from incidents?
5. Is the Programme Directorate managing and owning the final ERTMS product?

Background

An Operational Concept Description document (OCD) describes operational concepts for migration steps. An OCD is intended as a description and not a specification. In the context of the ERTMS Programme, the OCD sometimes acts as a source of requirements that cannot be derived from other documents (for example: Scope and Programme of Requirements). The purpose of this OCD is twofold. First of all, it is the communication tool within the PD and between the PD and surrounding parties including the Implementing Organisations (IO), describing the impact of ERTMS from the operational context. Second, it is the basis for justification of transport system requirements to the extent they cannot be derived from the SMART PVE and/or from the scope document. This includes requirements related to the operational use of the transport system to be realised in the migration step.

Findings

Scope freeze

From the ProRail briefing at the initial workshop, and from later interviews, the expert committee became aware of possible delaying factors in the future, significant complexity, and risk arising from the aspirations to try out new versions of ERTMS as well as new concepts such as ATO trials and Hybrid Level 3. This possibly causes delays while discussions on these techniques are ongoing. This will also add development risks into projects which should by now be delivering on the fixed and known scope. According to the OCD and the programme briefing, the first 8 lines for which ERTMS is being implemented represent a small proportion of the overall network in the Netherlands. Based on the OCD information and workshop briefing the ERTMS programme covers 600 route-km (predominantly double track) which represents about one third of the Dutch railway network. So, it would seem to make logical sense to experiment with developing new approaches

to ERTMS such as ATO and Hybrid Level 3 away from the committed deliverables: the first eight lines. This will take development and programme risks away from the critical path of the ERTMS programme.

In addition, there seems to be confusion about whether axle counters are to be implemented or not. This confusion appears to be linked to both the lack of requirements flowdown, as well as the unrealistic aspirations for testing and commissioning.

From government objectives to system requirements

From the interviews carried out across multiple parties, it seems that the top-level SMART requirements have been disaggregated to an extent, but none of the project delivery IOs appear to be monitoring the satisfaction of their portion of those requirements. Flowdowns are needed in a way that makes sure people understand the objective of the programme, and in a way that they can understand their part in making sure this objective is achieved. The Programme Directorate must then make sure all of those individual components come together to deliver the programme objectives. These flowdowns need to be developed more robustly to make sure that all requirements are allocated. And as part of the planning, the sum of the parts must also add up to the whole model of the railway performance.

This also means that someone will have to manage the assumptions in every model to make sure they are consistent across the railway. All in all, each Implementing Organisation (IO) should be aware of their part in delivering overall requirements, and each IO should be monitoring how compliant their current stage of work is to those requirements and should be highlighting any deviations.

The following are examples of top-level requirements:

- E-1A – 2% - 3% reduction in technical driving time
- E-2A – 25% reduction in follow-up time
- E-26A – 15% reduction in minimum crossing time over all ERTMS equipped corridors.
- E-12A – same or reduced crossing closing times
- E-13A – digital cyber security requirements
- E-21B – planned nuisance for travellers and shippers during conversion of infrastructure to ERTMS to be weighed up in the triangle of quality, costs, and nuisance.

On E-21B specifically, the proposed four-month closure of a line for integration testing and operational trials seems particularly high on nuisance value. The expert committee considers this a very surprising position when compared to benchmarked countries that have implemented ERTMS projects. There will be no guarantee of success at the end of the four-month period, considering that the find-to-fix times associated with any software related issues picked up is typically in excess of four months. Far better techniques are commonly used, such as over-and-back testing, and multiple shorter closures, e.g. during periods where travel is commonly reduced due to public holidays. See, also, the comments regarding the effectiveness of axle counters in support of over-and-back testing and commissioning approaches.

A review of the Operational Concept Description (Migration steps 9-15) dated 21 April 2023 v0.8, lists many open actions – of 23 open actions, 19 are listed as 'not planned', 2 are 'to be dropped', one is 'included in planning' and one is listed as 'not yet scheduled'. This seems a concerning position and has been reinforced by feedback given at some of the interviews, which is that the programme has concentrated on the simpler 'happy flow' of requirements; in other words, concepts for how the systems will be operated and function in normal conditions, leaving the more difficult situations to emergencies, and operation in degraded modes as open items. Experience worldwide, as well as in the Netherlands, from initial implementations of ERTMS lines, is that the degraded

modes of operation are the more difficult things to implement and will tend to delay the programme when performance and recovery requirements cannot be met.

The GSM-R network is being upgraded to GPRS / ETCS data performance requirements. This is necessary for ETCS Level 2 operation for all eight ETCS implementation lines, and more widely upgraded across the Netherlands. The expert committee has been told at several times that this upgrade programme is running well ahead of the required delivery milestones and has not been followed up further in this 'second opinion' review.

Chain Management development is using the Information Technology Infrastructure Library (ITIL) framework for its delivery. This seems like a good approach to this area of the programme. However, it is recommended that more emphasis is given to using the entire lifecycle and making sure that Service Strategy has been documented and checked against the top-level disaggregated requirements. It was not clear from the interviews in this area whether traceability had been carried out back to the top-level requirements. Even if this has been done, the gaps and open actions from the Operational Concept Description document would have been highlighted again.

In relation to Performance and Reliability, Availability, Maintainability and Safety (PRAMS), the ERTMS programme as it stands today focuses primarily on delivering ETCS Level2, baseline 3 on straight tracks. The current approach results in ATB islands around the major stations, where there is a transition to legacy systems. It is noted that, on the track sections that are in scope all stations will be converted to ERTMS, however, this will not include major stations like Amsterdam, Utrecht and Rotterdam. The trains will be dual fitted (with STM) because they will run on the ATB-tracks, on routes beyond the fitted lines. The transition period for the entire network is the driving factor behind this decision. This will cause a performance issue, as it means all trains must be dual fitted and will need to transition successfully as they enter the station area, in these major stations the impact of such disruption is major to the network. Furthermore, a high number of transitions during the train mission has implications for the overall performance (see also assumptions in Subset 91). Therefore, these aspects should be managed at the highest level, otherwise these kinds of complexities will decimate the railway performance. There does not seem to be much evidence of a proactive approach to PRAMS modelling, and disaggregation of requirements to each of the Implementing Organisations, with the corresponding regular check of requirements satisfaction at the overall railway level.

Configuration management

The Second Opinion Committee (expert committee) considers the programme would benefit from a more robust approach to software management, meaning configuration control of specific software from each supplier as well as suites of software. This relates directly to the approval certification and whether all the combinations of all these levels of software have been tested together.

Procurement for the onboard systems is not necessarily consistent. It is noted that the procurement strategy was chosen by trainset, with the intention to involve the train OEM in the integration and homologation. Considering this approach, there is a need for improved management to ensure that the configurations and specifications of each of the onboard systems are compatible, will meet the outcome and work together with the trackside systems.

The expert committee felt that there is an anticipation of changes in the numbers of different software releases. It is likely there will be many more software releases than have been planned for today, and the implication of these changes on the schedule are significant. The expert committee recommends the Programme Directorate (PD) reinforce their approach to Software Configuration Management and establish a proactive software management team that promotes collaboration across all the IOs. At the same time the PD needs to be authorised to determine the

software build deployed to each lab, test site, and railway line controlled by the PD at any moment in time.

Conclusion

Based on the available information, the Second Opinion Committee (expert committee) concludes that the Programme Directorate (PD) is not providing strong enough technical management of the ERTMS Programme. In delegating detailed systems engineering to the Implementing Organisations (IOs), it is not sufficiently informed whether the individual components will meet the overall objectives of the programme.

Review of the Operational Concept Description document (OCD) indicates good levels of detail for normal operation (the 'happy flow') of the ERTMS railway but has many outstanding actions that are not yet planned regarding recovery after incidents and operation of the railway during degraded modes. In the expert committee's view, the degraded mode operation and recovery from incidents are the more difficult things to get right and will most likely involve updates to procedures, resources and systems becoming necessary. These things generally need priority attention and should be resolved as early as possible in the programme, as they present a high-risk to completion.

The expert committee's understanding is that most of the past implementations were in the greenfield environment and as overlay. The change to a brownfield environment and ETCS Level 2 only railway will need to be carefully assessed from an operational point of view.

The expert committee welcomes the use of the Information Technology Infrastructure Library (ITIL) framework for the delivery of Chain Management but is concerned that not all aspects of the ITIL framework appear to have been utilised. For example, there is no sign of the Service Strategy having been documented nor of that being compared to the top-level requirements from the ERTMS Programme.

There are gaps in the systems engineering flow of information especially regarding performance and benefits requirements, so it is not clear whether each Implementing Organisation (IO) has linked the disaggregated requirements of the ERTMS Programme to its own work. The expert committee concludes that Performance, Reliability, Availability, Maintainability and Safety (PRAMS) modelling has not been carried out in sufficient depth to give clear disaggregated requirements to the various IOs, so that when they implement their parts of the system the overall functionality can be demonstrated to meet the overall railway-level PRAMS requirements.

Sources

The following sources were used for theme 2:

Name of source	Sender	Date of document
Migratiestrategie 6.0	PD ERTMS	31-08-2018
Actieplan kwartiermaker ketenbeheer ERTMS ProRail v1.0	ProRail	24-11-2022
Commissioning advise Start Experience driving Hanzelijn en Amsterdam	PD ERTMS	30-01-2023
Commissioning Teams ppt	PD ERTMS	23-04-2023
Eerste Assessment Proces Ketenbeheer ERTMS	*ProRail*	21-02-2023

ERTMS – Operational Concept Description (OCD) van migratiestap 9 t/m 15 v0.8	PD ERTMS	21-04-2023
ERTMS – SSS0 mds-09.20 v4.0	PD ERTMS	15-02-2023
ERTMS SSDD0 mds-09.20 – met interfaces	PD ERTMS	15-02-2023
ERTMS SSS0 mds-01.10	PD ERTMS	23-11-2021
ERTMS SSS1 IBS-ProRail voor mds-09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-NS voor mds09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-Qbuzz voor mds09.20 (nieuwe rolling stock)	PD ERTMS	16-02-2023
Extra commissioning team Experience driving	PD ERTMS	23-05-2023
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Inrichtingsvoorstel Ketenanalyseteam	*ERTMS @ NS*	11-05-2023
Kennisdocument 31ppro en traceability	PD ERTMS	28-04-2022
Kennisdocument architectuur	PD ERTMS	26-04-2022
Kennisdocument Product Based Planning	PD ERTMS	01-04-2022
Masterplanning 7.2	PD ERTMS	04-05-2023
Memo vaststellen bandbreedte planning 7.0	PD ERTMS	01-08-2022
Migratieplan 1.4	PD ERTMS	13-04-2023
NS Implementation plan mds-05.10 & 06.10	NS	21-12-2022
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Ontwikkeling realisatieplanning (migratiestappen)	PD ERTMS	31-05-2023
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Probabilistic Planning Analysis Master Planning 7.0	PD ERTMS	Q2 2022
ProRail ERTMS Aanbestedingen Kalender (PEAK)-werkbestand	PD ERTMS	21-06-2023
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SMART PvE vervoersysteem met ERTMS v2.2	PD ERTMS	17-02-2021
Systeemintegratiestrategie, v6.1	PD ERTMS	22-08-2022
X2 Planning note Realization phase	PD ERTMS	04-05-2019

Theme 3: System integration and integration management

Framework

In this theme the Second Opinion Committee (expert committee) explains its findings in relation to systems integration and the integration management of the Dutch ERTMS Programme.

The analysis focuses on whether technical management has been properly included in the programme by examining the following topics:

1. Is there enough focus on operational readiness?
2. Does the migration plan have enough detail?
3. Is there enough time in the migration planning to absorb any disruptions or slippage that may arise?
4. Is the PD pulling together the knowledge and resources of the implementing organisations?
5. Are design details being checked regularly and routinely against the (overall) programme requirements?

The focus of the analysis was to establish how the ERTMS Programme Directorate fulfils the Systems Authority role, making sure that the sum of all the deliverables (IOs output) provide a fit-for-purpose solution which fulfils the government's objectives. This theme focuses on how integration issues are managed, and systems are commissioned into service. Requirements Management is covered in more detail in theme 2: Technical Management and Scope.

Specifically, the expert committee has focused on how the Programme Directorate manages systems integration, both technically and programmatically. The expert committee also looked at perception and management in relation to Systems Authority, how the IOs programmes are technically integrated, and how operational readiness is checked at each of the migration steps.

Background

As explained in Chapter 2, the migration strategy consists of 17 migration steps. Each migration step must independently result in a sustainable functioning transport system, which is why testing and integration are an integral part of each migration step. Each migration step consists of five phases and six milestone moments (go/no-go decisions).

Testing is an integral part of each migration step. Testing is performed repeatedly to ensure that the system functions as expected. Fall-back options and criteria to trigger these are determined in advance for each step. To reach the fifth milestone, a joint decision must be made on whether or not the performance is acceptable and whether any modifications are necessary. The most extensive modification is to revert the migration step (fall back). This means that each migration step must be reversible.

System integration follows the course of the migration steps. System integration is a coherent set of activities designed to ensure that modifying and adding ERTMS components to the existing transport system is well-coordinated. ERTMS is being introduced into an operational environment, making system integration a crucial activity. The role of the System Integrator has been assigned to the ERTMS Programme Directorate.

The System Integrator operates in a risk-driven manner. Together with the participating organisations, the systems integrator starts identifying (integration) risks as early as possible. Based on the outcome, integration work is planned, which includes: validating assumptions,

exploring alternatives, explicitly addressing integration risk aspects, and selecting a solution approach to handle the potential consequences of the risks.

Several steering mechanisms for systems integration have been implemented in the ERTMS Programme: there is a change process, configuration management, a validation and verification process, and a test and simulation process. Specific attention is paid to the content and responsibility of system integration activities in the contracts with all suppliers. These activities are monitored by the ERTMS Programme Directorate. Agreements are made or are to be made with all participating organisations (infrastructure managers in the Netherlands and neighbouring countries, carriers, rolling stock owners, etc.) regarding the integration tasks they handle themselves and the responsibilities of the System Integrator.

All migration steps are linked to the four levels of system integration, where each migration step begins at level S4 with the integration of components within one object and ultimately ends at level S1 with a comprehensive transport system. Figure 2 shows the four levels of system integration.

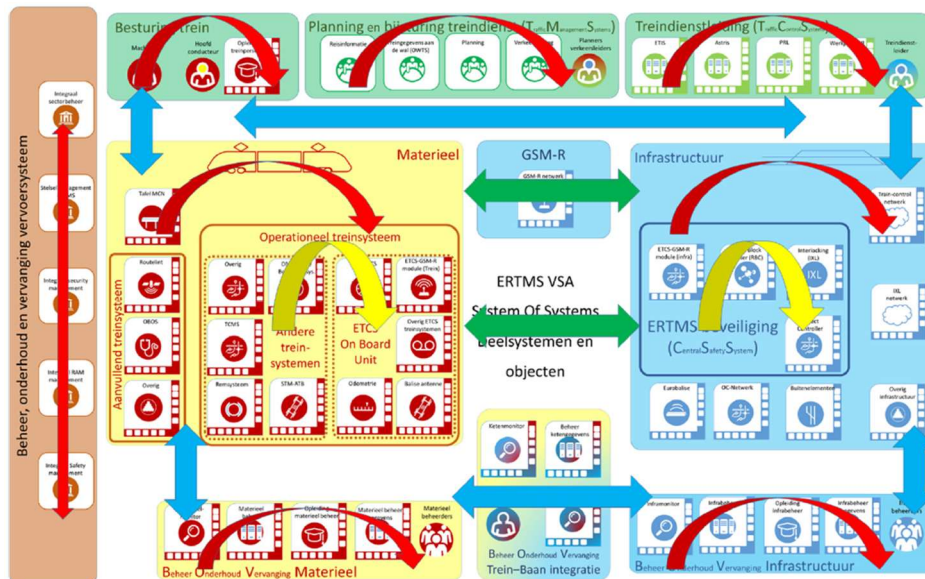Key: level 4 = yellow, level 3 = red, level 2 = green, level 1= blue.

Figure 2: Four levels of system integration for ERTMS in the Netherlands.
(Source: system integration strategy).

Yellow arrows indicate the integral functioning of all components within one object. At this lowest level of system integration, components are distinguished, designed, and realised independently. For each of the 10 subsystems, components or services of this kind are ordered, which in turn, are composed of sub-components etc. This level is contracted to suppliers through output specifications and the procurement process. The component suppliers are responsible for ensuring the proper independent integration of those components in accordance with the responsibility defined and documented in the contract.

Red arrows indicate the integral functioning of all objects within one subsystem. At this level, a participating organisation (infrastructure manager, carriers, rolling stock owners) ensures that the components are properly integrated within their own area of responsibility.

Green arrows indicate integration between train and track subsystems. Here, responsibility is shared between the infrastructure manager and the rolling stock owners. The ultimate responsibility of the system integration lies with the System Integrator. The System Integrator sets

requirements for the plans, approves plans, monitors and assesses progress, addresses issues, and resolves them.

Blue arrows indicate the overall integration and management between the 10 subsystems at people, process, track, train, and GSM-R technology level. This level involves the functioning of the transport system as a whole, including the logistics aspects such as planning, operational deployment, and adjustments. This level involves the infrastructure manager, carriers and rolling stock owners, who have a shared responsibility. Similar to level 2 (green), the ultimate responsibility for systems integration lies with the System Integrator.

Findings

The framework for Systems Integration has been documented above under the Background heading. This gives clear direction to the parties involved in delivering the ERTMS Programme, but it is the practical implementation which is faltering. To deliver a collection of projects, each Implementing Organisation can choose its own approach and monitor technical delivery against its own set of standards and requirements. However, to deliver an integrated programme, in the expert committee's experience, priority must be given to working in common data environments, creating a standard approach, and automating feedback as much as possible so that timely decisions can be taken to support the programme direction.

This typically means working with the same or compatible tools, and referring to programme requirements to check these are being fulfilled at regular intervals: weekly or monthly at minimum. This does not appear to be the case for the Dutch ERTMS Programme. During the interviews, little reference was made to a disaggregated programme requirements by each IO, and Systems Engineering has been described as a 'hands-off approach', in other words, heavy reliance upon delegation to the IOs.

Furthermore, interviews clarified that the Traffic Control System (TCS) functionality is being changed substantially to make use of the bi-directional feedback available in ERTMS, level 2, baseline 3. Developing the TCS has made good progress thanks to rapid application development techniques. As a result, later in 2023, the Central Safety System (CSS) will be integrated into the TCS, and the systems on either side of the interface will be adjusted as required following testing at the Rail Centre integration facility.

Based on the visit of the expert committee to the Railcenter, it is clear that this is a well-established facility, and while it is not a validated lab, it is nevertheless routinely used in integration testing to find failures as early as possible before site testing. It is currently being used to facilitate the onboard roll out on new rolling stock to be used on the existing ETCS baseline 2 lines in the Netherlands and is due to be upgraded for the ERTMS Programme and ETCS baseline 3 roll out.

Pre-integration testing with the CSS will take place from July 2023, and then formal integration testing from November 2024 for 18 months. To meet the deadlines in the migration plan, new lab facilities for ETCS System Compatibility (ESC) baseline 3 testing need to be available by the middle of 2026. Based on the expert committee's experience, it is highly unlikely this will be achieved in this timescale.

It is positive that Testing & Commissioning is now being pulled together at programme level. But for this to work, more highly-detailed plans are required along with a lot more thinking at railway level in terms of how it feeds into the approvals, safety cases, operator, and training plans. It is clear to the expert committee that a lot more needs to be done in testing and commissioning,

including how this is connected to the next level down, so there is a very clear avenue for how requirements are validated as they go through the stages.

Considering how critical the lab is for integration testing for all eight lines, and all the first-in-type fleet implementation, the expert committee recommends that the lab loading is stringently reviewed, and any additional facilities and resources required to address the peak volumes in the programme should be procured as a priority. There is also a need to cater for multiple software versions while bugs are fixed, as this in itself will be disruptive given the need to support the versions already installed (to validate fixes) as well as future versions (as they are being tested prior to implementation). It is apparent to the Second Opinion Committee that the expected volume of software changes for both trackside and onboard systems is being considerably underestimated.

Technical assurance at programme level should include design gates at the System of Systems level – i.e. reviewing to make sure that the sum of all the parts being developed and delivered by the Implementing Organisations delivers everything required to fulfil the government's objectives for the ERTMS programme. This approach will help drive the ministry's priorities into the programme and reinforce Requirements Management and disaggregation of top-level SMART requirements into manageable components for delivery by organisations and contractors.

During the interviews, there was little recognition for the part that each IO is playing toward the whole, and although it was stated that requirements have been disaggregated, there is no evidence of current measures to ensure compliance, nor any indication whether the sum of the parts satisfies the whole. The expert committee recommends the Programme Directorate plans a series of design gates/assurance gates, which work at the overall level, take the governments overarching functional needs and overall railway level functions into account, and ensure these are delivered through the sum of the parts. Currently, the expert committee has not been able to assess the maturity level of the designs that are being implemented.

For example, in the Operational Concept Document (OCD), 22 out of 23 actions are not yet planned. This needs serious attention and acceleration. Otherwise, significant gaps in IT system functions could only start revealing themselves late in the schedule, causing major slippage in the planning.

There is little evidence of development of an integrated programme schedule across the Implementing Organisations, nor of detailed management and control of this integrated schedule. The Programme Directorate's current approach seems limited to monitoring and reporting on the migration plan, rather than managing and controlling the plan. It is therefore highly likely that, without optimisation and adjustment, the overall schedule will drift further and further out. For example, there appear to be few or no firebreaks between IO schedules. Also, it became apparent during the interviews, that the IOs were critical about the understanding of any impact slippage may have on other activities, and hence the impact on the overall programme.

The expert committee recommends the Programme Directorate management team is expanded and resourced so it can take detailed deep dives into IO schedules. The overall programme schedule should be reworked to include firebreaks between major IO milestones. Monthly schedule reviews and management action should become the regular routine for the organisations involved. The PD should have authority to call the IOs to account, and to drive more realistic programme approaches, e.g. over-and-back testing and commissioning, rather than line closures.

As mentioned, the migration steps are currently defined at concept level and need to be developed to a lot more intricate and comprehensive detail. The definitions need to be at railway level and must define practically every asset on the railway. This means a bottom-up definition of every

single asset, making sure that the status of each asset at that point in the migration is understood. This also means clear entry/exit criteria including RAMS criteria for each of these milestones, answering questions such as: What is the expected performance? What timetable will the railway run? What assets are needed? This will enable holistic management at the railway level, and will also activate delivery management as the implementation is divided into measurable deliverables. However, as things stand today, there is not enough detail to do that.

As part of the exercise to define migration points in more detail, the expert committee believes the leadership of Approvals and Safety Case development needs to be strengthened. This includes documenting the ERTMS Programme Safety Strategy in full detail, and describing the responsibilities for a high-level Safety Case, in line with Dutch and European legislation.

Conclusion

Based on the information available, the Second Opinion Committee (expert committee) concludes that the Programme Directorate (PD) is not providing strong enough leadership of Systems Integration and Software Engineering, which is currently only being done by the IOs individually. As such, the PD does not provide any ERTMS System Authority and is *not deciding* when to implement instructions; when to allow changes in the ERTMS functionality; and when to freeze the scope for the sake of timely delivery of the programme. Examples of this include considering Automatic Train Operation (ATO), and adopting Hybrid Level 3, both of which appear to be possibly distracting the delivery parties away from the ERTMS Programme which is there to deliver an ERTMS Level 2 baseline 3 solution.

The Programme Directorate does not lead practical integration for Systems Engineering. For example, the expert committee gathered from the interviews that the PD allows IOs to use different Requirements Management tools, or no tools at all, which means that tracking requirements delivery to the government's overall objectives throughout the project life cycle is ineffective. To illustrate: ProRail and the PD are using Relatics; NS is using Polarion; and Arriva is using Excel. The PD should put a central requirements repository in place that is compatible with all the tools used by IOs.

There is little sign of the PD holding the IOs to account for their part in the delivery of an integrated whole transport function in accordance with the overall Dutch ERTMS Programme Schedule. IO projects seem to be managed as a collection of individual projects rather than a technically integrated whole-system implementation.

Sources

The following sources were used for theme 3:

Name of source	Sender	Date of document
Migratiestrategie 6.0	PD ERTMS	31-08-2018
Actieplan kwartiermaker ketenbeheer ERTMS ProRail v1.0	ProRail	24-11-2022
Commissioning advise Start Experience driving Hanzelijn en Amsterdam	PD ERTMS	30-01-2023
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ERTMS SSDD0 mds-09.20 – met interfaces	PD ERTMS	15-02-2023
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ERTMS SSS1 IBS-ProRail voor mds-09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-NS voor mds09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-Qbuzz voor mds09.20 (nieuwe rolling stock)	PD ERTMS	16-02-2023
Extra commissioning team Experience driving	PD ERTMS	23-05-2023
Implementation plan MDS 05.10 en 06.10	ProRail	05-07-2021
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Kennisdocument 37ppro en traceability	PD ERTMS	28-04-2022
Kennisdocument architectuur	PD ERTMS	26-04-2022
Kennisdocument Product Based Planning	PD ERTMS	01-04-2022
Masterplanning 7.2	PD ERTMS	04-05-2023
Memo vaststellen bandbreedte planning 7.0	PD ERTMS	01-08-2022
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NS Implementation plan mds-05.10 & 06.10	NS	21-12-2022
NS Vervoersmodel explainer	*ERTMS @ NS*	15-06-2023
Ontwikkeling realisatieplanning (migratiestappen)	PD ERTMS	31-05-2023
Opstellen Operating Model Ketenbeheer ERTMS	ProRail	16-02-2022
Overall planning Experience driving MS 5 & MS6 0.4 draft	PD ERTMS	March 2023
Planning 7.0	PD ERTMS	05-08-2022
Planninganalyse Q1 '23 vs. Masterplanning 7.0	PD ERTMS	Q1 2023
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ProRail ERTMS Aanbestedingen Kalender (PEAK)-werkbestand	PD ERTMS	21-06-2023
Scopedocument 6.2	PD ERTMS	07-12-2020
SMART PvE vervoersysteem met ERTMS v2.2	PD ERTMS	17-02-2021
Systeemintegratiestrategie, v6.1	PD ERTMS	22-08-2022
System engineering & design		
X2 Planning note Realization phase	PD ERTMS	04-05-2019

Theme 4: Programme costs and forecast

Framework

This theme assesses the overall estimated costs of the Dutch ERTMS programme, further referred to as the final financial forecast or *Prognose Eindstand* in Dutch. All estimates are expressed in the price levels as per end 2022.

The following terms are used in this theme:

- Budget – money (EUR 2,475 million, prices lifted to 2022 level) made available to the ERTMS programme, based on the programme decision (PE rapport dec 2022)
- Original scope – as defined in the initial programme decision (2019)
- Current cost estimate – current estimate (Dec 2022) of the original scope
- Additional scope – additions proposed after 2019 programme decision was agreed, including ERTMS for Northern Lines (infrastructure + Arriva trains), axle counters for six ERTMS lines (excluding EKB[13]), changes to the test track section (proefbaanvak) and national roll-out feasibility study (planstudie landelijke uitrol),
- Final Financial Forecast (Prognose Eindstand (PE)) – latest cost estimate for the overall ERTMS programme, which covers both the original scope and additional scope.

To assess whether the Final Financial Forecast is adequate, the Second Opinion Committee analysed the Final Financial Forecast based on the following supporting questions:

1. Is the forecast complete and are all the necessary budget items ('must costs') included?
2. How is the programme financed?
3. Does the forecast sufficiently cover all items?
4. Are risks sufficiently accounted for?
5. Are the costs of the Dutch ERTMS programme aligned with those of peer programmes and projects in other countries?
6. Are there any cost-saving opportunities?

The Final Financial Forecast and its source material form the basis for the factual findings and analysis made by the expert committee in its second opinion of the programme's cost estimates. In addition to this, the expert committee has used (confidential) cost data from eleven (to a large extent completed) reference ERTMS projects or programmes in other countries. To uphold confidentiality, inputs from these projects has been anonymised in this report; data adjusted to the Dutch scope[14] and price base, and so no original data is revealed.

Furthermore, interviews were conducted with relevant Dutch ERTMS programme business units, as well as with other relevant stakeholders about the scope, budget, cost assessment and controls.

Background to the ERTMS programme financial forecast

A decision on the direction of the migration strategy to ERTMS in the Netherlands was taken in 2016, resulting in a programme decision in 2019. The original (2019) budget for the ERTMS programme was EUR 2,475 million (prices lifted to 2022 level). As the Final Financial Forecast

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[13] ERTMS Kijfhoek – Belgian boarder
[14] e.g. full generic application, centralised interlocking and RBC, TMS adjustments but no TMS replacement, axle counters replace track circuits

stands today[15], the overall programme cost estimate for the ERTMS implementation in the Netherlands is EUR 4,348 million[16]. This can be explained as follows.

1. Compared to the original budget of the initial programme decision, the current cost estimate shows a EUR 860 million increase in estimated programme costs. In the Final Financial Forecast, the ERTMS Programme Directorate explains this increase in two ways: it is either due to further elaboration and new insights as the programme progressed, or is due to greater complexity encountered than previously foreseen.
2. Compared to the original programme scope, several projects have been added to the scope, including: National roll-out feasibility study (Planstudie Landelijke Uitrol); Adding Northern Lines (Toevoeging Noordelijke lijnen); Changes to the test track section (Wijziging Proefbaanvak); and Additional axle counters for 6 track sections (Assentellers bijbestelling 6 baanvakken). Combined, these account for approximately EUR 1,013 million. The table below illustrates this, in EUR million, accrued and at 2022 prices:

Figure 3 (see conclusion section of this theme) shows that, overall, the Prognose Eindstand is transparently divided into sections for infrastructure, vehicle equipment and general/shared costs. These shared costs can then be split across the costs of the various organisations, for example, Programme Directorate, ProRail/IEP and NS.

Findings

Adequacy of the budget

The Final Financial Forecast presents the bottom-line costs for the ERTMS programme. This means the overall costs of the ERTMS programme in EUR (at 2022 prices) once the programme has been finished. The expert committee has not considered how the budgets are spread over time (e.g. monthly or yearly), but has analysed whether the Final Financial Forecast is sufficient as a cost-to-complete forecast. As such, the expert committee has not considered over- or underspending in the current day-to-day programme management. Instead, the committee has considered:
1. whether the overall bottom-line programme costs would be sufficient given the scope,
2. whether all budget lines have been accounted for sufficiently,
3. how this overall cost estimate (Final Financial Forecast) compares to the ERTMS project costs in other countries.

The expert committee considers the forecast comprises a very diligent translation of the scope of the programme. The forecast matches the programme structure, and it presents a sound breakdown of the overall bottom-line programme cost positions. On top of that, the expert committee finds that the estimates added for unforeseen costs are also adequately presented, sufficiently reflecting general and specific risks.

The forecast of the remaining costs per end of 2022 includes EUR 3.194 million of 'foreseen' costs and EUR 754 million of 'unforeseen', risk-related costs. The risk-related costs are 23,6% of the foreseen costs. Other countries may have higher percentages for explicit risk costs, but on a lower 'foreseen' base. The absolute amount of risk-related costs in the forecast appears adequate.

However, the expert committee also finds that telecom and data transmission, and yellow fleet roll out may not have been translated into the programme costs sufficiently, which gives rise to the

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[15] Document consulted: *221207 - Totaal PE (freeze PE 7 december 2022 met actual budget 220930) input definitieve PE rapport dec 2022*
[16] These costs are per the end of 2022, excluding VAT.

question whether the forecast in of these elements is complete and realistic. Other projects show that the costs of telecommunication and data transmission are often underestimated in the forecast. The forecast covers comparatively few costs for telecommunication and data transmission. Regarding the yellow fleet costs, the committee finds the costs of retrofits per vehicle adequate, even considering that the yellow fleet comprises many costly 'first-in-class' applications. However, the number of yellow fleet vehicles considered for retrofitting seems rather low, compared, for example, with Denmark and Norway.

In addition, the expert committee finds that, if the programme planning version 7.0 is achieved, the programme costs in the forecast ought to be enough to cover the implementation of ERTMS in the Netherlands, within the original and additional scope (as defined above) and schedule of the programme. However, in the event of significant further delays, there is a risk that the current budget might not be sufficient[17].

Benchmark with (completed) projects in other countries

The expert committee also considered how the Dutch programme compares, when benchmarked against other countries that have implemented ERTMS. The first thing to point out here is the way in which the implementation is being done in the Netherlands differs from the way implementation has been managed in other countries. For example, in benchmarked countries, installation of a new system is procured on the market, whereas in the Netherlands the soft- and hardware items are delivered by the system suppliers and then given to the railway companies for installation, integration as well as testing & commissioning. This finding also has consequences for the overall programme costs, seeing that there is limited competition in terms of detail design & installation, and hence limitations to driving down the costs through the market. The same can be said for the decentralised way in which the Implementing Organisations buy from their suppliers.

The expert committee finds that the estimated ERTMS infrastructure costs per Signalling Equivalent Unit (SEU) are significantly higher compared to other countries. The SEU method is a way of accommodating the complexity of a signalling scheme so that estimations, comparisons, and reporting are undertaken at a common level. ProRail counts points and block sections as SEU, to which the international benchmarks add controlled level crossings. The high signalling complexity in the Netherlands is reflected in a high 'SEU density' (more than 5 SEU per track km), based on data provided to the expert committee. The average in other ERTMS projects in Europe is 2,8 SEU per track km. Considering the assumed high signalling complexity in the Netherlands, the cost comparison per SEU is appropriate to the Dutch cost position rather than, for example, a cost comparison per meter of track.

The costs needed to refurbish the current train fleet are assessed per vehicle (multiple units, locomotives, yellow vehicles).

The costs of the ERTMS programme in the Netherlands has been benchmarked against projects in other European countries. At EUR 4.3 billion before tax, in accrued costs and prices per end of 2022, the programme is by far the most expensive compared to the eleven European projects recently analysed for ERTMS cost benchmarking. Normalised for differences in scope, infrastructure costs per track km and per SEU, the Netherlands project costs are estimated twice as high as the average of other projects in the benchmark. The average per-vehicle cost estimate for onboard equipment is 25% higher than in other countries[18]. The high infrastructure estimate has been

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[17] Additional information on expenditure vs. deliveries would help assess this further, however is not available. Given that the PE including 'unforeseen' is so high above the international benchmarks, the committee ventures the opinion that the estimated costs suffice to cover delays to some extent.
[18] Total vehicle equipment costs divided by total number of vehicles.

extrapolated to other routes from the costs incurred for the EKB network section. A number of budget items should be checked, such as the savings potential on axle counters and cabling. Regarding the vehicle equipment, it is noted that the number of vehicles converted correspond to the number of the vehicles in the concessions. However, it is worth reconsidering whether so many vehicles need to be converted in a first step on the basis of true operational need.

Risks

There is a risk of exceeding the PE if the programme duration has to be extended. The expert committee considers the risks positions included in the PE forecast may be enough to cover some delay as some 'unforeseen' costs are included. However, the longer the Netherlands ERTMS programme takes, the higher the risk that the current budget estimate is insufficient to cover all programme costs.

To sum up, the expert committee identified the following risks which might be underrepresented:

- Lack of feasibility of the programme schedule which could lead to additional costs for several more years. Further delays to the ongoing ERTMS programme will only increase costs and push benefits further out into the future.
- There are many interdependencies between the ERTMS programme and other projects, meaning that any delay in any of these projects can lead to other delays, and therefore funding issues elsewhere.

Conclusion

Based on the information available, experience and data from the Netherlands and from other countries, the expert committee has drawn several conclusions regarding the Final Financial Forecast.

1. Prognose Eindstand completeness

The committee concludes that the forecast of EUR 4,348 million (at 2022 prices, excluding VAT) is generally complete, all 'must costs' are covered. [19]

Cost area	infrastructure	vehicle equipment	general/ shared	total
Subtotal initial programme decision (original scope) • Programmadirectie • IEP – Infrastructuur ERTMS ProRail • NS • Overige vervoerders • IO Overstijgende & nog toe te wijzen scope • Overige • IO Overstijgend onvoorzien	1.792	1.173	370	3.335
Grand total (originel + added scope) • All of the above as well as: • Planstudie landelijke uitrol • Toevoeging Noordelijke lijnen • Wijziging Proefbaanvak • Assentellers bijbestelling 6 bvk-en	2.700	1.275	374	4.348

Figure 3: High-level overview of the Prognose Eindstand
(in EUR million, accrued and at 2022 prices, excl. VAT)

Note that an amount of EUR 400 million has already been spent up to the end of 2022. The expert committee was not able to conclude that the programme can deliver the scope against the budgets, as adequate historic cost, schedule and performance data re not available.

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[19] The full table (divided by post) is placed in a confidential annex due to the confidentiality of the budget.

There are, however, some costs that expert committee questions: the estimated amount for telecommunications and data transmission, and the total costs for retrofitting the yellow fleet. The expert committee finds that even though the assessed costs per vehicle seems to be adequate, the number of yellow fleet vehicles considered for retrofitting seems rather low. The expert committee also notes that change management, which has been a specific budget item in various large-scale ERTMS programmes, is not explicitly visible in this forecast.

The expert committee also observes that the Final Financial Forecast includes a significant cost estimate increase for the original scope of the ERTMS programme, EUR 860 million (35% of the original budget)[20]:

	Budget	Current Prognose	Diff. current ./. Budget
Totaal initiële Programmabeslissing • Programmadirectie totaal • IEP totaal • NS totaal • Overige vervoerders totaal • IO Overstijgende & nog toe te wijzen scope totaal • Overige totaal • IO Overstijgend onvoorzien totaal	2.475	3.335	860

Figure 4: Budget comparison with current cost estimate for the original programme scope (in EUR million, accrued and at 2022 prices, excl. VAT)

ERTMS Programme Directorate explains this increase in two ways: either due to further elaboration and new insights as the programme progressed, or due to a higher complexity encountered than previously foreseen. The expert committee considers this increase percentage high.

Moreover, the additional scope cost estimates (see definition above) are estimated at EUR 1,013 million, which significantly impacts the overall forecast.

2. How is the programme financed?

The expert committee observes that approximately 70% of the Final Financial Forecast will be funded through MIRT and is thus under the PD's direct control. Up to 30% will be funded from other sources (BOV, Ministry (IenW), provinces, vehicle owners), which weakens the PD's control.

3. Forecast accuracy

The expert committee finds the Dutch estimates conservative. They are calculated with high foreseen costs and considerable surcharges for unforeseen costs. This conservative approach is clear, in particular when comparing the Dutch estimate with costs of (completed) ERTMS projects abroad, especially on the infrastructure side.

4. Coverage of risks

The Final Financial Forecast generally appears to adequately cover the programme risks. The overall risk contingency amounts to 17,3% of the overall forecast and 23,6% of the remaining foreseen costs.

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[20] The full table (divided by post) is placed in a confidential annex due to the confidentiality of the budget.

However, some risks which might be underrepresented, namely the ERTMS Programme schedule's lack of feasibility , could lead to additional costs for more years to come. Delays have been a major problem in all ongoing ERTMS programmes and have been a prime reason for cost overruns. The 'foreseen' estimate covers the ERTMS Programme costs [Programmakosten] up to 2029. An unforeseen estimate, for all IOs [IO overstijgend onvoorzien] covers risk PD54 'Extra programme costs due to delays after 2030 (based on PPA) [Extra programmakosten als gevolg van vertragingen programma, (o.b.v. PPA)].

Given that many people involved in the project consider completion will be in 2031 at the earliest, this provision for unforeseen costs appears low. A longer programme schedule is also likely to affect other stakeholders, contractors etc. In addition, interdependencies between various projects could also mean that delays in one of these projects can lead to other delays, and consequently, funding issues.

5. Forecast alignment with comparable ERTMS implementations abroad

When comparing the forecasted costs for the ERTMS implementation in the Netherlands with other countries, the expert committee concludes that the Final Financial Forecast for infrastructure costs per track km or per Signalling Equivalent Unit (SEU) and for onboard-related costs per vehicle is significantly higher than European benchmarks from Switzerland, Italy, France, the UK, Denmark, Norway and Sweden.

Figure 5: PE forecast SEU cost and amount per track km vs. other ERTMS implementations

The benchmark includes ETCS L2 projects from Sweden, Norway, Denmark, the UK, France, Switzerland and Italy. Seven projects have been completed, two are ongoing (with 'cost to complete' estimates incl. risks), two are 'estimates for future' projects. The scope is adjusted to the Netherlands, covering, e.g., a full generic application, centralised interlocking and RBC, TMS adjustments but no TMS replacement, axle counters replacing track circuits. Costs were raised to 2022 levels with national producer price indices, based on OECD data. Foreign currency is converted with OECD rates to Dutch purchasing power (e.g., Italian project costs in euros are multiplied by 1.21 to reflect that similar projects would be more expensive in the Netherlands).

This applies to (contractual) system delivery, internal resource costs and overhead, and risk-related costs.

The expert committee considers that such a significant difference should be further investigated in detail. It could be that the way of procuring, level of competition, as well as current market situation significantly contribute to the higher estimates. Moreover, limited effectiveness of control and accountability of the ERTMS PD over ERTMS infrastructure cost may mean the estimate is higher than expected.
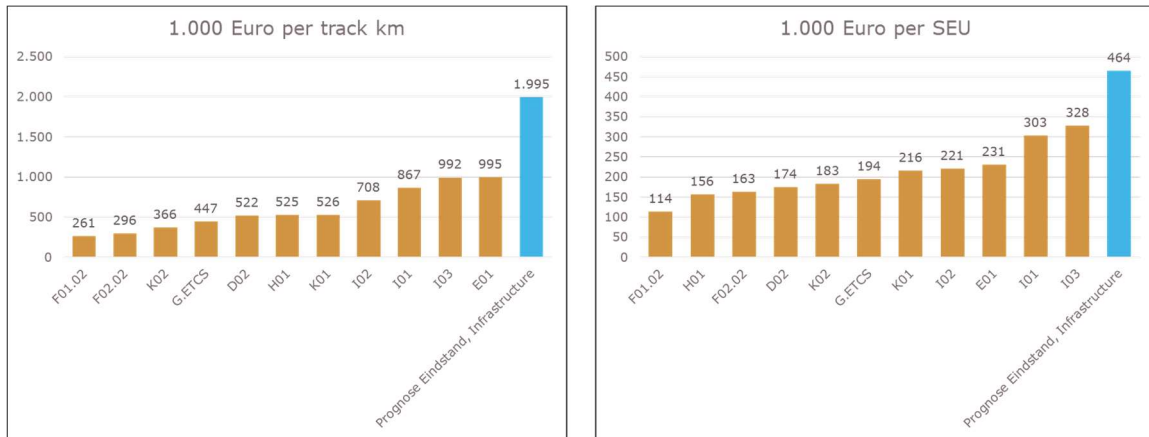
Figure 6: Two different ways of benchmarking infrastructure costs as presented in the forecast, with
the costs of international projects
(in EUR million, at 2022 prices, excluding VAT, adjusted to Dutch programme scope)

Lack of efficient ERTMS PD control combined with lack of competition can also be seen in the
costs for equipping Dutch trains compared to costs abroad (K01).
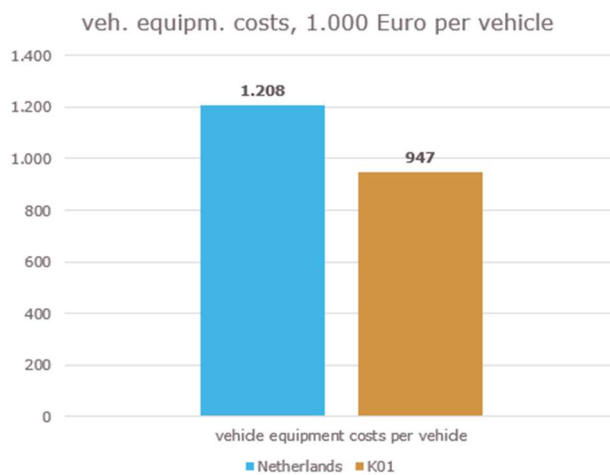
Figure 7: Costs of retrofitting or upgrading trains,
EUR 1000, at 2022 prices, excluding VAT

In summary, the expert committee finds that the Final Financial Forecast significantly exceeds
costs known from successfully completed ERTMS projects abroad.

7. Cost-saving opportunities

The Second Opinion Committee (expert committee) concludes that cost-saving opportunities may
be found as the Final Financial Forecast includes several areas with substantial uncommitted
costs, such as:

- EUSI roll-out including Hanzelijn test track section, the Northern Lines and axle counters
- High cabling and axle counter costs
- Additional management and maintenance
- Developing and commissioning ERTMS
- Uncommitted NS retrofits

Cost savings may also be found by reassessing the procurement strategy and the real needs in those areas as well as reassessing the number of vehicles included in the budget for retrofitting or upgrading to ETCS L2 baseline 3.

More international cooperation/co-funding (such as CINEA funds) could also be an area to consider for finding cost-saving opportunities.

The expert committee considers that if the ERTMS Programme Directorate exercises better budgetary control on the real programme needs, and focuses more sharply on the programme scope defined, this can be more effective than actively searching for cost-saving opportunities. These may be hard to find, difficult to implement, and that implementation of specific measures might lead to further delays and cost overruns in general.

Sources

The following sources were used for theme 4 (costs):

Name of source	Sender	Date of document
Migratiestrategie 6.0	PD ERTMS	31-08-2018
Migratieplan 1.4	PD ERTMS	13-04-2023
Planning 7.0	PD ERTMS	05-08-2022
Scopedocument 6.2	PD ERTMS	07-12-2020
Herijking financiële Prognose Eindstand programma ERTMS – Programma ERTMS, 2022	PD ERTMS	2022
Overzicht investeringskosten naar financier EKB raming D6.0 vs 0.2 d.d.	PD ERTMS	01-03-2023
Overzicht investeringskosten naar financier EKB raming D7.0 vs 2.0 d.d.	PD ERTMS	15-03-2023
INTEGRALE SSK raming EKB Kijfhoek-Belgische grens_D6.0_PROBA	PD ERTMS	28-03-2023
AA Overzicht investeringskosten naar financier EKB raming D6.0 vs 0.2	PD ERTMS	01-03-2023
20230228 INTEGRALE SSK raming EKB Kijfhoek-Belgische grens_D6.0_PROBA	PD ERTMS	28-03-2023
PE December 2022 file package, encompassing the subdirectories Besluitvorming, Geconsolideerde PE bestanden, PE – initiele scope programmabeslissing, PE – wijzigingen en bijbestellingen, Rapportage PE"	PD ERTMS	December 2022
Multiple interviews (see appendix B)	Multiple people	May – June – July 2023

5. International comparison

Below (figure 8) is a comparison table, that compares the relevant features of the Dutch ERTMS programme with other benchmark countries. The data indicates a few notable areas of deviation namely:

- The Dutch programme is procuring lineside CSS equipment from a contractor, and separately contracting the design and installation. All other benchmark countries have taken a more turnkey approach with output performance guarantees on the contractor. The Dutch approach has the effect of placing major performance risk on the programme, which coupled with the use of five different design organisations and four different installation organisations, means that the risks associated with interfaces and integration is also exacerbated, placing more demands on the programme to proactively manage them. It is noted that the Dutch approach is following a similar model used for other projects on the network and therefore uses standard contracting mechanisms and processes.
- The Dutch ERTMS programme has chosen to employ a four-month closure on the first deployed line, whereas all other countries have chosen to use normal access rules with extended weekends and closures no more than two weeks, which primarily covers the final commissioning period. The use of extended closures is generally considered a luxury, as it is expensive and also disruptive. Extended closures also come with significant risks, as a larger amount of work is concentrated in a short amount of time, placing a higher burden on the projects for management and logistics. These closures also place demands on the Assurance processes to provide the needed approvals in shorter periods of time to proceed through stages and into service, requiring a more coordinated and agreed criteria earlier.
- The Dutch programme is planning to go to full ERTMS Level 2 in fitted areas (no overlay nor temporary over-and-back capability), whereas most other countries have employed one of those approached to mitigate the potential impacts of issues that may delay commissioning. Some of this risk has been mitigated by the Dutch programme through the use of simulators and test facilities, however location specific issues are not uncommon, especially when software find-to-fix times typically taking longer than four months.
- The Dutch programme has chosen not to fit major stations like Amsterdam, Utrecht and Rotterdam in the initial steps[21], thus introducing 'ATB islands' within the network. All other countries have fully fitted the lines as part of the initial rollout of a line. The trains will be dual fitted (with STM) because they will run on ATB-tracks, regardless of the main stations. The transition period for the entire network is the driving factor behind this decision. These ATB-islands require trains to be dual fitted and also introduce a risk of transition between signalling systems. The timetable will demand 1000's of trains to successfully transition per day, trains failing to transition between signalling systems are very disruptive to the railway, causing delays whilst resolution is deployed. In addition, the major stations would still have to be fitted at a time in the future, causing additional disruption at a later date.
- Onboard procurement model varies between countries, where the strategy is adopted to fit the nature of the local industry. In the UK for instance, passenger fitment is funded and managed by the operator/owner as part of their franchise obligations, however freight is funded and centrally managed by Network Rail under a funding arrangement with the Department for

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[21] On the tracks in scope all major stations will be converted to ERTMS, not only the straight tracks between the station. However, this does not include stations like Amsterdam, Utrecht and Rotterdam.

Transport. However, in all cases, there is central control of specifications and delivery programmes for the fitment. The Dutch programme carries similar traits however, there is less central control of the specifications and programme.

Category	Netherlands	Denmark	Norway	Belgium	United Kingdom
Baseline	ERTMS level 2, Baseline 3 R2	ERTMS level 2, Baseline 3	ERTMS level 2, Baseline 3	ERTMS level 2, Baseline 3**	ECDP - Baseline 3 MR2
Overlay or full rollout	Full rollout (with ATB islands as	ERTMS only - full decommissioning of the legacy system	ERTMS only - full decommissioning of the	Overlay	Overlay with migration to no signals
On Board procurement model	Full funded passenger, 50% funded freight, managed by Operator	Client (Banedanmark) for all passenger trains, Client provided framework for freight; 50% funded first come basis for freight	System authority (Bane NOR) for generic app and test trains; financial aid scheme (FAS: 50% of all-in	passenger (SNCB) fully founded; freight not funded	Passenger funded through franchise - frieght fully funded through NR FCA
Number of Onboard retrofit supplier		1 supplier for all passemger trains (Alstom)	1 supplier for participants in FAS; non-participants are free to procure onboard ETCS themselves	2 suppliers	Passenger 3 - 4 suppliers - Frieght 1 at the moment
Procurement strategy onboard	Fully managed by the Operators and owners	Programme contract: vehicle owners could chose between different installation and maintenance packages with varying contractor involvement	Programme contract: Equipment delivery plus standard price for installation; vehicle owner can opt out of contractor's installation. Hourly rates for maintenance services and unit prices for spares.	Installation kit delivery to passenger operator or full installation by supplier.	Full installation by supplier or fitted from new for passenger. New £37m contract just awarded to Siemens by GTR for Thameslink on-board upgrade of all Class 700 fleet to BL3 in readiness for running on East Coast ETCS. Passenger fleet fitment is managed by the franchise operator or owner, exceptions are for national fleets funded by the DfT. Freight fitment is managed by Network Rail centrally.
Signalling Procurement	Equipment procured	D&B (DBM, full maintenance 25 years after final delivery)	DBM, helpdesk and 3rd and 4th line maintenance 25	D&B	Turnkey D&B
ETCS or Legacy 'islands'	Yes, ATB islands in major stations (as consequence of roll-out strategy)	No	No	Final stage - ETCS only network consisting of sections with L2, L1FS or L1 Limited Supervision	No
Traffic Management	No	Yes, East and West basic functions Advanced functionalities for the	New traffic management system	Not in scope, but as an ealier enabling project	Separate National procurement
Over and Back Strategy	None, full rollout	Full Rollout, O&B on first line in West; on all lines in East.			Over and back to allow for testing
Possessions strategy generally	Use engineering hours for most of the installation. For first line long possession for operational trails.	Use of engineering hours for most installation activities	Use of engineering hours for most installation activities		Use of engineering hours for most installation activities and long weekend blockades
Closure/Possession Strategy (during test		Possessions: mostly weekends and maximum 2 weeks closure)		possessions mostly at nigths + weekends	Short possessions
Initial Line Strategy	4 month closure	Early Development Lines (East and West)	L2 B2 pilot line commissioned before Programme; test line Roa-Hønefoss as part of the	3 EDL sections - ETCS open line, ETCS +ILX, new interlocking	Cambrian Line as early deployment 2.3.0d, Thameslink 2.3.0d and Crossrail BL3 MR1-ECDP is first national scheme
Line Rollout Strategy	Parallel, post Initial Hanzelijn	Sequential rollout post EDL - but contractor working on upto 5 lines in different phases in parallel	Line-by-line rollout with some schedule overlaps	parallel rollouts	Each line is a separate programme
Level Crossings		Yes (replace all trackside interlocking systems)	Replace all trackside interlocking systems (e.g.	No	Yes, on Cambrian
Lineside Design Procurement Strategy	Multiple under Design frameworks	D&B (East and West)	Lineside engineering (detail plans) inhouse at Bane NOR; Signalling: specific application by contractor.	D&B	D&B turnkey/Client Migration and Scheme Design
Lineside Rollout Installation Strategy	Multiple under Maintenance frameworks	D&B (East and West)	Signalling system installation by contractor; separate civil work contracts; telecom installations by Bane NOR	D&B	D&B turnkey
Maintenance Strategy	Partly conform current maintenance policies and partly CSS supplier.	25 years maintenance for D&B supplier	SigSys contract: 25 years of 3rd-and-4th line maintenance after final delivery; TMS: full maintenance service, shorter duration; Onboard contracts: Service agreement at vehicle owner's discretion	5 years guarantee + 15 years maintenance for D&B supplier (optional)	Crossrail - 30 year Maintenance contract between TfL and Alstom, includes ETCS on-board. Separate NR Maintenance contract with Alstom for Heathrow infrastructure.

* Belgium trackside data - in relation to Level 2 only, other 2 levels (L1 FS and L1 LS not taken into account in this review)
** East Coast Depolyment Project (ECDP) is the first UK national scheme including freight - Thameslink and Crossrail schemes are limited in scope and did not include freight

Figure 8: international comparison table

6. Answers to the Steering Committee's questions

In this chapter, the Second Opinion Committee (expert committee) presents its answers to the six main research questions posed by the Steering Committee, based on all the findings presented in chapter 4, themes 1 to 4.

1. *Given the implementation strategy, does our approach lead to a transport system in which technical and operational aspects, such as human factors and processes, are sufficiently taken into account? What risks does our approach pose? To what extent have we taken this sufficiently into account?*

The expert committee does not find that the current approach will lead to a transport system in which technical and operational aspects are sufficiently taken into account. The approach taken in terms of the managing of the scope as well as the delivery of the ERTMS programme implementation plan is inadequate. Considering the complexity of the ERTMS implementation in the Netherlands, it is the committee's observation that the programme structures, for governance and management, need to be improved to adequately support the implementation plan (see recommendations in chapter 6).

The implementation strategy appears to be based on the assumption that the train and trackside systems will work together perfectly from day one. However, having the ability to fall back to degraded modes and allow ample time for the recovery from incidents and software updates are currently not taken into account in the implementation strategy. Therefore, from experience, the expert committee seriously doubts whether the implementation strategy is realistic.

The expert committee found evidence that the Operational Concept Description document has a large number of outstanding and unplanned actions, some of which, if not addressed could have significant implications on the operability of the finished railway. Typically, the Operational Concept document is key to developing the functional requirements.

The expert committee notes the Chain Management workflow as a very positive effort to account for operability, primarily focused on processes. However, it is currently in its infancy and does not involve all the operators. This shortfall also needs to be addressed.

Regarding operational readiness, the programme plans a 1-year operational trial on the Hanzelijn to achieve operational stability, successful completion thereof is a gate to allowing subsequent line roll outs. The expert committee recommends that there are solid exit criteria for this activity, as the period of 1 year seems a long time to wait if measurable and desired benefit is justified and recorded. Detailed planning of the scenarios has yet to be identified and will need careful planning to achieve the goals. This activity could be used to mitigate the operational and procedural risks in the future; however it is considered too late in the process to implement such design changes to address any shortcomings.

The expert committee has not seen whether human factors are adequately accounted for. For example, human factors workload assessments are normally done based on tasks and scenarios derived from the Operational Concept document (assuming the desired functionality is delivered). The outstanding issues therefore require urgent attention.

Specifically in terms of driver training, this is still based on the requirement that all drivers will have to be able to drive on all track lines throughout the Netherlands. This requirement hampers the implementation strategy. Certain opportunities in this regard have not been sufficiently explored (see recommendations in chapter 6).

To a large extent, risks are linked to the approach taken. However, the IOs seem to manage their own part of the implementation as a set of projects or their own internal programme, instead of as part of an integrated ERTMS programme which is managed top-down. Linked to this, there is a risk that without fully-resourced Systems Engineering (Requirements Management, in particular) the transport system will not function properly. Many of the risks addressed in themes 2 and 3 also have an impact on the programme's ability to deliver on time. The Programme Directorate still has to address these risks adequately.

> 2. *To what extent is our approach comparable to the implementation of ERTMS elsewhere? Would a different approach fit in the Netherlands? What are the risks of taking a different approach?*

The Netherlands has chosen a specific approach for implementing ERTMS which attempts to respond to the national situation and context. As such, the Dutch approach has some unique features.

The table in figure 8 provides a high-level comparison of the approaches taken in different benchmark countries. Each country has taken a slightly different approach, depending on the risks involved. As such, it is important to assess the choices made by those countries which vary from the major commonalities.

These deviations in approach introduce risks that are worth highlighting:

Management control and responsibility:

One of the key differences from the approach taken in other countries is that the Dutch ERTMS Programme Directorate is not in control of the entire implementation or at least the significant parts. Instead, implementation is managed loosely and divided among the various Implementing Organisations.

Consider the approach taken in Denmark, where the Programme was *the only* implementing organisation responsible for implementing ERTMS on the entire national network. In Belgium, the implementation management responsibility is with IOs (mainly NMBS and Infrabel) with no programme structure. However, Infrabel has overall responsibility for integration. Also, in Belgium, escalations between IOs are dealt with by a Technical Committee which falls under the Minister of Mobility. Major stakeholders, including the Safety Authority (DVIS) participate in this committee. Denmark and Belgium both have clear accountability for the Programme delivery. In the UK, while there is an overall ERTMS Programme, the lines are managed as separate projects and are held accountable for the total delivery. In the UK the central (Network Rail) programme also controls the scope, specifications and standards to be adhered to and remains the System Authority.

The expert committee has made recommendations to mitigate this risk, by giving the Programme Directorate authority and responsibility to deliver the ERTMS programme.

Procurement of ERTMS Lineside

All other countries have taken a D&B approach for procurement of the lineside design and installation. This makes a single entity, the contractor, responsible for the roll out against a fixed budget, time and scope, with performance guarantees.

The Dutch lineside D&B strategy is to procure equipment from the contractor, and to contract the design to five engineering companies and the installation to four separate entities, so a total of ten different entities, including the PD, are involved. This means that the programme directorate takes the overall performance responsibility and leaves itself vulnerable regarding the integration between all parties. There is an additional vulnerability with multiple sources of delays on the same or all lines. For example, the design for the EKB line was done by all five Engineering companies, meaning that even in a single line there are multiple designers and contractors, increasing the burden of management, consistency and integration. There is also a real risk that the signalling equipment (and interfacing equipment) could require integration-related design and software changes, which besides cost exposure can also result in significant time delays.

The expert committee has not recommended a change to this approach as the signalling contractor has already been committed. However, the expert committee notes that the design and installation contracts have not yet been procured. The expert committee recommends that these risks be considered as part of the procurement strategy.

Full ERTMS implementation by line

In the Dutch strategy, the major stations of Amsterdam, Utrecht and Rotterdam are not fitted (leaving them as 'ATB islands' until future rollout). This creates an operational performance risk due to a dependency on a large number of transitions demanded for every train entering and exiting non-ERTMS areas, especially in these complex areas. All other countries have chosen full implementation by line with no 'legacy islands'. While the expert committee acknowledges the complexities involved, the committee recommends that the programme reconsiders this decision, including for example rolling out these areas in overlay.

Line closure strategy

A line closure strategy (beyond a nominal two weeks) has been avoided by other countries owing to its disruptive nature. More importantly, the risks of overrun are high as a significant amount of work is planned for completion in a window, with inadequate time for recovery if major (especially software) issues are encountered.

In the case of the Hanzelijn, as the strategy is to decommission the ATB with no temporary 'over-and-back' facility (during testing and commissioning), returning the railway to service while issues are resolved will not be possible. This could result in delays to reopening the line.

Other notable points for comparison are:

- none of the benchmark countries have taken a line closure strategy for the initial line
- installing equipment for freight varies in terms of installation and funding (extremes: UK provides no passenger but full installation costs for freight. Belgium provides full funding for passenger but no funding for freight.)

The expert committee does not recommend changing the entire approach, as this would pose significant risks to both delivery and planning of the programme. However, elements of the approaches taken by other countries could be made to fit the approach taken in the Netherlands. It must be noted that adopting such changes at this stage of the programme would mean a major change to its planning and scope and should therefore be explored only very carefully.

3. *Does the forecast represent a good financial translation of the scope? Have the risks been sufficiently included in the forecast? What do you specifically think of the unforeseen percentages used? Is the Final Financial Forecast complete and realistic?*

The expert committee has drawn up a list of cost and budget items that typically occur in ERTMS/ETCS L2 projects, so called 'must costs', and checked the Final Financial Forecast to identify whether any of those budget items are missing or obviously insufficient. Based on this, the expert committee concluded that the Final Financial Forecast is generally complete; all 'must costs' are covered.

However, there are some elements that do require more attention, such as the costs of telecommunications and data transmission and the estimates for retrofitting the yellow fleet. Furthermore, change management has been a specific budget item in various other large-scale ERTMS projects. This budget item is not explicitly visible in the Final Financial Forecast. The ERTMS programme should assess whether change management costs are adequately covered.

Regarding risks and unforeseen costs, the forecast of the remaining costs per end of 2022 includes EUR 3.194 million of 'foreseen' costs and EUR 754 million of 'unforeseen', risk-related costs (excluding VAT). The risk-related costs are 23,6% of the foreseen costs. The expert committee finds the Dutch estimates conservative, calculating with high foreseen costs and adding considerable surcharges for unforeseen costs on top. In general, the Final Financial Forecast appears to cover the programme risks adequately. Other countries may have higher percentages for explicit risk costs, but a lower 'foreseen' base. The absolute amount of risk-related costs in the Final Financial Forecast therefore appears adequate.

The expert committee has identified the following risks which might be underrepresented and should therefore be reassessed:

- The expert committee considers that the schedule, as presented, is unrealistic (see Question 4 below). Therefore, the Programme schedule's lack of feasibility could lead to additional costs for more years to come. Delays have been a major problem in all ongoing ERTMS programmes and have been a prime reason for cost overruns.
- Interdependencies between various projects mean that any delay in one of these projects can lead to other delays, and consequently, funding issues elsewhere.
- The expert committee recommends that the Programme Directorate costs are reconsidered based on the findings stated here.

    4. To what extent will we be able to deliver on schedule, what risks are involved? What cost risks will be a consequence of this?

The expert committee considers the current schedule unrealistic. It is unnecessarily highly complex and significantly 'back-end loaded'. Furthermore, the committee observes a lack of trust of the plan, and as such the plan does not have the necessary stakeholder buy-in. It is not considered realistic to steer a programme towards a deadline that is not universally perceived as achievable.

The deterministic programme plan is to complete the ERTMS implementation in 2029 according to the programme decision planning, and in 2030 according to the deterministic planning 7.0, and has been assessed by the programme to have a 1% probability of success; the P85 plan (85% probability of success) extends the completion date by two years to 2031. The IOs are operating based on the P85 schedule rather than the deterministic schedule; however, there are still perceived doubts about its deliverability.

The expert committee observes that the P85 schedule is 'back-end loaded', indicating a high level of parallel working in 2030/31, whereby all 8 lines complete their delivery in 2031. This poses several issues relating to deliverability: it places high demands on resources (people, equipment and infrastructure, training, assurance etc.); it does not take account of a learning curve to enable such a high delivery rate; and it places a risk on the continued operation of the network during delivery, therefore making such a plan unrealistic. The expert committee therefore considers the

schedule does not adequately consider the practicalities of delivering on such a busy network, nor does the schedule consider the demands this will place on the industry to deliver.

In comparison to the Danish programme, a mature programme that has benefitted from the learning curve in many ways has managed to deliver between 200-250 track km per calendar year, whereas the Dutch programme plans to deliver almost 900 kms of track in 2031. International benchmark evidence would suggest a minimum risk of two years.

There are also risks to the schedule connected to the expert committee's observation that a stronger focus on operational readiness is needed at all levels of the programme. For example, the operational concept document (OCD) needs to be given significant attention, as currently only 1 out of 23 actions in the OCD are planned. This can lead to significant gaps in the IT system functions, which could only start revealing themselves late in the schedule, in turn potentially causing major slippage in the planning.

If these issues regarding the schedule are not addressed, the programme will risk significant cost-overrun connected to both programme costs and costs related to delays in interdependent projects. See Question 3 above.

5. *To what extent are the expected costs for the implementation of ERTMS in the Netherlands – taking into account the specific circumstances – in line with those in other countries? If not, which programme components deviate (to a large extent) and to what extent (approximation in a percentage)? How can you explain these deviations?*

The estimated costs for the implementation of ERTMS in the Netherlands are considered high when compared to other countries: the infrastructure costs and line signalling costs are more than double in the Netherlands compared to other countries, and the vehicle equipment costs are roughly 25% more expensive. The expert committee notes however, that the cost structure of the programme is comparable to that of other countries.

The Dutch ERTMS Programme is an ERTMS L2 baseline 3 implementation, as is also pursued in other countries. As in other countries, the ETCS introduction in the Netherlands is combined with centralising interlocking and includes replacing track circuits with axle counters.

When comparing the Dutch approach with other national programmes in Europe, the current Dutch Programme covers only a part of the network and leaves the three large stations with class B systems. The rest of the network, including large stations, will be converted in the national rollout of ERTMS. Other countries are replacing the entire signalling infrastructure and traffic management systems. The Netherlands has more vehicles to retrofit and, hence, also more train operating staff to retrain. The Netherlands appears to be using signalling contractors mainly for system development and delivery, while other countries have contracted with signalling suppliers for lifetime support: development, delivery, installation, commissioning and maintenance after final delivery.

The Final Financial Forecast for infrastructure costs per track km or per SEU and for onboard-related costs per vehicle is significantly higher than European benchmarks from Switzerland, Italy, France, the UK, Denmark, Norway and Sweden. This applies to (contractual) system delivery, internal resource costs and overhead, and risk-related costs. Possible reasons for this can be of a technical nature, related to the market in the Netherlands or the specifics of the Dutch railway industry (see also Theme 4).

In particular, the way in which implementation is managed in the Netherlands is different when compared to other countries. In the benchmarked countries, development, design and installation of a new system is procured on the market in a single contract, whereas in the Netherlands, it

appears to be more common that the procurement of software/hardware such as system development, signalling layout, installation and maintenance are procured as singular elements resulting in multiple contracts.

This finding also has consequences for the overall programme plan as well as for the costs. For the programme plan, because the interfaces between all the consultants, suppliers and installers will drive up time and costs, in the sense that (i) more time is needed with all the transitions and back loops; (ii) there are no learning curve gains, as the scope is divided among many consultancies and installers; and (iii) there is a lack of incentives to optimise. In similar vein, seeing that there is limited competition in terms of design & installation, there is also no market mechanism that drives down the costs. The same can be said in terms of the decentralised way in which the Implementing Organisations buy from their suppliers.

6. *What cost-saving opportunities do you see? Do these opportunities entail additional risks?*

The expert committee sees cost-saving opportunities which are linked to the procurement strategy. In certain areas, reassessing the procurement strategy could lead to more competitive costs. The areas with substantial uncommitted costs (and, hence, good opportunities for cost savings) are, for example:

a. EUSI roll out including the Hanzelijn test track section, the Northern Lines and axle counters
b. Additional management and maintenance
c. Developing and commissioning ERTMS security
d. Uncommitted NS retrofits

Cabling and axle counters are elements where technical solutions and economies of scale may have a particular potential for cost savings. Further cost-saving opportunities could be found by reassessing the number of vehicles included in the budget for retrofitting or upgrading to ETCS L2/B3. It could also be worthwhile considering opportunities for international cooperation and/or co-funding in this area.

The programme could also look at the 'first-in-class' costs as this figure currently sits around EUR 1.6 million, which the expert committee considers relatively high. Combining resources for acquisition and standardising the approach across implementing organisations could also be an area where costs can be saved.

However, the search for cost-saving opportunities in itself includes the risk of further delays. The ERTMS Programme may be best advised to concentrate on getting (remaining) work started in due time and avoiding any further delays, as these are costly and postpone realising any of the benefits. In addition, implementing the recommendations for Programme Directorate control would serve to mitigate the integration, schedule and cost risks associated with the fragmented nature of the programme.

7. Recommendations

Recommendation made in relation to question number	1	2	3	4	5	6
Full list of recommendations						
1. The Programme Directorate (PD) should insist on fixed scope at least for the first eight lines being fitted. This should be the well-established and proven ERTMS Baseline 3 Maintenance Release 2, with no other add-ons or developments. Automatic Train Operation (ATO) and Hybrid L3 development should take place separately from the first eight lines.	X	X		X		
2. The PD should consider instructing ProRail to use over-and-back techniques by having train detection with axle counters interfaced to the new Interlockings and Radio Block Centres, co-existing alongside track circuits, relays and the current interlocking systems that are used to control the ATB-protected railway that is in service today. This would avoid prolonged closure of lines for commissioning and would facilitate reverting back to the existing system should operational issues become apparent after commissioning. The expert committee recommends that this is done at least for the first line/lines until some level of proficiency is reached.	X	X		X		
3. The expert committee recommends that each Implementing Organisation (IO) has clear disaggregated requirements that link back to the overall SMART Requirements, and that Programme level assurance reviews are implemented to make sure that the sum of all IO deliverables equals fulfilled top-level requirements for the programme. i.e. a review at the System of Systems level.	X					
4. The expert committee recommends that concepts be developed to plan for how the railway will be operated and function in emergencies and for recovery after emergencies. This should also include developing operational concepts in degraded modes which should be given very high priority and documented in the Operational Concept Description (OCD).	X			X		
5. The expert committee recommends that the readiness of GSM-R is reviewed, particularly to make sure that the eight initial lines of the ERTMS Programme are given priority over other Dutch railway lines. Specifically, the expert committee recommends that the test methods to validate and verify sufficient coverage are double-checked and that dynamic testing with a vehicle is completed in good time for all eight prioritised lines.	X			X		
6. The expert committee recommends that the Service Strategy for Chain Management, and other documentation from the entire ITIL lifecycle is developed, published, and tested against the disaggregated requirements, so that a prioritised list of any procedural and system gaps can be developed and addressed.	X			X		

Recommendation made in relation to question number	1	2	3	4	5	6
7. The expert committee recommends that PRAMS modelling be reinforced at the PD level, and that disaggregated requirements are clearly communicated to each of the IOs, and that Entry/Exit criteria are established per Programme Migration Step to manage IO progress to their next phase in the lifecycle.	X			X		
8. The expert committee recommends that the Programme Directorate reinforce their approach to Software Configuration Management and establish a proactive software management team that promotes collaboration across all the IOs, and which is authorised to determine the build that is deployed to each laboratory, test site, and railway line controlled by the PD at any moment in time.	X					
9. The expert committee recommends that recommendations 1 to 8 are reviewed carefully. This to make sure that the eight initial lines of the ERTMS Programme are prioritised against other Dutch railway lines, and that the test methods to validate and verify sufficient coverage are double-checked and that dynamic testing with a vehicle is completed in good time for all eight prioritised lines.	X	X		X		
10. The expert committee recommends that the Programme Directorate be authorised to act as System Authority for the implementation of the Dutch ERTMS Programme. The PD should then act to define and mandate the implementation of ERTMS prioritising the delivery of the schedule over the development of new functions. This would most likely mean a scope freeze for the first seven or eight lines without the distraction of considering ATO, Hybrid Level 3 or Future Railway Mobile Communication System (FRMCS).	X	X		X		
11. The PD should mandate the use of specific Requirements Management and other Systems Engineering tools across the Implementing Organisations, thus forging closer collaboration and management of the engineering lifecycle through use of common platforms.	X	X				X
12. The PD should recruit Systems Engineering specialists into their organisation to add to their existing capabilities. This way, as the Systems Authority, they can have a more proactive role in Systems Engineering, including Requirements Management through each phase of the lifecycle, software configuration management, and leadership. The expert committee considers that the architectures need a much more detailed definition. The system architectures are currently at a fairly high level. However, these need to be detailed to the next level down so that they can be used to better manage interfaces, functions, and even migration. Architectures will be a fundamental part of defining the Migration Stages in more detailed.	X					
13. The PD should place high focus on defining the Migration Stages to a greater level of detail, covering the entire railway configuration at a physical asset level (all assets beyond the ERTMS scope), functional level (covering all railway functions that work with assets beyond ERTMS scope) as well as operational level (including timetables to be operated). To accomplish this, the expert committee recommends the PD is boosted with additional resources to further develop these areas, possibly through embedded domain experts seconded from the IOs. Each Migration Stage must also be accompanied by Entry/Exit criteria, to enable programme level management of readiness ahead of achieving the milestone.	X	X				

Recommendation made in relation to question number	1	2	3	4	5	6
14. To support the volume of testing and commissioning required in the ERTMS Programme, the expert committee recommends that the Integration Laboratory loading is stringently reviewed, and any additional facilities and resources required to address the peak volumes in the programme should be procured as a priority. It was noted that there are currently 10 vacancies for lab staff. This area of the programme should be managed as a critical bottleneck and any resource deficiencies (people, processes and facilities) must be addressed as one of the highest priorities.				X		
15. The expert committee recommends considering combining ProRail and NS testing laboratory resources particularly if (for example) there is an overall shortage of testing staff. It could be that combining the resources of ProRail and NS will help overcome the staffing shortfall, rather than each entity competing against the other in a constrained marketplace.	X			X		
16. The expert committee recommends that the Programme Directorate takes leadership of high integration functions at the railway level. There are many functions that run across disciplines and delivery organisations. The expert committee recommends that the PD plan a series of design gates / assurance gates that work at the overall level. These must take account of the government's overarching functional needs, making sure that these are delivered through the sum of the parts. These sorts of reviews are recommended at three gated points in the programme: at approx. 30% design maturity (i.e. concept stage), approx. 60% design maturity (i.e. scheme design stage), and at the 90% stage when detailed design is complete. At this point the reviews need to address the system and process design for the normal modes (the 'happy flow'), but also the degraded modes and recovery from incidents.	X					
17. The expert committee recommends that the PD management team is expanded and resourced so it can take detailed deep dives into IO schedules. The overall programme schedule should be reworked to include firebreaks between major IO milestones. Monthly schedule reviews and management action should become the regular routine for the organisations involved.	X					
18. The PD must take a leadership role in managing the overall System Safety and Approvals. Traditionally, safety and associated approvals is the final element prior to achieving operational readiness, any delays in this area have a direct impact on the achievement of the schedule. The ERTMS programme has numerous approvals at the equipment level as well as at railway and operational levels. For an accurate assessment of the health of the project, proactive management is required. The expert committee also considers that overall Integrating Technical Safety Cases will be required to consolidate the programme risk and confirm appropriate mitigation.	X			X		
19. Even though the expert committee concludes that in general the final financial forecast is complete, the expert committee recommends the Programme Directorate reassess several cost items.			X		X	

Recommendation made in relation to question number	1	2	3	4	5	6
20. In line with the expert committee's recommendations for changes in in the programme organisation, the committee recommends that the Programme Directorate's budget should be reassessed for those changes. It should also be ensured that the Programme Directorate's budget covers an eventual extension of the ERTMS programme beyond 2029 or 2031 respectively.			X		X	X
21. The expert committee has identified several areas with substantial uncommitted costs. The expert committee recommends reassessing the real needs and procurement strategy in those areas to achieve more competitive costs. Specifically, the expert committee recommends reassessing the number of vehicles included in the budget for retrofitting or upgrading to ETCS L2/B3MR2. Considering international cooperation/co-funding opportunities in this area (e.g. at CINEA)It should also be worthwhile.			X		X	X
22. Notwithstanding, the expert committee recommends that the ERTMS PD concentrates on getting (remaining) work started in due time and avoids any further delays, as these are costly and postpone benefit realisation. That means the focus should not be on looking for cost-saving opportunities when this detracts from fulfilling the current plan.	X		X	X		X
23. The expert committee recommends that the Dutch ERTMS programme actively seeks to transition from development/conceptual stage to delivery stage. This requires a revised governance within the programme; between the programme and the implementing organisations (IOs) and between the programme and the Steering Committee.	X					
24. Regarding a revised governance, the expert committee suggests that the Steering Committee setup could benefit from a two-level approach. • At the first level: an operational, smaller steering group led by the Programme Directorate, meeting more frequently (monthly), and with a clear mandate to directly solve problems and make decisions; • A second level: matching today's Steering Committee should continue being the benefit realisation group, where specific decision can be taken to make sure that key stakeholders benefit to the greatest extent from the ERTMS conversion.	X			X		
25. The programme organisation needs to manage more and facilitate less. This can be achieved by strengthening the programme management disciplines and emphasising their presence in the day-to-day-programme management. The Programme Directorate must exercise more control and decision power over the programme scope.	X	X				
26. An increased programme reporting frequency (preferably monthly), focusing on assessing progress booked in the past recent month and any consequences (emerging risks and issues) for delivering the programme objectives on time should be documented. The report data close-off date and reporting due date must be within 1,5 weeks to allow for sharing information, overseeing progress, and so that potential escalation points can shared and discussed in due time. Financial status and costs can be assessed quarterly.	X			X		

Recommendation made in relation to question number	1	2	3	4	5	6
27. The nature of the reporting must shift from the current qualitative dialog based reporting to more quantitative reporting, where the evidence of progress is clearly stated and is based on data presented. Narrative can be included to justify/explain and/or offer mitigating actions. This should include KPIs on things Requirements (flowdowns, compliance, verification, validation), Benefits Realisation, Work progress against Schedule, Assurance, Procurement, Cost and Risk.	X					
28. The expert committee recommends that the PD management team is expanded and resourced, so that: • detailed deep dives into IO schedules can be undertaken; • the overall programme schedule can be reworked to include firebreaks between major IO milestones; • monthly schedule reviews and management action becomes the regular routine for the organisations involved. The PD should have authority to call the IOs to account, and to drive more realistic programme approaches, e.g. over-and-back testing and commissioning, rather than line closures.	X	X				

Appendix A – Documents consulted

Name of source	Sender	Date of document
AA Overzicht investeringskosten naar financier EKB raming D6.0 vs 0.2	PD ERTMS	01-03-2023
Actieplan kwartiermaker ketenbeheer ERTMS ProRail v1.0	ProRail	24-11-2022
Commissioning advise Start Experience driving Hanzelijn en Amsterdam	PD ERTMS	30-01-2023
Commissioning Teams ppt	PD ERTMS	23-04-2023
Eerste Assessment Proces Ketenbeheer ERTMS	ProRail	21-02-2023
ERTMS – Operational Concept Description (OCD) van migratiestap 9 t/m 15 v0.8	PD ERTMS	21-04-2023
ERTMS – SSS0 mds-09.20 v4.0	PD ERTMS	15-02-2023
ERTMS SSDD0 mds-09.20 – met interfaces	PD ERTMS	15-02-2023
ERTMS SSS0 mds-01.10	PD ERTMS	23-11-2021
ERTMS SSS1 IBS-ProRail voor mds-09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-NS voor mds09.20	PD ERTMS	16-02-2023
ERTMS SSS1 SOS-Qbuzz voor mds09.20 (nieuwe rolling stock)	PD ERTMS	16-02-2023
Extra commissioning team Experience driving	PD ERTMS	23-05-2023
Herijking financiële Prognose Eindstand programma ERTMS – Programma ERTMS, 2022	PD ERTMS	2022
Implementation plan MDS 05.10 en 06.10	ProRail	05-07-2021
Inrichtingsvoorstel Ketenanalyseteam	ERTMS @ NS	11-05-2023
INTEGRALE SSK raming EKB Kijfhoek-Belgische grens_D6.0_PROBA	PD ERTMS	28-03-2023
INTEGRALE SSK raming EKB Kijfhoek-Belgische grens_D6.0_PROBA	PD ERTMS	28-03-2023
Kamerbrief achttiende voortgangsrapportage ERTMS	Staatssecretaris van Infrastructuur en Waterstaat	03-04-2023
Kennisdocument 59ppro en traceability	PD ERTMS	28-04-2022
Kennisdocument architectuur	PD ERTMS	26-04-2022
Kennisdocument Product Based Planning	PD ERTMS	01-04-2022
Masterplanning 7.2	PD ERTMS	04-05-2023
Memo vaststellen bandbreedte planning 7.0	PD ERTMS	01-08-2022
Migratieplan 1.4	PD ERTMS	13-04-2023
Migratiestrategie 6.0	PD ERTMS	31-08-2018
NS Implementation plan mds-05.10 & 06.10	NS	21-12-2022

NS Vervoersmodel explainer	ERTMS @ NS	15-06-2023
Ontwikkeling realisatieplanning (migratiestappen)	PD ERTMS	31-05-2023
Opstellen Operating Model Ketenbeheer ERTMS	ProRail	16-02-2022
Overall planning Experience driving MS 5 & MS6 0.4 draft	PD ERTMS	March 2023
Overzicht investeringskosten naar financier EKB raming D6.0 vs 0.2 d.d.	PD ERTMS	01-03-2023
Overzicht investeringskosten naar financier EKB raming D7.0 vs 2.0 d.d.	PD ERTMS	15-03-2023
PE December 2022 file package, encompassing the subdirectories Besluitvorming, Geconsolideerde PE bestanden, PE – initiele scope programmabeslissing, PE – wijzigingen en bijbestellingen, Rapportage PE"	PD ERTMS	December 2022
Planning 7.0	PD ERTMS	05-08-2022
Planninganalyse Q1 '23 vs. Masterplanning 7.0	PD ERTMS	Q1 2023
Probabilistic Planning Analysis Master Planning 7.0	PD ERTMS	Q2 2022
Programmaplan ERTMS realisatiefase 2.0	PD ERTMS	10-04-2019
ProRail ERTMS Aanbestedingen Kalender (PEAK)-werkbestand	PD ERTMS	21-06-2023
Railmap 4.0	PD ERTMS	03-05-2019
Report Review of the Financial Final Position Forecast ERTMS Programme v1.1	PD ERTMS	Year-end 2022
Risicomanagement document realisatiefase Programma ERTMS (incl IEMeV)	PD ERTMS	15-02-2023
Risicomanagementplan realisatiefase Programma ERTMS	PD ERTMS	01-12-2022
Scopedocument 6.2	PD ERTMS	07-12-2020
SMART PvE vervoersysteem met ERTMS v2.2	PD ERTMS	17-02-2021
Steering Group meeting documents (agendas, minutes, memos and decision lists) from meetings between December 21st, 2021 until March 9th, 2023)	Steering Committee ERTMS	2021 – 2023
Systeemintegratiestrategie	PD ERTMS	22-08-2022
Systeemintegratiestrategie, v6.1	PD ERTMS	22-08-2022
VGR 1 – 17 (as reference)	Ministerie van Infrastructuur en Waterstaat	30-06-2014 to 26-10-2023
VGR 18 ERTMS (as baseline)	Ministerie van Infrastructuur en Waterstaat	31-02-2023
Website ERTMS (www.ertms.nl)	Public website	
X2 Planning note Realization phase	PD ERTMS	04-05-2019

Appendix B – Interviews

Between May 2023 and July 2023, the following 28 interviews were conducted for the second opinion:

- Interview 1: Governance and organisational change – expert committee, ERTMS Programme, Ministry of Infrastructure and Water Management
- Interview 2: System management, Europe, neighbouring countries – expert committee, ERTMS Programme, Ministry of Infrastructure and Water Management
- Interview 3: System integration – expert committee, ERTMS Programme
- Interview 4: System architecture and design (SE, interfaces) – expert committee, ERTMS Programme, IEP/ProRail, NS
- Interview 4b: System integration (verification, validation, testing) – expert committee, ERTMS Programme, IEP/ProRail, NS
- Interview 5: Safety, certification and authorisation – expert committee, Inspectie Leefomgeving en Transport
- Interview 6: Planning - expert committee, ERTMS Programme
- Interview 7: Risk management - expert committee, Riskineering, ERTMS Programme
- Interview 8: Costs, project Kijfhoek, Belgian border – expert committee, ProRail
- Interview 9: Preparation of operation: commissioning teams – expert committee, ERTMS Programme
- Interview 10: CSS and lab – expert committee, ProRail
- Interview 11: Freight carriers – expert committee, RailGood, InteVice
- Interview 12: Passenger carriers – expert committee, Arriva, Qbuzz, ERTMS Programme
- Interview 13: Chain management - expert committee, ProRail, NS
- Interview 14: ICT (tooling, networks, system adjustments) – expert committee, ProRail
- Interview 15: Infradata (chain management) – expert committee, ProRail
- Interview 16: Cost estimation (total) - expert committee, ERTMS Programme
- Interview 17: Freight carriers – expert committee, Rail Force One, Captrain
- Interview 18: NS (timetable, technical) – expert committee, NS
- Interview 19: Planning trackside implementation ProRail – expert committee, ProRail
- Interview 20: ERTMS Programme units 4, 9 and 10 (4: project office; 9: analysis, monitoring and reporting; 10: business office) – expert committee, ERTMS Programme
- Interview 21: System engineering – expert committee, ERTMS Programme
- Interview 22: Role of ERTMS Programme in certification process – expert committee, ERTMS Programme
- Interview 23: Additional interview Ministry – expert committee, Ministry of Infrastructure and Water Management
- Interview 24: Additional interview NS – expert committee, NS
- Interview 25: Safety – expert committee, PD ERTMS
- Interview 26: Additional interview Ministry on governance - expert committee, Ministry of Infrastructure and Watermanagement
- Interview 27: System architecture and design (SE, interfaces) – expert committee, ERTMS Programme
- Interview 28: NS engineering systems approach – expert committee, NS

Appendix C – Migration steps

Migration step	Date (planning 7.0)	Bandwidth (planning 7.0)
1. MS00. Preliminary steps		
2. MS01. Chain management is ready for operations		
3. MS02. Logistics chain is ready for operation	January 2024	2024 – 2024
4. MS03. Passenger rolling stock converted to ERTMS starts commercial operation with ATB	April 2024	2024 – 2024
5. MS04. Freight rolling stock converted to ERTMS starts commercial operation with ATB	December 2024	2024 – 2025
6. MS05. Experience driving for staff starts on harmonised track section Hanzelijn	September 2023	2023 – 2024
7. MS06. Experience driving for staff starts on harmonised route section Amsterdam-Utrecht	September 2023	2023 – 2024
8. MS07. Start of commercial deployment of passenger rolling stock with upgrade in operations at home and abroad	December 2022	2022 – 2023
9. MS08. Start commercial operation on Hanzelijn - Lelystad and Lelystad Opstel	April 2027	2027 – 2029
10. MS09. Start commercial operation at Kijfhoek – Belgian border with Level 2 Only	June 2028	2028 – 2030
11. MS10. Start commercial operation on OV SAAL east with Level 2 Only	July 2029	2029 – 2031
12. MS11. Start commercial operation at Hoofddorp - Duivendrecht with Level 2 Only	July 2029	2029 – 2031
13. MS12. Start commercial operation at Utrecht-Meteren with Level 2 Only	January 2030	2030 – 2031
14. MS13. Start commercial operation at Roosendaal - Den Bosch with Level 2 Only	December 2029	2030 – 2031
15. MS14. Start commercial operation at Meteren - Eindhoven with Level 2 Only	June 2030	2030 – 2031
16. MS15. Start commercial operation at Eindhoven - Venlo with Level 2 Only	June 2030	2030 – 2031
17. MS17. Begins commercial operation on Northern Lines with Level 2 Only	August 2028	2028 – 2031