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CREAM

Customer-driven **R**ail-freight services on a **E**uropean mega-corridor

based on **A**dvanced business and operating **M**odels

Instrument: INTEGRATED PROJECT

Thematic Priority: Sustainable Surface Transport

CREAM report: Demonstration of advanced implementation concept of Betuweroute in the framework of the European rail freight (DA 5.1)

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Foreword

The Betuweroute is a dedicated *freight* railway line between the port of Rotterdam and the Dutch/German border. This railway line should be integrated into the existing European rail network and more in particular into the CREAM corridor, which consists of the main railway axes connecting the North-Western part of Europe (The Netherlands and Belgium) with the Mid-European (Germany, Austria) and South-East European countries (the Balkan countries, Greece) and Turkey.

In Research Activity RA 5.1 (report DR 5.1) we have analyzed which activities were needed to start-up commercial services on the Betuweroute.
The result, the technical-operational and economic plans for the Betuweroute, were put to the test via training (report DT 5.1) and demonstration activities. This report contains experiences from demonstrations until the end of 2010.
What is new to the Betuweroute is that the infrastructure manager, Keyrail, is not the commissioner (supervising construction and renovation) nor the owner of the infrastructure. These tasks were given by the Dutch government to ProRail, who is also the infrastructure manager for the rest of the Dutch railway infrastructure. The task of Keyrail is to manage and maintain the infrastructure in a commercially viable way, which means that the reliability and availability of the infrastructure and in particular of the technical systems in and around the rails and tunnels are decisive for the quality of rail services and for the income Keyrail receives from its infrastructure management. This is not the case for ProRail, an organisation that belongs to the Ministry of Transport.
What is also new to the Betuweroute is that it is equipped with technical systems, many of which are new to The Netherlands and in many cases either did not exist in other countries and/or had to be adapted to the Dutch requirements.
When commercial services started, the starting conditions for freight train services, as assumed by Keyrail when it signed the management contract with ProRail and the Ministry of Transport, were not available, an inevitable conclusion after reading all relevant documents and assessing information from Keyrail and users of the Betuweroute.

As a consequence, customers of Keyrail could not be offered the quality of infrastructure required to run commercial services in the most optimal way both in the demonstration phase as well as in the commercial phase.
Formally, only when the remaining (technical) issues are solved, the demonstration phase is over. In 2009 and 2010 significant progress has been made to solve these issues. Thanks to this, the line is now used by 350 trains per week and the trend is upward.
Improved reliability of the technical installations not only supports current traffic volumes, but even more the forecasted – several times larger – traffic volumes. This contributes to the development of an efficient and reliable intermodal transport system, able to fulfil the requirements of intermodal customers.
It is important to realize that these technical issues and therefore also their solutions are determined by financial, organizational and institutional conditions, which are the result of choices by all parties involved in the process of building, demonstrating and commercially using the Betuweroute. What has become apparent is that the lack of a system integrator – neither the Ministry of Transport and Public Works, nor ProRail has fulfilled this role – has made the project Betuweroute much more complex than necessary. Many issues discovered during the demonstration phase could have been prevented by different design choices, better coordination by a system integrator, a clearer division of roles and more communication among the parties involved. We reached the same conclusion in our analysis of the problems with ERTMS on the Dutch high-speed passenger line. Also there, the development and teething issues postpone(d) commercial services.

This document was crafted by the undersigned in close contact with Keyrail. Next to internal (Dutch) documents and interviews, I have also used many public documents. Kombiverkehr has provided two documents about their activities related with this advanced freight railway line. Their findings have been integrated in this and report DT 5.1. The experiences with the Betuweroute and Chain Management was also discussed with staff from DB Schenker Rail Nederland N.V.
As far as the CREAM project is concerned, Demonstration Activity 5.1 is now finished.
I hope that this extensive report, the preparation of which took considerably more time than initially planned, provides lessons for other (European) railway projects as well.

Delft, January, 2011 Dr. Jaap Vleugel

1. Introduction

1.1 Objectives

According to the Technical Annex [1] the objective of DA 5.1 is to prove the advantages of an efficient implementation concept of the Betuweroute in the incumbent European rail infrastructure; including a maintenance concept for a new high tech infrastructure. DA 5.1 comprises a 1:1 field validation. DA 5.1 will be dedicated exclusively to the Betuweroute (under consideration of the interfaces with the incumbent infrastructure). The implementation of DA 5.1 will include the operation of test trains by Kombiverkehr.

The success of DA 5.1 depends on the acceptance of the developed implementation concept. Keyrail (former BREM) as infrastructure manager will have to link the concepts with the European rail concepts. The performance indicator is the extent of compliance of Keyrail with the developed concepts. During the demonstration phase the concept will be continuously validated against these performance indicators.

1.2 Participants

Partners in DA 5.1 were Keyrail (former BREM), Kombiverkehr and OTB. Keyrail transferred project leadership and responsibility for the documentation of RA, DA and TA 5.1 to OTB in 2008.

[1] Amendment to TA of 1-07-2010, p. 88/184.

2. Description of work

2.1 Introduction

The following tasks were part of this workpackage [2]:

1) Step-by-step implementation of the technical / operational implementation plan of the Betuweroute (chapter 3);
2) Field evaluation of the technical / operational plans and coordination loop with RA 5.1 if necessary (chapter 3, section 3.8);
3) Implementation of the economic implementation plan (chapter 4);
4) Performance of a coordination loop with the RTD activities if necessary (all chapters);
5) Achieving the required high level of commitment by continuous feedback / coordination procedures with the Railway Undertakings involved (chapter 5);
6) Demonstration of operational trains Rotterdam-Duisburg/Dortmund by KV (chapter 6);
7) Implementing demonstration for "Betuweroute" by in particular implementing a "Ketenregie" involving the intermodal terminals, and installing a new software system able to support "Ketenregie" (interaction with terminals, railways and intermodal operators) (chapter 3, in particular sections 3.5.4 and 3.5.5);
8) OTB accompanying demonstration activities on "Betuweroute" implementation (all chapters).

The intimate relations between workpackages RA 5.1, TA 5.1 and DA 5.1 have insured coordination between these three activities. Chapter 7 finishes this report with an overall evaluation, including recommendations. Appendix 1 describes the Training and Demonstration concept developed by Keyrail. which forms the basis for DA and TA 5.1. Finally, Appendix 2 and 3 contain useful technical and non-technical explanations.

2.2 Expected results

The final result of this activity is that the concept developed in RA 5.1 was demonstrated in pre-commercial daily operation. The prologing of the demonstration activities (either finished or unfinished) into the commercial phase has also been documented.

[2] See footnote 1.

3. Demonstration of the technical-operational plan

3.1 Introduction

The Betuweroute is a new line, accesible only to freight trains. A five-year concession makes Keyrail (Keyrail, 2007, p. 6) responsible for:

- "management of capacity, traffic management and asset management (excluding renewal) of the port railway line and the A15-trajectory;
- management of capacity, traffic management and asset management (excluding renewal) of the marshalling yards at IJsselmonde and Feyenoord;
- development and management of an incident management organization for the Betuweroute."

The reader is referred to chapter 3 of report DR 5.1 for the specs of the Betuweroute.

3.2 The technical-operational plan

The technical-operational plan for the Betuweroute consisted of a series of (connected) activities, which have been summarized in Appendix 1. The key issues were thematically grouped together. Later in this report, each of them will be described in terms of (where applicable) aims, available options, decision process, time-path, main stakeholders, final choices, intermediate and final (expected or planned) results. The related training activities have been described in report DT 5.1.

The following demonstration activities have been documented:

- Interoperability (sections 3.3/3.4):
    - Conversion of the Port Line (25 kV and ERTMS);
    - Inflow and certification of ERTMS Level 2 and Level 1 locomotives;
- Line capacity management (section 3.5):
    - Impact of ERTMS braking curves;
    - International train path coordination and line capacity management;
    - ICT support tool for Pilot Ketenregie (SPIN);
    - Adaptation of Sophia tunnel regime;
    - Tests with trains longer than the average 400-600 m;
    - Removal of voltage sluices at Zevenaar and Kijfhoek (also interoperability).

- Safety (section 3.6):
  - Experience with Tunnel Technical Installations (TTI);
  - Evaluation of Hand Held Terminal (HHT);
  - Local firefighting and environmental permit.
- Maintenance concept (section 3.7):
  - Field experience with maintenance contract.

The report describes all relevant activities in the period 2008-2010, starting with the conversion of the Port Line in the next section.

3.3 Conversion of the Port Line

3.3.1 Towards interoperable railways in Europe

Historically, railway networks have been developed largely in isolation from neighbouring networks. This explains why there is an important number of technical and operational differences in the way railway networks are managed and maintained by their (national) network managers. Adding to this is the fact that each railway undertaking may have different operational practices, while its rolling stock and locomotives are supplied by different suppliers using dedicated technological solutions for similar applications. The activities of network managers and railway undertakings are governed by national, regional and local laws, regulations and rules, which also differ across Europe.

These differences represent a lack of technical and operational standardization. This is a major problem for international transport of goods by rail, as an important share of rail freight is international. By crossing national borders, a train (driver) has to adapt to different technical standards, operational rules and procedures. Usually a change of locomotives and staff takes place. Then there may be customs control and technical inspections of the load units. These border procedures may take a (relatively) long time. A study of 22 train services in the CREAM corridor revealed that a loss of time between 5.7% and 36.6% of the total transport time can be found (average 21.4%) compared to only 5.7% for other stops (Hacon, 2010). Such losses cannot be compensated effectively in other parts of the corridor. Border crossings go along with additional information requirements, risk of errors and other issues, which are not, or to a smaller extent, found in trucking. There we find a more standardized and harmonized operating environment.

The lack of standardization and harmonization is commonly referred to as *a lack of interoperability*. Interoperability as a concept was conceived in 1991 (Davis et al., 2001). It may be defined as "the capacity of the various national networks to interact, without interruption, with the adjoining networks, enabling a passenger or goods train to circulate without distinction on any section of the large trans-European railway network." (CZ, 2008)

Standardization is the ultimate form of interoperability. It is however a costly and time-consuming process. As an in-between option several technical and operational bypasses of the aforementioned problems have been elaborated over time, like multi-system locomotives, multilingual staff etc. Such adaptations may work in some cases, but they may increase operational complexity and reduce reliability as well. Over time, the EU has become aware of the need for (more) structural solutions in order to safeguard a safe and (minimally) uninterrupted movement of trains at the specified levels of performance.

In this realm, the EU has issued a range of harmonization efforts, which first concentrated on economic issues (level playing field, market entry), and later on expanded into the technical arena as well (see for instance Directive 96/48/EC). This led to a series of technical stimulation programs (see for instance: EC (2010) for ERTMS). In case of the Betuweroute, standardization means conversion to new systems:

- Introduction of ERTMS and 25 kV on the Rotterdam Port Line infrastructure;
- Inflow and certification of ERTMS Level 2 locomotives (Betuweroute);
- Inflow and certification of ERTMS Level 1 locomotives (Port Line).

In this section, practical experience with interoperability will be discussed.

3.3.2 Conversion project start

The Port Line consists of all running lines and sidings in the Rotterdam harbour area (exclusively) used by railway undertaking to run, park and shunt full trains, wagon groups or single wagons from and to port industries. It has a length of 48 kilometers. In the harbour area only freight trains are allowed to operate.

To better understand the conversion project and process, it is important to make a distinction between the situation before and after December 2009.

With the opening of the A15-trajectory of the Betuweroute in 2007, ERTMS/ECTS train control system Level 2 and 25 kV AC power supply became operational. ERTMS fulfils the highest safety standards (SIL 4). Where the A15-trajectory crosses the conventional mainline railway network, at Zevenaar and Kijfhoek, ATBEG (SIL 2/3) and 1500 V DC systems continue to be used [3]. The Port Line kept its signalling system ATBEG and 1500 V DC power supply system until October resp. December 2009. Both systems are the standard on about 90% of the Dutch railway network. The step-wise change is due to the incompatibility of ERTMS/25 kV AC/JADE and ATBEG/1500 DC/GRS (see report DR 5.1 for more information).

The need for a 25 kV power supply can be derived from increased operational requirements. The existing power supply of 1800 V DC (4000 A max.) can at most provide 6 MW [4]. The actual current demand of trains depends on many factors. Particularly relevant for heavy freight trains is the train length and weight. The longer and/or heavier a train, the more current is needed. If this is not available, the train cannot run at all or only at reduced speed [5], with negative logistical implications. The timetable is a complementary factor here. If two or more trains are running with a short interval between them, then they are likely to use a common supply section, which means that the available voltage per locomotive drops. This cannot be compensated by a much higher current, because of overload prevention in substations. Another option is to build more substations along a line, but this has its limits as well [6].

This power supply issue explains why heavy freight trains in the Netherlands are either headed by multiple diesel units, or a combination of multiple diesel locomotives and one electrical locomotive or one or two electrical multi-system locomotive (MSL).

With 25 kV, supply voltage increases by a factor of 16.7, while current can be reduced by at least 75%. As a result, at least five times more power (20 MW or more) is available, which is a huge difference, offering many advantages, for the operator and the infra provider. For the latter, among the benefits are much lower costs of power line (construction) and higher electrical efficiency.

Crossing the (then existing) technical barriers between the A15-trajectory and the Port Line demanded either a change of locomotives at Kijfhoek or the use of MSL. MSL with ERTMS were only available in limited (but growing) numbers, because ERTMS specifications were still under development and as a consequence, ERTMS was hardly used in Europe.

[3] Section 3.5.9 discusses options to remove these so-called ‘voltage isles’.
[4] 1800 V DC without load gives on average 1500 V DC under load conditions. Power MW(att) = voltage U times current I.
[5] Current is related non-linearly with (inter alia) momentary train speed and/or drive torque.
[6] This option was already implemented in The Netherlands.

MSL are supplied with a DMI with an ECTS On Board Unit (OBU) parallel to conventional (national) modules. Compared to single-system locomotives these are more expensive to buy and more complex to operate and maintain, hence have higher operational costs per unit. Upgrading of existing locomotives (retrofit) is also quite expensive. In some cases retrofit does not make sense, as the investment cannot be recovered given the remaining life time of the locomotive series involved. ERTMS and 25 kV (IEC 60850) are regarded as the new European standards for signalling and power supply systems. ERTMS is mandatory on new railway lines according to the EU, hence its deployment on the A15-trajectory. ERTMS removes a major safety flaw from the ATBEG system. The decision to install ERTMS and 25 kV AC on the Betuweroute involved a major investment in infrastructure and rolling stock.

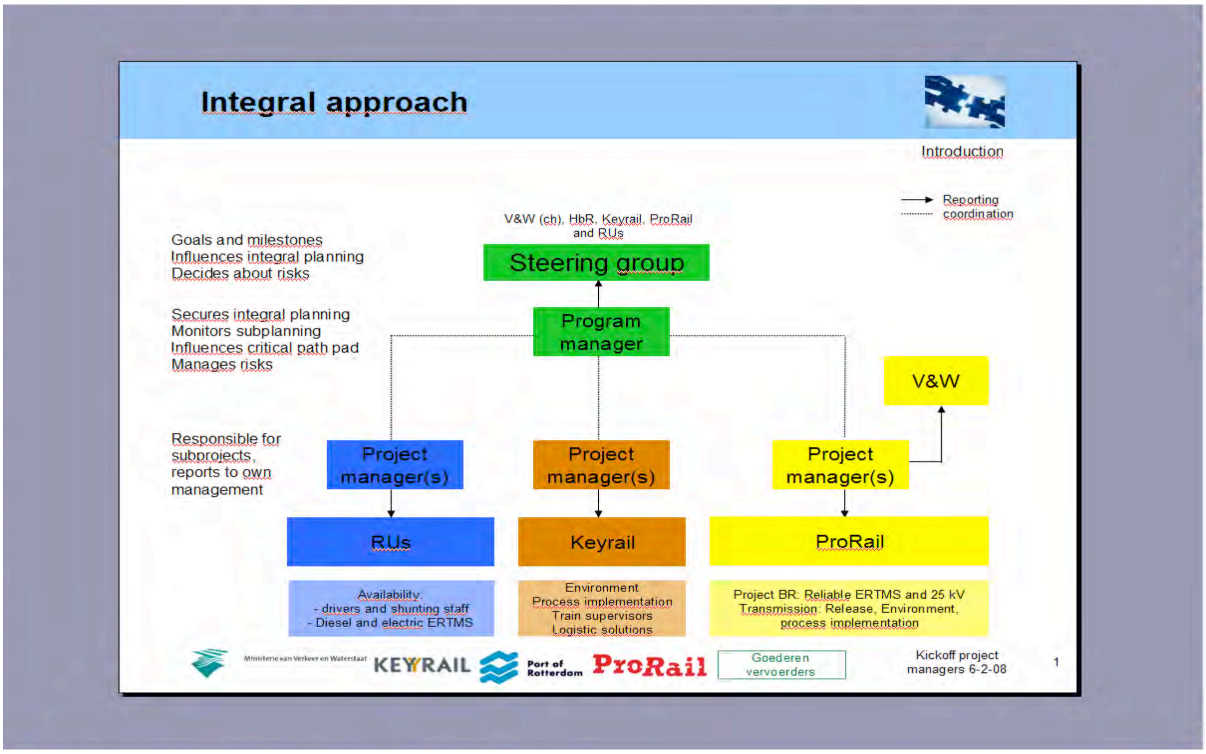
The installation of ERTMS and 25 kV AC on the Port Line means that the same mainline locomotive from that moment on could be used for the whole distance between origin and destination. Locomotive changes at system or national borders are not necessary anymore. Only a change of locomotive driver may take place at a location that suits the railway undertaking. As a result transport time can be reduced and diesel locomotives can be employed elsewhere (logistical benefit). The removal of a stop at Kijfhoek means that less parking space is needed for locomotives at Kijfhoek. Instead, they can now be parked in the Port area. But, also there parking space is scarce.
Electrical locomotives have a higher energy efficiency (of the engine) and no local emissions compared to diesel locomotives.

3.3.3 Project and process management

The conversion of the Port Line was a complex process. Many stakeholders were involved and their interests should be taken care of in a balanced way. A key requirement was that **logistics should be disturbed as little as possible (trains should run)**. This was a key argument against a total closure (a ‘big bang’) of several months, in which all systems would be replaced. As a consequence, the lead-time of the project was extended. Second, many bigger and smaller projects should start in parallel, with technical, organisational and logistical interdependencies, hence major consequences in case of insufficient coordination or even mismatches between decisions in different projects. Planning should prevent deadlocks and 'chicken-egg' situations [7]. Time, money and risks should be managed jointly.

To coordinate all the subprojects, a Steering Group (in Dutch: "Stuurgroep Havenspoorlijn") was installed, in which the Ministry of Transport and Public Works (V&W), infrastructure managers Keyrail and ProRail, the Rotterdam Port Authority (HbR) and the railway undertakings took part (Figure 1). It had a kick-off meeting on February 6, 2008.

Figure 1. Organization of the Port Line conversion



Source: Stuurgroep Ombouw Havenspoorlijn, 2008a (translated).

Note: V&W is the Dutch Ministry of Transport and Public Works. Project BR refers to the organisation responsible for the Betuweroute.

The Steering Group defined the **scope** of the project as follows (Table 1), separating Port Line projects from A15-trajectory projects, in order to simplify matters as much as possible.

[7] For instance, logistics required that locomotives should be ERTMS-ready when the new technical systems were installed and tested ok.

Table 1. Scope of Port Line conversion process

In scope	Out of scope
Infrastructure, including sidings New systems (ERTMS Level 1, 25 kV) Environment (e.g. firefighting, canals) Connection and communication with terminals Logistic processes Locomotives, drivers, shunting staff, train supervisors Law, regulations, permits Safety and release	Finalisation of A15-trajectory No reorganisation of terminal processes

The projects within the scope were clustered into five working groups: general, infrastructure, logistics and exploitation, locomotives/drivers/shunters, safety.

The project deliverables were defined as follows (Stuurgroep Ombouw Havenspoorlijn, 2008a, p. 5/25):

1) Prepare a list of separate subprojects. For each project it was necessary to determine
   - its main purpose(s);
   - its current status;
   - its milestones;
   - its critical success factors – conditions;
   - its risks;
   - its fall back scenarios;
   - its dependencies;
   - who are the responsible, involved and to be informed organizations and individuals in these organizations.
2) Prepare an integral planning with critical path, conditions and critical issues.
3) Analyse the most important issues.
4) Make a list of decisions with alternatives and consequences.
5) Define next steps.

The Steering group made a set of rules for process, content and communication between the partners and the outside world. A system of 'traffic lights' was used in order to mark the status of a topic and its urgency over time.

A very important remark about planning was made: when making decisions etc., distinguish between facts and expectations (Stuurgroep Ombouw Havenspoorlijn, 2008a, p. 7/25).

We will not describe the conversion process in full detail, but describe the initial plans, expectations, ideas, and solutions and see how these changed over time in response to experience gained. Central to process management was the principle that conversion should only occur at a **well-considered** moment in time (in Dutch: "verantwoorde omschakeling"). This means that the moment of conversion should be such that the risk of missing essential deadlines was minimized and that logistic processes should be disturbed as little as possible.

3.3.4 Planning on the move

The initial goal was to have the Port Line ready for commercial operations at the start of the new Year Plan, on December 14, 2008 (Stuurgroep Ombouw Havenspoorlijn, 2008a). This required a certified [8] ERTMS Level 1 installation on July 1, 2008, followed by the installation of 25 kV three months later, on October 1, 2008.

In a linear fashion, the following sequence for the operations was foreseen:

1) final ERTMS specs available;
2) verification of ERTMS specs, safety case including eventual adaptation;
3) development of training requirements;
4) development of training courses and adaptation of complete staff training;
5) start of train-track integration testing (in Dutch: "trein baan integratie"' or "TBI");
6) development of examination requirements for train drivers;
7) training of staff by Keyrail, training companies and railway undertakings (see report DT 5.1);
8) start of phase 1: operational testing and learning;
9) ERTMS Level 1 goes live on Port Line;
10) start of phase 2: commercial services.

[8] This refers to the installation of necessary hard- and software, a test of train-track integrity and validation by a qualified certifying body.

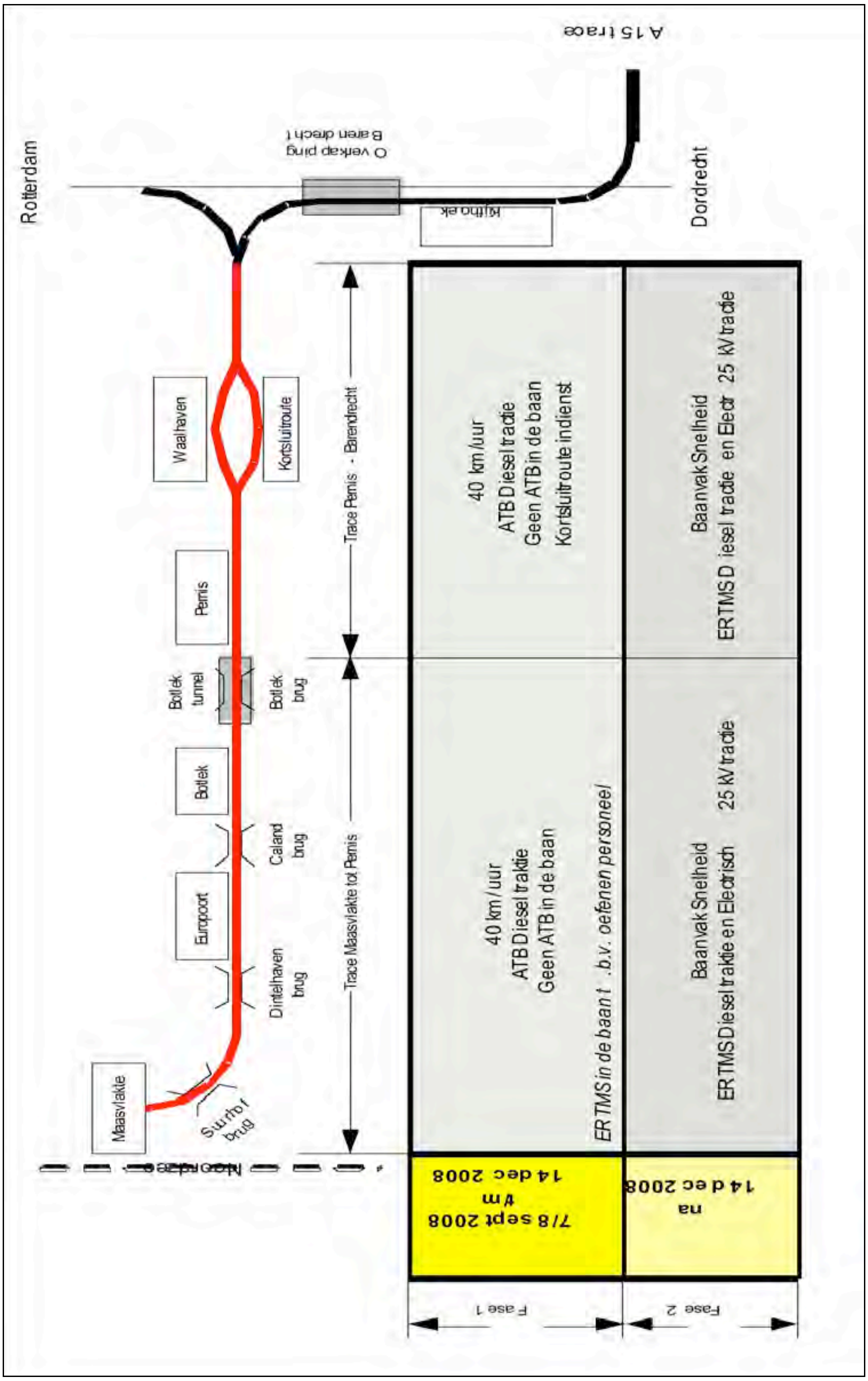
During March 2008 it became apparent that this planning was far too optimistic. Delays were inevitable, because the ERTMS specifications were not final, hence railway undertakings and rolling stock leasing companies could not place orders for retrofit or new build with the locomotive suppliers. Without compatible locomotives, staff training was impossible. Next, the planning had no slack and there were no fall back options. This led to the development of three scenarios (see Table 2 and Figures 2-4), which then went through a risk analysis (Ten Pierick, 2008a).

Table 2. Result of risk analysis

Scenario / ***Requirements***	**Two-phase**	**Three-phase**	**Four-phase**
ERTMS, 25 kV available	No fixed dates Dec 14, 2008 ready	Somewhere in 2009	No fixed dates, far into 2009
Fall-back	No	No logistic fall-back	Full
Locomotives available	Not certain	Not certain	Not certain
Consequences if not met	Serious logistic problems: -25% reduction of transport volume, increase in transport time	Serious logistic problems: -25% reduction of transport volume, increase in transport time	
Safety	No low speed protection		
Balance between costs, benefits, availability	Lack of locomotives and drivers	Lack of locomotives and drivers	Best, but no full guarantee

The risk analysts' advice in favour of the four-phase scenario was accepted by the Steering Group in March 14, 2008.

Figure 2. Two-phase scenario



Note: Legend after Figure 4.

Figure 3. Three-phase scenario

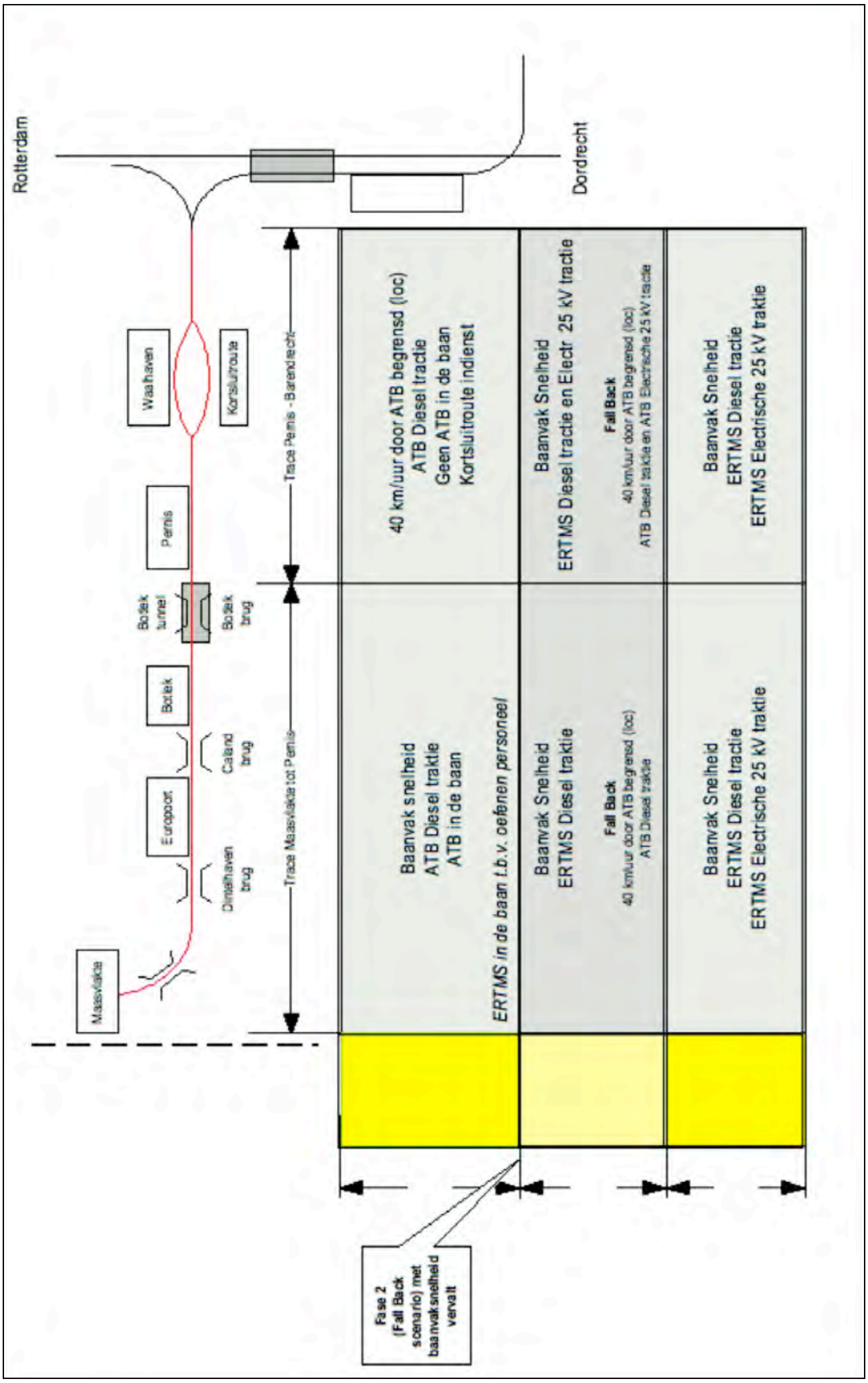
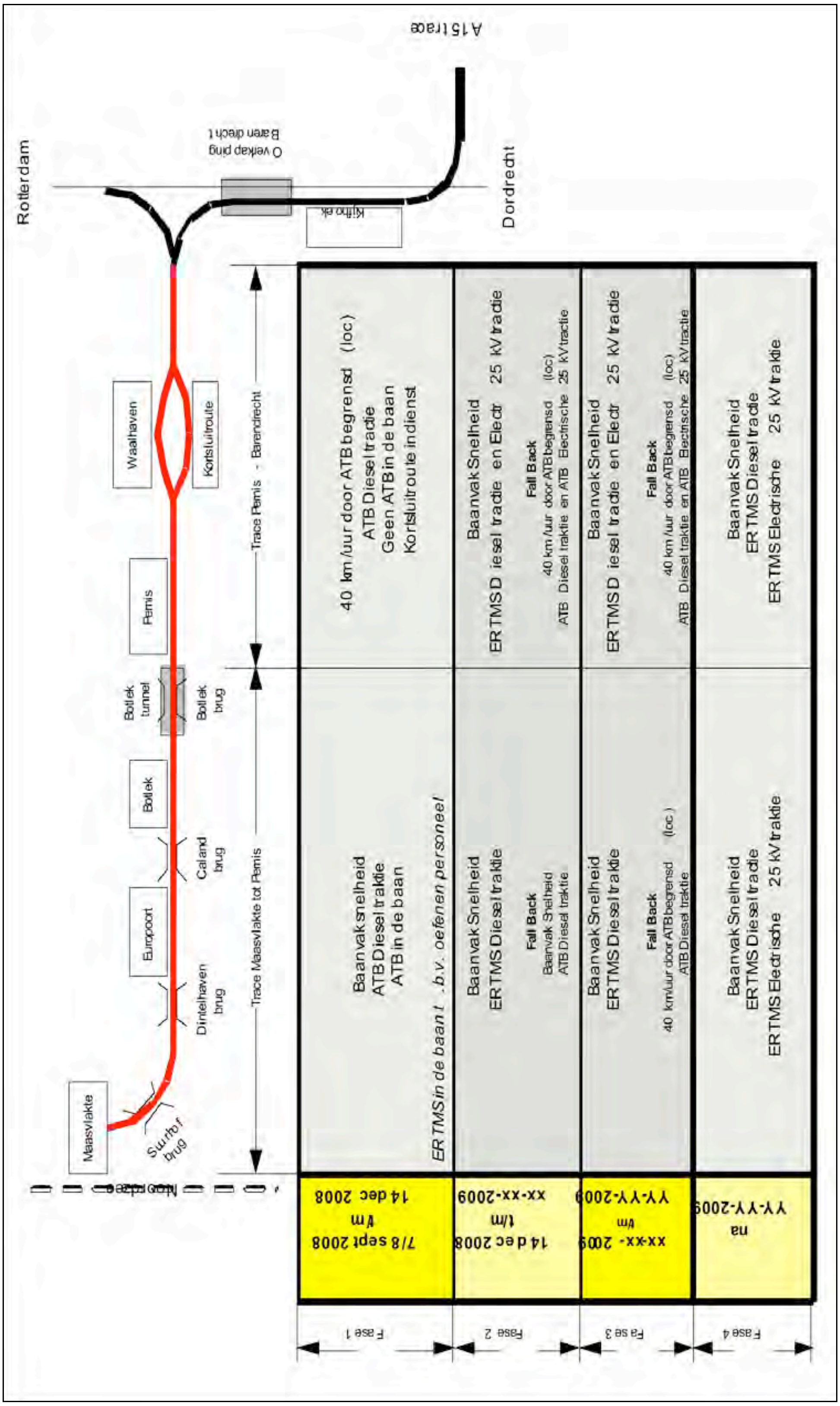


Figure 4. Four-phase scenario



Legend to Figures 2-4
- Trace = track section. 40 km/uur = 40 km/h. Traktie = traction. Elektrisch = electrical. - Geen ATB in de baan = no ATB in infrastructure. Kortsluitroute in dienst = bypass in use. Baanvak Snelheid = allowed maximum speed in a section. - Brug = bridge, overkapping = section in tunnel. - t/m = from/to. Na .. = after (date). - T.b.v. oefenen personeel = in favour of staff training. - Door ATB begrensd = speed reduced to 40 km/h by ATBEG. - Earliest moments (Change schedules): XX = 26 January 2009. YY = 14 June 2009.

Deadlines

According to the initial planning, ERTMS Level 1 should be ready on July 1, 2008 and 25 kV on October 1, 2008. On December 14, 2008 all technical projects should be ready. In order to meet this planning, the following *related* criteria should be met (Stuurgroep Ombouw Havenspoorlijn, 2008b):

1) Locomotive criterion:

A sufficient number of locomotives from the series BR189, BR203, G1206, Class 66 and 6400 should be available. Each of these should have a positive safety case, necessary to get access permit VGB3 (ERTMS Level 1) . But, ProRail nor Keyrail had objective norms to test stability of ERTMS (Stuurgroep Ombouw Havenspoorlijn, 2009a).

2) Driver criterion:

At least 50% of the train drivers should have made a test run at the monitoring date.

3) Logistic criterion:

For each locomotive/train combination at least 3 subsequent faultless trips should be made between Kijfhoek and the tracks west of the Botlek tunnel, in both directions. The following five frequent failure situations should be simulated:

a) Recall of right of way due to a mistake made by a traffic controller;

b) ERTMS error;

c) Non-planned corrective action via siding;

d) Wrong voltage change (25 kV AC ←→ 1500 V DC) at voltage sluice;

e) Wrong use of L/H signals at Botlek bridge. These signals are only valid for freight trains. especially when running on graded tracks (in tunnels and on bridges).

Faults were analysed and evaluated. Next, mitigating actions were taken.

It became clear that none of these criteria could be fulfilled at the initially planned dates. After criterion 1 was not met, criteria 2 and 3 could also not be met. It became certain that the new systems would not be available on December 14, 2008 (Stuurgroep Ombouw Havenspoorlijn, 2008b).

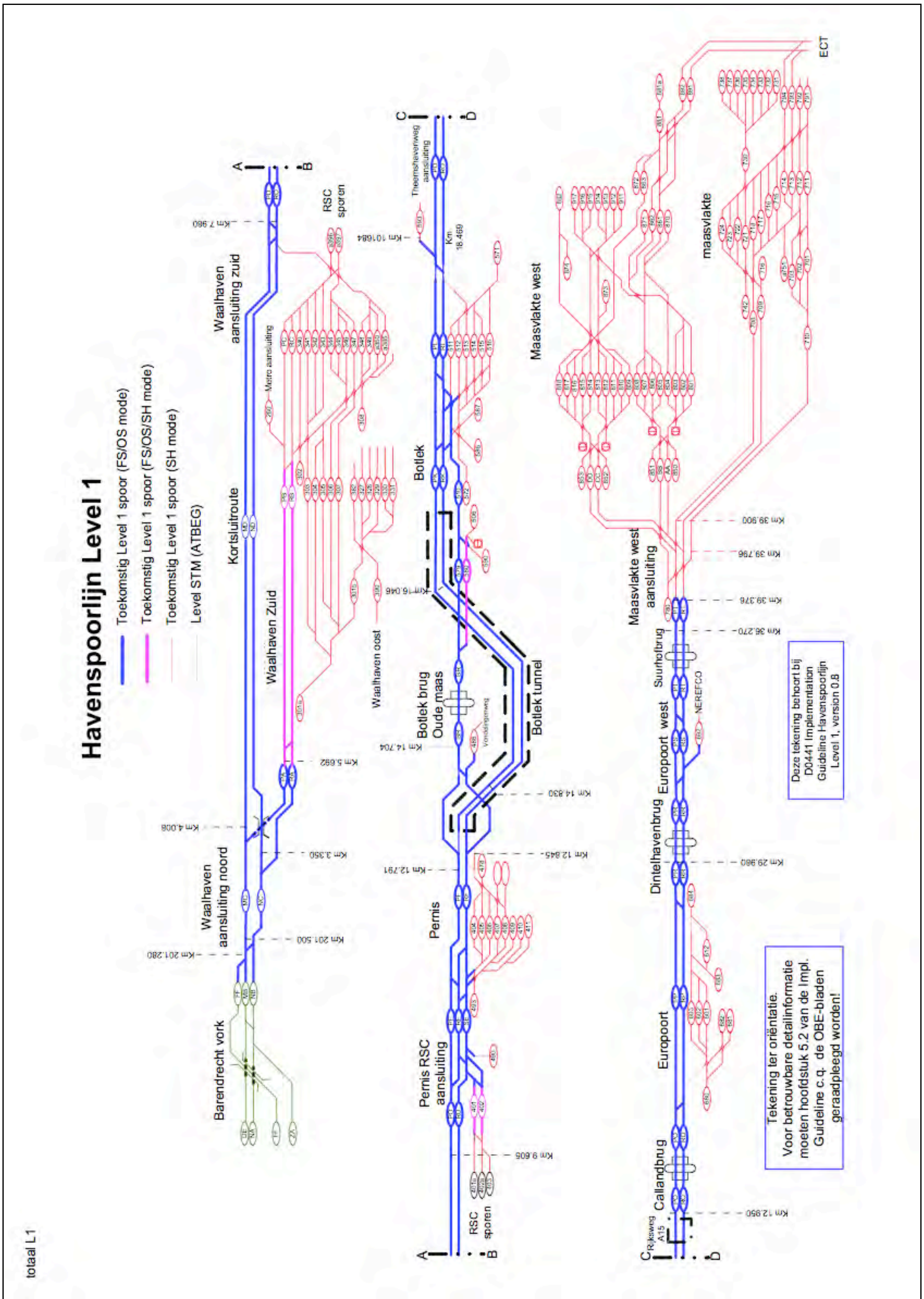
3.3.5 Change requests

There were four ideas for additional changes of the rail infrastructure, which could be carried out at the same time, in order to optimize the available out-of-service period(s). They are referred to as Change Requests (CR) (see e.g., Stuurgroep Ombouw Havenspoorlijn, 2008a):

1) To create through tracks at the sidings at Waalhaven, Pernis, Botlek and Europoort. This would mean that ERTMS Level 1 FS/OS/SH [9] mode could be used instead of the planned SH-mode. In SH mode, the driver has to stop his train before he can change ERTMS mode. After this change he may continue his trip. This stop means a delay for the operator and a loss of line capacity for Keyrail. This CR was not carried further (decision on July 4, 2008);
2) To link track section RD (see Figure 5) with section RC at Waalhaven in order to bypass turnout 207 (a switch diamond, in Dutch: "Engels wissel"). The location of this turnout makes it failure-prone. If it fails, all traffic is blocked. A bypass would reduce this failure risk, while offering more flexility in the use of tracks. Trains could then enter and leave Waalhaven from the west;

[9] See Appendix 2 for an explanation of ERTMS operating modes.

Figure 5. Port Line network design



Source: Meijer, 2010 (translated).

3) To install catenary (overhead power line) on all instead of on only four tracks on the Maasvlakte-West siding. This would increase logistical capacity (to allow the predicted growth of direct shuttles [10]) and connect ECT, Euromax and Maasvlakte 2 terminals. By reducing the use of diesel locomotives, local environmental impact can be reduced. Engineering works related with this CR were continued (decision on July 4, 2008);
4) To install catenary on track 580, a bypass at the westside of the Botlek bridge. This would allow electrical locomotives to use tracks 579 and 580 for entry and exit, improving flexibility and line capacity.

These CR's have logistical benefits, but only the first of them follows directly from the conversion project. The CRs demand investments by the Ministry of Transport and Public Works. In November 2008, it agreed that CR 3 and 4 should be implemented. However, at that moment there was no budget for these projects.

3.3.6 Key decisions made in 2009

We cannot give a complete overview of the decision-making process of the Steering Group, but will refer to the final results as follows (Steenbeek, 2009a):

- To build the Bypass route (in Dutch: "Kortsluitroute") parallel to the Waalhaven yard. This project was realised on September 8, 2008;
- To change the voltage on the Kijfhoek – Pernis trajectory. Since the beginning of 2009 locomotives equipped for 25 kV could be used until the Waalhaven yard. This ended the change of locomotives at Kijfhoek. On December 13, 2009 the Port Line was ready for 25 kV AC. Since December 14, 2009, 25 kV is in use on the complete Port Line;
- To replace ATBEG by ERTMS Level 1 on the complete Port Line. When ATBEG was in use on the Port Line, a train driver was required to manually select ATBEG or ERTMS, effectively reducing operational speed to 40 km/h max. Since October 5, 2009, Level 1 is operational. On running lines, operating speed is now 80 km/h (in the Botlek tunnel 100 km/h) and on sidings 40 km/h max.

[10] Direct trains with fixed composition are favoured over trains, which stop at several points, allowing removal or addition of wagons or load, because direct trains reduce the number of train movements, hence less capacity is needed. As a consequence, either smaller volumes are not transported by rail anymore or additional feeder services are employed to compose complete trains at another location.

3.3.7 Different interests

While there was agreement between the companies involved in favour of the target-driven scenario (see Table 3 below), in practice not every company was able or willing to stick to this agreement, as each had his own set of goals, which were not necessarily compliant.

ERTMS as a complicating factor

The development of ERTMS is rather problematic (see report DR 5.1). The system is developed and produced by several suppliers, effectively creating a multi-source environment. In order to assure a proper technical matching of the various components in train and track, standardization is a prerequisite. Standardization is a very complex area, however. Standards are the result of negotiations, which can result in multiple solutions. Legally, standards have a voluntary basis. When approved, standards are often out of date and due to their compromise nature not necessarily representative of best practice. Consideration of commercial issues is neglected. Compliance can vary, and does not guarantee system safety. In the standardization process, there can be too much focus on the process itself and not on the outcome (Davis et al., 2001).

In case of the Betuweroute these problems were clearly visible. Alstom (Atlas system) and Bombardier were key suppliers of ERTMS equipment. They developed two different implementations of ERTMS, both in terms of hardware and software. With respect to software, there was Alstom, who migrated towards version 5.2.0 and Bombardier, who had two 'final' versions, P3'' (a variant of their P3 version) and P5. These versions underwent the tests as described above (Stuurgroep Ombouw Havenspoorlijn, 2009b, p. 10). Lloyds was responsible for the certification of ERTMS equipment supplied by Bombardier. KEMA Rail Transport Certification (RTC) was responsible for the certification of Alstom equipment.

Three scenarios were made for the availability of ERTMS software (see Table 3).

Table 3. Scenarios and their consequences

Issue	**Target driven**	**Bottom up**	**Low risk**
25 kV Barendrecht- Pernis	14-12-2008	14-12-2008	14-12-2008
ERTMS Port Line completed	1-10-2009	1-2-2010	1-8-2010
25 kV Pernis – Maasvlakte	13-12-2009	12-6-2010	12-12-2010
Risks	Bombardier, Lloyds,	Bombardier, Lloyds, safety 40 km/h	Safety 40 km/h
Costs - System - Infra - Training/logistics - Total	 € 6 m € 5.2 m	 € 2 m € 7.7 m →Δ € 3.1 m →Δ € 1.6 m	 € 2 m € 10.2 m →Δ € 3.0 m →Δ € 5.5 m
Remarks	Fast 25 kV implementation	Last step possibly 1,5 month shorter	Last step possibly 1,5 month shorter
Line capacity		Kijfhoek increasingly a bottleneck	Kijfhoek bottleneck for growth
Feasibility	Depends on development of P3''	Very uncertain due to complexity P5 and possible impact on Alstom locos	Enough time, high

These scenarios influence Criterion 1 (availability of locomotives), which is important for the realization of the chosen four-step scenario.

The companies and the Ministry of Transport and Public Works agreed that the target-driven scenario + software version P3'' should be followed, however the Ministry wanted to share the risks of this choice with the commercial partners, which they refused. Next, new negotiations led to the following outcome (Stuurgroep Ombouw Havenspoorlijn, 2009c, d):

- P3 + target-driven scenario will be followed, but if the time-line of the target-driven scenario is not feasible, then the individual companies have to bear their own (additional) costs;
- The cost of upgrading locomotives towards Level 1 and 2 (2.3.0.d) will be paid by the Dutch government for a period of 5 years after December 13, 2009;

- Costs of upgrades of the software after this 5 year period will be paid by the locomotive lease companies and/or railway undertakings, unless different agreements will be reached in the framework of the national ERTMS implementation plan.

Smaller agreements regarding other costs were made, but the Ministry of Transport and Public Works did not a priori accept them.

The choice in favour of the target-driven scenario was based on the following (Stuurgroep Ombouw Havenspoorlijn, 2009f):

- Technical feasibility:
  - to realise a manageable conversion as soon as possible;
  - to have the required number of certified locomotives and the tracks ready in a technically feasible way;
  - to make acceptable commercial agreements with suppliers (in terms of time and money).
- Logistic feasibility:
  - to comply with the Year Plan.
- Risk management:
  - to analyse the risks and costs of alternative scenarios;
  - to have a plan to manage risks.

3.3.8 Remaining risks

After the earlier mentioned agreement, many issues remained (e.g., Stuurgroep Ombouw Havenspoorlijn, 2009i, l):

- despite political initiatives in this direction, automatic cross (X) acceptance is not practiced, yet. The German resp. Belgian infrastructure providers EBA (PZB certification) resp. Infrabel (border crossings) have separate certification protocols and planning. Pressure from another country to shorten such procedures is not easily accepted. In Belgium Infrabel demands Lloyds to insure itself for 175 mln Euros before it is allowed to test ERTMS installations in Class 66 locomotives as part of the validation process. At the same time, EBA has not certified this locomotive series, hence the demand for an extension after the existing license stopped at December 31, 2009;
- the Dutch VGB-3 license stopped after December 31, 2009, hence also here an extension was needed;

- theft of copper wire, which halted (test) trains frequently;
- optimisation of braking curves;
- GSM/radio problems. This caused Lloyds/Bombardier locomotives to halt unnecessarily on the A15-trajectory (including the tunnels);
- logistic capacity (e.g., locomotive changes, parking places, tanking);
- a pro-active attitude of all railway undertakings.

The risks can be linked with the main development lines as follows (Stuurgroep Ombouw Havenspoorlijn, 2009e; see Table 4).

Table 4. Development trajectories and risks

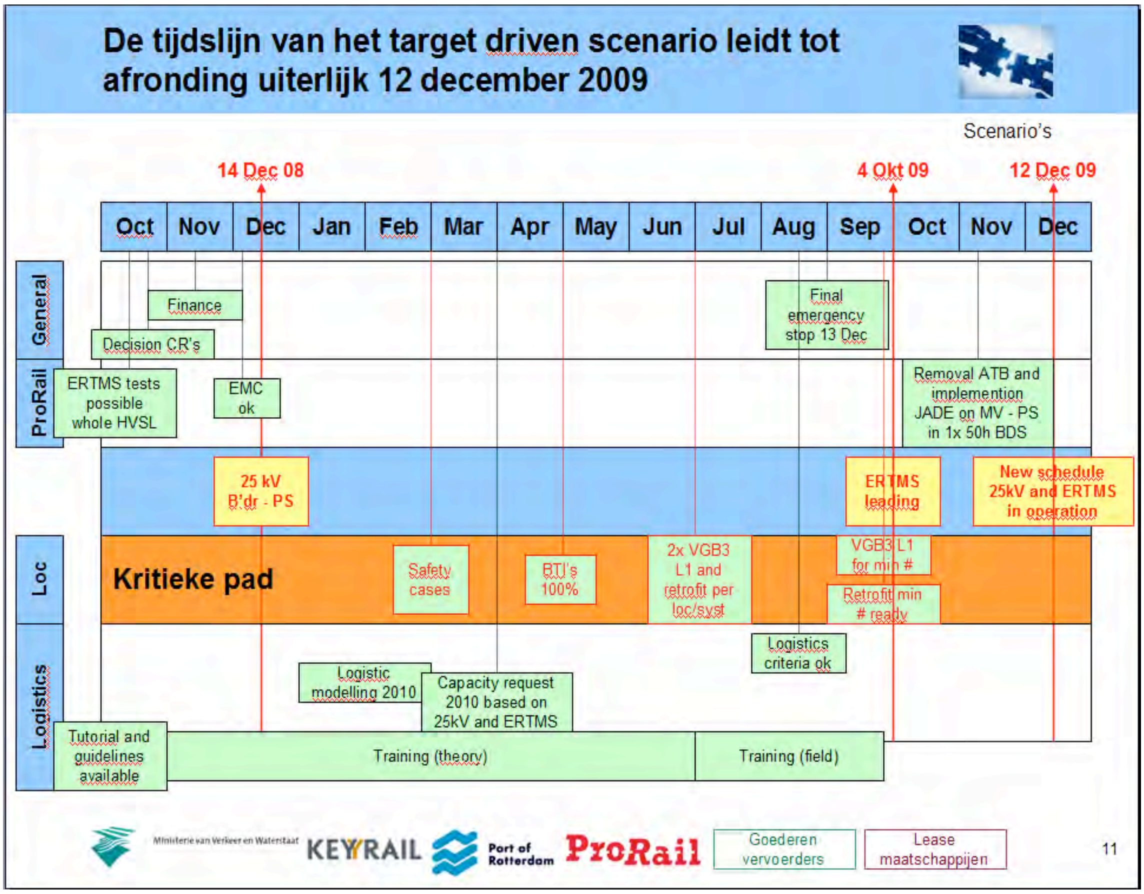
	Period	Responsible	Primarily involved
Locomotives	March-June/July	Alstom, Lloyds	Locomotive owners, BB21, railway undertakings, Keyrail
Training	March-September	Railway undertakings	Keyrail, IVW
25 kV	October-December (March- for CRs)	Project Organisation Betuweroute	Keyrail, railway undertakings, BB21, IVW

The key uncertainty was the timely availability of the required number of electrical and diesel locomotives. Orders for the conversion of the locomotives were halted until the 'final' ERTMS specifications (which were dependent on the installation of a final, working ERTMS implementation in the tracks) were available. These specifications of course awaited lab and field testing etc.

With the new planning, the focus shifted towards training (see report DT 5.1).

Figure 6 shows the many interrelations between the subprojects.

Figure 6. Time-line of the target driven scenario



Planning according to the target driven scenario became as follows. The label 'Kritieke pad' in the row related with locomotives (Loc) refers to the already mentioned main bottleneck: the timely availability of a sufficient number of certified locomotives. The period between October and December 2009 was very critical, because the final conversion of technical systems took place. Replacement of ATBEG detection by ERTMS was done in a 50 hour out-of-service period (in Dutch: "Trein Vrije Periode" or "TVP"). The criterion to remove ATBEG would be that ERTMS Level 1 would be robust after 14 days of intensive testing (Stuurgroep Ombouw Havenspoorlijn, 2008c).

3.3.9 Final steps and remaining issues [11]

ERTMS

According to the final planning ERTMS was switched on in the morning of October 4, 2009. This had a limited impact on operations, as only 2,5% 'issues' were found, most of which were due to inexperienced train drivers. Those involved agreed that the conversion went better than expected.

When trains cross the Dutch/German border, ERTMS should automatically change from the German GSM-R network to the Dutch. In practice, this does not always function as expected. As a result, train drivers loose contact and trains stop. This so-called GSM radio problem has been reduced via technical adaptations (Stuurgroep Ombouw Havenspoorlijn, 2009j). There are still communication issues, which create strandings of trains. There are many causes of this problem, including the lack of a system integrator. A new ERTMS working group has started to deal with this issue.

Certification of locomotives is still an issue. In terms of technology, nothing has been arranged. For locomotives "The European Technical Specifications for Interoperability (TSI) only cover basic requirements and also cross acceptance agreements only cover part of the approval parameters. A locomotive placed into service in one country must nevertheless be authorised for all non TSI parameters according to the national requirements in each additional Member State." (UIRR, 2010, p. 4)

In this case the extension of the Dutch VGB 3 license was available on time, but the process and the (division of) costs met criticism. An extension of the German cross acceptance process into 2011 was accepted (Stuurgroep Ombouw Havenspoorlijn, 2008n). Locos still have to be changed when going from Belgium to Holland. Acceptance on paper does not guarantee practical functioning, on the contrary, cross-acceptance is a 'disaster'. If software changes are needed, then a new cycle of certification starts.

Baseline (see Appendix 2) 2.3.0d will be installed on the A15-trajectory. In baseline 2.3.0d for the locomotive CR 504 will also be implemented. CR 504 deals with 1. very slowly accelerating heavy trains, unable to reach the next infill balise group or 2. having a stand-still in front of a H-signal. In the first instance, movement authority (MA, see Appendix 2) will not be renewed on time, hence the train brakes will be engaged automatically. In the second case, the train cannot move forward, because there is no release speed allowing the train to reach the next balise.

[11] This section includes information from the interview with Mr. de Mol and Mr. van Dort.

A temporary workaround for locomotives without the CR504 patch has been developed in order to deal with both exceptions (Van Zandvoort, 2009a). By the end of 2010, baseline 2.3.0d should become operational.

Each ERTMS upgrade demands an investment. Many locomotives are owned by lease companies. For an upgrade (box), the customer has to pay additional fees. So, the customer waits until there is a final and correct version available. So, he avoids interim software versions with additional cost. Then he signs a contract which should allow him to use the loco everywhere.

Now there are standards per corridor, but what is needed is a European obligation regarding updates and responsibilities (track and train). Train operators do not use a locomotive in one single corridor (narrow scope), but they want to use the same locomotive on several lines (wider scope). Otherwise, they would need a loco set for each corridor, which is not cost-effective. ProRail, like the infrastructure managers in neighbouring countries, does not feel any responsibility for ERTMS (software) issues. Since decision making occurs at the level of infrastructure mangers, the problem remains.

There is no reference regarding the future costs of ERTMS, as we are just at the beginning of the life-cycle. It is expected that the infrastructure costs will not go down due to ERTMS.

When the conventional ATBEG system was installed, train-track integration was dealt with within one single company (NS). The key problem with ERTMS is the organizational split between train operators and infrastructure managers, which operates wih an 'open source system' by multiple suppliers. From a technical perspective integration is needed, but there is no system integrator. This is not only a problem for ERTMS itself, but also for essential support sytems, like GSM-R. The Ministry of Transport/ProRail and rail operators expect the other party to act, but their responsibilities are not clearly outlined.

In order to manage the installation of ERTMS, Keyrail used a shadow time table. It was accompanied by continuous monitoring. As late as 2009, ProRail became aware of the need for a monitoring system on the A15-trajectory (see section 3.4.3).

The number of registered ERTMS mistakes was reduced significantly due to additional training. Nevertheless several issues remain:

- logging of ERTMS train data is insufficient, which hampers monitoring;
- ProRail/Keyrail have little information about the follow-up by Alstom/LRRE;
- certification by Infrabel is not ready due to insurance and liability requirements;

- the 2.3.0 d upgrade is planned for February (Bombardier P5), April (Alstom diesels) and December 2010 (189 series).

The strandings of trains supervised by ERTMS level 2 stayed at a high and unacceptable level during the second half of 2010. For Keyrail and the railway undertakings this is a major problem, because a lot of strandings take place in tunnels, which has a very huge impact on train operations. A steering committee headed by the Ministry of Transport has started to analyse the causes of the strandings and to propose solutions to solve these problems. First results are expected at the start of Q2 2011.

25 kV traction supply system

This system was switched on at December 12, 2009. Implementation included the two planned CRs (see section 3.3.5) 'Electrification of the Maasvlakte' and 'Bypass track Botlek bridge'. After this step, hardly any trackside problems occurred.

3.3.10 Outlook

The Steering Group not only dealt with issues directly related with the conversion of the Port Line, but also produced a list of requirements and recommendations for (the) future (projects) (Stuurgroep Ombouw Havenspoorlijn, 2009l-n):

1. It is important to have an integral, transparent approach with the right people;
2. The process structure should be comparable to the one chosen for the Port Line;
3. Ministry of Transport, safety regulatory authority IVW, should have a leading role in future projects;
4. It is important to organize operational monitoring of use of the tracks and rolling stock and initialization of necessary improvements (braking curves, DMI). The question is who should do this, because IVW only deals with safety;
5. A common strategy for passenger transport in Europe for the year 2040 is needed. It should be developed by the Ministry of Transport, NS, KNV and ProRail. The aim of this strategy should be to install ERTMS in Dutch tracks and rolling stock in such a way that national and international rail transport becomes more effective, with a minimal impact on sunk costs and maximum guarantee that transport flows are not disrupted during migration;
6. There are additional issues to be elaborated: voltage isles (see section 3.5.9), standardisation, interoperability, version management etc.;

7. Integration of SRS 2.3.0. d cannot wait for a common ERTMS strategy;
8. Transition towards SRS 2.3.0. d asks for a steering group comparable to the one for the Port Line.

The Steering Group made a proposal for an integral steering group and project management group, which should deal with the following subjects (see Table 5):

Table 5. Important issues to be solved in future

Subject	**Goal 2010**	**Remark**	**Scope**
Monitoring ERTMS	Real picture with mechanism for active improvement	Focus on safety, training, capacity and availability	Betuweroute +
Operational issues	Solve transport bottlenecks	E.g. radio problems on A15, braking curves	Betuweroute
(Re-)access NL	Monitoring of acceptance and new process for BTI and MTL	MTL = allowance to use	NL
Access other countries	Access Belgium Effective and structural process Belgium and Germany	Also for other countries	EU
2.3.0 d locos	Implementation in locos	Alstom (March), Bombardier (2 steps) and Siemens (Dec)	Betuweroute +
2.3.0 d track	Y/N decision about upgrade A15	Eventually combining with labour guarantee (EU subsidy for limited period) or High Speed Line upgrade (2.2.2c -> 2.3.0.d)	Betuweroute +
Voltage isles	Time planning and decision about Kijfhoek and Zevenaar	Pressure due to 'protectionism' and safety	Betuweroute

Source: Stuurgroep Ombouw Havenspoorlijn, 2009n.

3.4 Inflow and certification of ERTMS locomotives [12]

3.4.1 Level 2 – A15-trajectory

Slow start-up of services

The start-up of services on the A15-trajectory was slow due to the following reasons:

- the infrastructure developed under supervision of ProRail (lower part of Figure 8) did not meet the quality targets assumed by Keyrail in its business model. Commercial services started, while reconstruction and repair works were carried out, making it impossible to reach the planned number of trains (see section 3.5 of report DR 5.1 and section 3.7 of this report for the current state of the infrastructure);
- trackside (TRK) and trainborne (TRB) ERTMS hard- and software was not working as expected, complicating train-track integration;
- (as a consequence) the required number of certified locomotives was not available.

Only locomotives fitted with ERTMS Level 2 were allowed on the A15-trajectory of the Betuweroute. Initially, such locomotives were hardly available. This affected the test runs and (later on) also commercial services, making it a major hindrance for railway undertakings to use the A15-trajectory. For trains between Rotterdam and Germany they continued to rely on existing mixed-traffic routes, in particular the one via Dordrecht-Breda-Eindhoven-Venlo.

Increasing the number of locomotives

The existing locomotives (retrofit) and new locomotives had to be ready for ERTMS. If we restrict ourselves to retrofit, then we may say that retrofit should be possible or make sense in terms of

- technical and physical requirements: to have the space to build in additional equipment, (non-)interference with existing equipment, (solutions to adapt) braking curve, etc.
- business-economic considerations: a retrofit is expensive (about Euro 400.000 per locomotive plus Euro 100.000 rent for a replacement locomotive (NT, 2010)) and the investment should therefore have a reasonable payback period. A retrofit of a locomotive close to its out-of-service date makes no sense. Locomotives could also be

[12] This section includes information from the interview with Mr. de Mol and Mr. van Dort. See Appendix 2 for more specialized information about ERTMS.

exchanged between railway undertakings (due to excess capacity, loans, mergers between companies etc.).

- (primary) deployment area: will the locomotive be used on the A15-trajectory or not? Will this remain the case in future as well? In case of locomotives also used for north-south traffic (Belgium-France) the lack of cross acceptance was a complicating factor. German certification was not a key for acceptance in Belgium. Belgian infrastructure manager Infrabel required a new certificate. Next to that, Infrabel also had its own priorities concerning certification.
- planning and logistic considerations: the retrofit should comply with the planning of the supplying company (workforce and materials planning) and the railway undertaking or leasing company.

Siemens/Alstom have supplied trackside and trainborne ERTMS equipment, but Bombardier supplied only trainborne ERTMS equipment. This made track-train integration easier for locomotives equipped with Alstom ERTMS equipment than for locomotives supplied with Bombardier ERTMS equipment. Bombardier had to adapt to the ERTMS implementation of competitor Alstom. The test and certification procedure will not be discussed here. It is similar to the one developed for the Port Line (see section 3.4.2).
The following locomotive series were involved in the certification process:

- Diesel: G 1206, G 2000, V 100, 6400, Class 66.
- Electric: BR 189, Traxx.

Due to retrofit and new (factory-ready) locomotives, the number of certified locomotives increased over time (Steenbeek, 2009b). After the conversion of the Port Line, electric traction dominates, especially after the inflow of Series 189 locomotives, including those supplied with automatic couplings (for coal trains, see Figure 7). There are sufficient locomotives to carry out the contracted train services.

Figure 7. Twin Series 189 with automatic couplings before coal train

Source: Google.

Monitoring ERTMS

The key reasons for monitoring ERTMS were the following (Van den Berg, 2009):

1) This is the first implementation of ERTMS Level 2 in the Netherlands. It is therefore important to
   - understand system behaviour;
   - understand quality of user processes (in Dutch: "Gebruikersprocessen");
   - improve train-track integration [13].
2) This project could be regarded as a pilot project for future ERTMS projects in the Netherlands (such as the Hanzelijn, Mistral, Amsterdam-Utrecht [14]).
3) To harmonise ERTMS in the Netherlands.
4) To satisfy Cenelec (the European Committee for Electrotechnical Standardization) requirements, in particular Safety Qualification Testing.

Monitoring of ERTMS took place in a period of changing conditions for using the A15-trajectory of the Betuweroute (De Boer, 2009):

- Since December 11, 2007, the Betuweroute was open to commercial services. But, only a limited number of locomotives had the complete access permit (VBG3), while the others had the restrictive access permit (VGB2), restricting deployment to weekdays.

[13] Trackside and trainborne equipment was developed and installed by different companies, they (partially) fulfil different tasks and are operated by different staff (RCC versus train drivers). Yet, they should cooperate effectively and efficiently.

[14] The first and second project are underway and the third is finished.

- Since June 15, 2008, the 'use permit' (in Dutch: "Benuttingsregeling") was valid. Parts of the infrastructure were not available: the branches towards 's Hertogenbosch-Utrecht and Nijmegen-Arnhem, CUP Valburg and the ZN (South-North) branch. The Hand Held Terminal was not used.
- In September 2008, the HHT was used in practice (see section 3.6.3).
- Since December 14, 2008, CUP Valburg was available for parking of trains and decoupling of locomotives, but shunting of trains was not allowed. The connections at Meteren and Elst were ready to be opened, but there was no demand from railway undertakings to use them, yet. The 'use permit' for the A15-trajectory was terminated. Keyrail and maintenance companies started using the Hand Held Terminal to protect maintenance workers.

The basic assumptions for the monitoring phase were the following:

- trains should be able to use predefined paths;
- train paths could be set by RCC staff;
- there are no large technical constraints.

With respect to ERTMS installations, the following assumptions were used (De Boer, 2009):

- the system configuration was fixed;
- the configuration and full functioning of ERTMS was checked;
- the safety cases provided enough confidence that ERTMS would function as intended;
- RCC staff was trained and ready;
- train driver training was finished.

Monitoring consisted of the following (Van den Berg, 2009):

- Getting ERTMS data and analyse them:
  - A15-trajectory: loggings of central systems;
  - Port Line: loggings of trainborne recorder.
- Conversion of loggings into readable information (this required tooling)
- Monthly reports
- A monitoring period of a least 6 months
- Specific issues were transferred to the ERTMS user group (in Dutch: "ERTMS gebruikersgroep").

The project organisation for the Betuweroute (B&B-BR) was engaged in the following activities:

- Validation of ERTMS Level 1 and Level 2;
- Train-track integration (VGB advisory for safety agency IVW);
- Definition of user processes;
- ERTMS Safety case (Level 1/Level 2) + permit for use (in Dutch: "Toestemming voor Gebruik" or "TvG");
- Monitoring / analysis of system behaviour on A15-trajectory and Port Line;
- A15-trajectory /Port Line system changes;
- STM – STM transitions; [15]
- Support for HSL-South high-speed line.

The following data were collected:

> *Train and track data*

- General information:
  - number of trips by locomotive type with Level 1/Level 2;
  - minimum / maximum / average speed;
  - transitions.
- Number of disturbances by ERTMS trackside equipment:
  - due to RBC/IXL; [16]
  - due to LEU / Balises (linking, default message);
  - due to GSM-R;
  - due to design choices.
- Number of disturbances by ERTMS trainborne equipment:
  - by locomotive type.

There was an obligation to deliver loggings. Data came from different sources (De Boer, 2009):

- safety data came from Alstom Betuweroute Maintenance. They prepared a cd

[15] STM (Specific Transmission Modules) units allow ERTMS-equipped locomotives to communicate with track sections protected by non-ERTMS signalling systems, like ATBEG or PZB. STM-STM transitions are used to enable such locomotives to move from a non-ERTMS section in country A to a similar section in country B. In case of the Betuweroute, the available options could be STM-ATBEG / STM-PZB (traffic with Germany) or STM-ATBEG / STM TBL/Memor (traffic with Belgium).

[16] IXL or Interlocking refers to a trackside (TRK) safety system for trains running in stations.

each week with logfiles containing VIS A&B [17], SDM, LDR, LDI and testconductor logfiles;

- VPT (RCC-related: WPK, KBV [18], TNV) data came from Loxia. They prepared a cd with VPT data per 14 days;
- SAP data about disturbances were mainly supplied by RCC staff;
- information about official train trips were acquired from RCC.

Monitoring was complex due to problems with logging data, data conversion and coupling of technical systems.

From the analysis, it became apparent (De Boer, 2009) that:

- there is no proof that RCC 'commands' (in the chain of IXL-VIS-TNV and IXL-VIS-KBV-PRL) were carried out in a wrong way or that ERTMS elements contain a wrong status;
- there are problems with ULB, the reason for their occurrence is unclear. They may or may not be related with the JADE detection system. As these were 'sealed' (restricting access) after October 2008, no information is yet available about this relation;
- at ATB-ERTMS transitions a relatively large number of failures and automatic braking occurred. Some of the train-related causes have been mastered. The communication between train and track is an area for further research, as the causes of some incidents could not be detected;
- LDR data are a source of information about train-track integration. A stable LDR is necessary to get the data. The conversion of such data relies on a tool, which converts all data in a fast way. In this area improvements are necessary;
- data for monitoring will also be used for incident analysis. Logging data should be more readily available in order to support incident analysis in a proper way.

> *Train driver input*

- Number of disturbances by wrong use:
  - mistakes during data entry;
  - overspeed (running speed is higher than the infrastructure design limit);
  - neglect of End of movement authority (STS-passage);

[17] VIS = VPT Interface Server.
[18] KBV = 'Koppeling Beveiliging-21 VPT'.

- wrong level / mode (NL, IS);
- neglect of ACK in level/mode transitions;
- wrong RBC-id/nr;
- neglect of TAF (Telematic Application for Freight).

▪ Speed, e.g., in tunnels.

With respect to trainborne (TRB) equipment, computer loggings were collected as a basis for monitoring how ERTMS behaves under different operating conditions. The following data were available:

A. UTC start time of service;
B. Local time;
C. Registration of trip;
D. N.a.
E. Train trip number;
F. ERTMS operating modes used during the trip, including maximum speed in the mode;
G. Filter: normal trip;
H. Filter: trip with FS/SN and SR/OS, speed V <= 40 km/h;
I. Filter: trip with UN-NL-IS or SR/OS > 40 km/h;
J. Filter: other mode SB-SL-SF-SE-RV;
K. Details about modes versus balises.

Table 6 shows the result of an analysis of data from the first half of 2009.

Table 6. Counts of train trips in the period January-June 2009

Nr.	Criterion	Number	%
	Total number of registered services	3093	100
1.	Normal services	2784	90
2.	SR/OS < 40 km/h (in combination with FS/SN)	214	6,9
3.	SR/OS < 40 km/h (in combination with FS/SN and TRIP)	48	1,6
4.	UF-NL-IS or SR/OS	41	1,3
5.	SB-SL-SF-SE-RV	6	0,2

Source: ProRail-Keyrail email of 24-8-2009.

It turns out that 90% of the services went as planned (nr. 1). In the remaining cases, the train driver had to change to a more restricted operating mode (nr. 2-4) or recover from failures (nr. 5).

There are traction providers who regard a communication about a failure as the end of the problem. They are not actively involved in solving the problem.

Experience with monitoring in 2008

According to an analysis of data and process by ProRail (Van den Berg, 2009)

- Monitoring demands a lot of effort and adequate tools:

- Conversion of raw data into information is difficult.

- Radio communication between GSM-R and ERTMS is not fault-free. Loss of carrier stops data communication (and causes a train to halt).

- Agreements are necessary to guarantee the acquisition of train loggings

- On the Port Line, an agreement with RRF had to be made.

- Feedback of users is necessary:

- The electronic desk of KeyRail (info@keyrail.nl) was used infrequently.

- Maybe an internet user forum via the Internet should be set up.

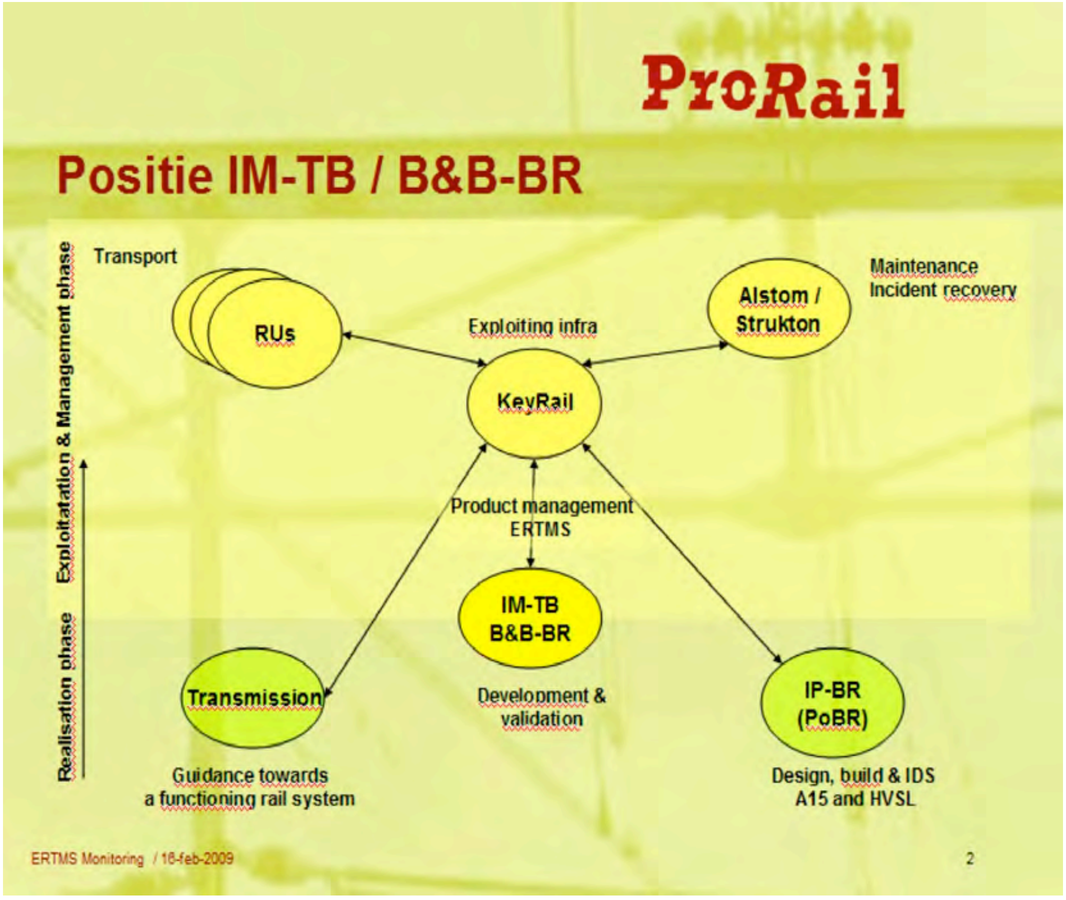
The most important issue is that monitoring was a short-lived activity. While problems continued with Level 2 (A15-trajectory) and Level 1 (Port Line), ProRail stopped the project due to lack of budget and unclear responsibilities. The Ministry of Transport also did not have a policy regarding system integration.
This issue will be addressed by the earlier mentioned Dutch ERTMS working group.

Involved companies

In June 2009 the following railway undertakings or traction providers were aiming to use or already using the A15-trajectory: ACTS, ERS, Rail4Chem, Rurtalbahn, Veolia, HGK, Kombiverkehr, SNCF, ITL, RRF, CTL, Railion, DLC. Next to these, maintenance company Spitzke was also using the Betuweroute.
Many locomotives belong to lease companies (Angel Trains, Mitsui and Sumitomo) and others (Alstom, CBR) and are leased to railway undertakings and traction providers.

As can be seen in Figure 8, Keyrail is the spider in the web.

Figure 8. Actors involved in the Betuweroute (project)



Source: Van den Berg, 2009 (translated).

3.4.2 Level 1 – Port Line

Certification: formal process and procedure

On the A15-trajectory ERTMS Level 2 was installed. The Port Line should be equipped with Level 1. Technically, Level 1 differs less from conventional signalling systems than Level 2. One would also expect that the experience from the A15-trajectory could be used when installing Level 1.

Level 1 can be used as a fall-back mode in dual systems when Level 2 is out of function. This would imply that Level 1 is a subset of Level 2, hence installation would be straightforward. This was a wrong assumption. As a consequence, a locomotive certified for Level 2 needed an additional certificate for Level 1 before it was allowed access to the Port Line.

In order to receive a Level 1 certificate, the infrastructure and the locomotive were tested both independently as well as jointly (in a test of train-track integration). The following test procedure was developed (Stuurgroep Ombouw Havenspoorlijn, 2008c):

1) ProRail carried out tests of the tracks in the following manner:

- validation on paper;
- test of components by their supplier;
- test of cables on site;
- lab tests (of the track with a simulated train).

Information about this set of tests was included in a so-called 'track dossier'.

2) The locomotive supplier carried out the following:

- validation on paper;
- test of ETCS equipment by the supplier;
- test of installed ETCS equipment (for each type).

Information about this set of tests was included in a so-called 'train dossier'.

3) Both 'dossiers' were analyzed by ProRail, who advised safety regulatory authority IVW. IVW then assessed if the information met its criteria. Following acceptance, IVW issued an access permit for the locomotive (in Dutch: "VGB3"). The locomotive then entered a monitoring period, after which ProRail advised IVW again. If again positive, IVW released a full use permit (in Dutch: "inzetcertificaat") for the locomotive.

Some of the tests overlapped one another. As a consequence, additional test capacity was needed and additional loss of time occurred. With respect to other parties in the chain, it would have been better if ProRail would have withhold from optimising its own organisation.

Certification: The reality

As explained in report DR 5.1, train-track integration was a major problem. Finding reasonable solutions for ERTMS-related issues took many months due to the following:

1) A general problem with the translation of functional specifications into technical specifications;
2) A gradually evolving ERTMS standard. Finally, the EU agreed on a national fix at level 2.3.0d. The Dutch implementation is not compatible with ERTMS Level 1 implementations in other countries;

3) The certification process determines the planning of the infrastructure (dependency relation). The practice is that the infrastructure provider makes his own plan, not involving locomotive- and logistic issues;
4) Commercial interests of the companies involved. Conversion of locomotives is expensive. Negotiations about specifications and price of ERTMS components, and who was responsible for technical mismatches were regular;
5) EU subsidy for Level 1 locomotives. Information about the subsidy was only available by the end of 2009 (Stuurgroep Ombouw havenspoorlijn, 2009h) and would be spent in tranches. Given the considerable costs of conversion, locomotive owners had a reason to wait as long as possible before signing orders for conversion. This contributed to the delay in conversion of locomotives;
6) Leasing companies played their own role in the process (Stuurgroep Ombouw Havenspoorlijn, 2008c). For instance, IVW issued a VGB3 certificate for a particular locomotive to the owner of the locomotive. If this was a leasing company, this company did not send the certificate to the traction provider, leaving him uninformed about possible use limitations of this locomotive. A locomotive with use restrictions should be treated differently in time table, but the traction provider could not tell Keyrail about this, hence scheduling became also more complicated than necessary;
7) A discussion between the actors involved about the question who should pay for the software migration and when. Should the Dutch government only pay for current trackside upgrades, and not for future ones, then it is clear that the railway undertakings wanted to have the latest and most complete version, which would take more time to develop and install. In practice the Dutch government agreed to pay for ERTMS software upgrades in the next five years in order to save time;
8) The lack of willingness of the ERTMS suppliers to accept technical risks and pay for the consequences (‘malus’ on the contract price).

It was important that Keyrail entered the loop. It was able to solve some of the issues by supplying infrastructure information to the traction providers.

3.4.3 Evaluation

After the opening of the Betuweroute, the lack of certified ERTMS locomotives was a major hindrance to the traction providers. Over time, the number of certified ERTMS locomotives increased substantially, allowing these companies to offer the services their customers asked for.

As ERTMS was a new and complex system it needed monitoring to make sure that all errors were recognized, analyzed and fixed. A monitoring procedure was developed and used by ProRail for a too short period of time.

The technical issues related with ERTMS have to a large extent been solved and they hardly affect commercial services anymore. It is important to prevent that with new versions of ERTMS the same learning curve has to be mastered.

3.5 Capacity management

3.5.1 Introduction

Management of resources is key to the success of a rail infrastructure manager. In section 3.5 the following demonstration activities, which have an impact on rail capacity, will be discussed:

- the impact of ERTMS on train operations and mitigating actions (example: braking curves) in section 3.5.2;
- cooperation between rail operators – international train paths in section 3.5.3;
- rollout of Chain Management/SPIN towards the whole intermodal sector in section 3.5.4;
- rollout of Chain Management/SPIN into Duisport in section 3.5.5;
- relation between safety requirements and capacity of tunnels (example Sophia tunnel) in section 3.5.6;
- technical feasibility of long trains (with test trains) in section 3.5.7;
- train scheduling in Q4 of 2009 in section 3.5.8;
- removal of voltage change overs (VCO's) at Zevenaar in section 3.5.9.

3.5.2 Braking (deceleration) curves

Introduction [19]

European railways use different train control systems and have different warning distances. To ensure interoperability, a common specification of the braking deceleration of trains fitted with ERTMS was necessary. In conventional ATP systems, braking performance is defined in terms of a *braked-weight percentage*. This is usually determined empirically based on stopping distances obtained after testing and using UIC leaflet 544-1. This is an effective way of expressing the ability of any train to stop over a certain distance while travelling at a given initial speed.

With ERTMS, (most of) the automatic speed supervision systems require knowledge of the braking performance of a train in terms of *instantaneous deceleration as a function of speed*. To get this data, a new method for describing the braking performance of all train categories within an ERTMS environment had to be determined. A conversion model converts the percentage value into a speed dependent deceleration-function expressed as a step function. By using the percentage value, the type of train (P/G), the train length and the P/G brake position as input, the model calculates the distance necessary to reduce the speed from the momentary value to the target speed.

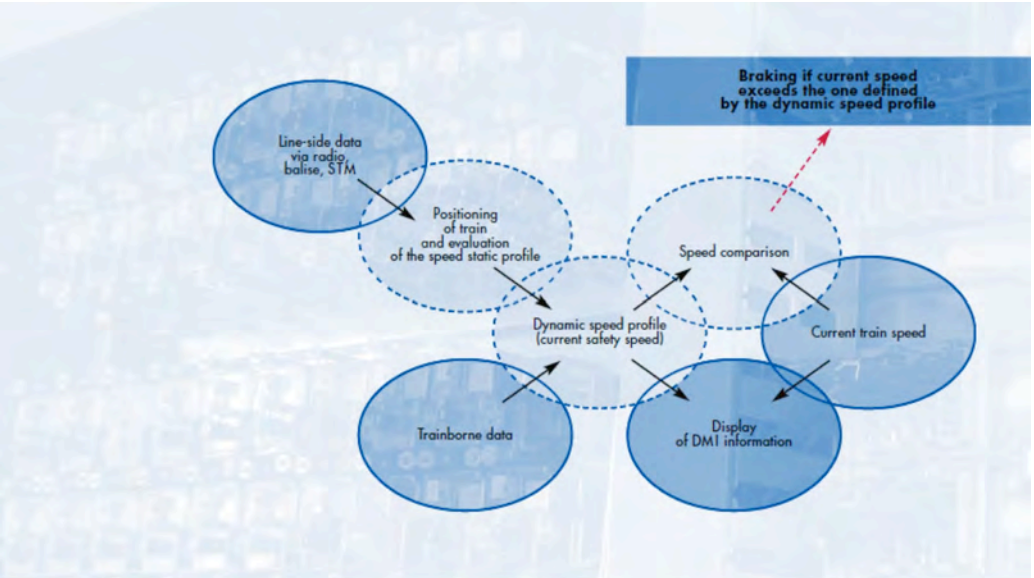
Speed curve supervision is one of the features of ERTMS. To prevent overspeed or STS-passages, an emergency brake can be applied to reduce the risk that a train passes a danger point to the absolute minimum. A curve in the speed-distance plane is calculated, which determines when to apply the emergency brake. The stopping distance must be very safe. In the calculation safety margins are used. Such safety margins should not be excessively high to avoid reduction of capacity and smooth flow of trains.

At present each national rail infrastructure manager in Europe has its own rules to determine this safety margin. UIC supported research has provided a methodology for the calculation of the safety margin. The discussion about a common European standard is in its final stage, but it is not part of the installed 2.3.0 d baseline of ERTMS. It will be included in baseline 3.0.0. The improved braking curve can therefore already been implemented in locomotive software. Alstom and Bombardier still have to do this, but continue using their own braking curve models, which are more simple than the UIC one.

[19] Source: UIC, 2010.

ERTMS trackside and trainborne equipment have to cooperate smoothly in order to optimize braking curves (see Figure 9).

Figure 9. Trackside and trainborne equipment determine braking curve



Source: RFI, 2005.

Due to the separation between infrastructure and services, as required by the EU, the traction providers and lease companies have not been very keen to deliver the parameter values of their own locomotives. They have also not formulated performance criteria. As a consequence the performance of some locomotive types (diesels, but probably also the electrical locomotives) is lower than possible. Causes behind this are fear among suppliers to take responsibility, insufficient communication and 'blaming the other' behaviour (Van Zandvoort, 2009b).

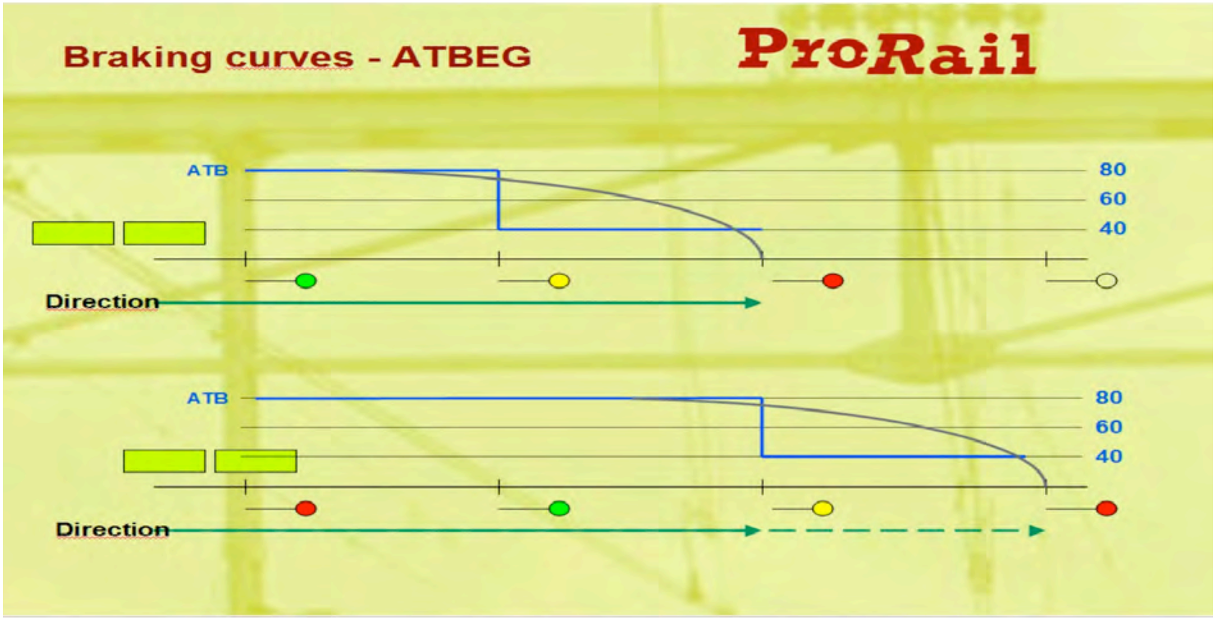
Why freight trains are different

ERTMS was originally designed for (high-speed) passenger trains, which have much different operating characteristics, are on average less old and have more homogeneous speed and braking characteristics than freight trains (Klomp et al., 2007).

Compared to the average passenger train, a (long and heavy) freight train needs more time to accelerate towards the intended speed, while deceleration and finally stopping takes more time. After a complete stop, restarting a freight train also takes much more time than starting a passenger train due to the more time-consuming technical (brakes and integrity) check.

In an ERTMS locomotive, the EVC computer uses dynamic (e.g., actual train speed) and static information (e.g. about gradients and braking capacity) to calculate the permitted speed and a safe braking profile when a train approaches the end of movement authority (EoA). Tracking of the train's position, allows the system to prevent that MA is not exceeded. Figure 10 shows the differences between ATBEG and ERTMS.

Figure 10. Braking curves with ATB



Source: Meyer, 2010.

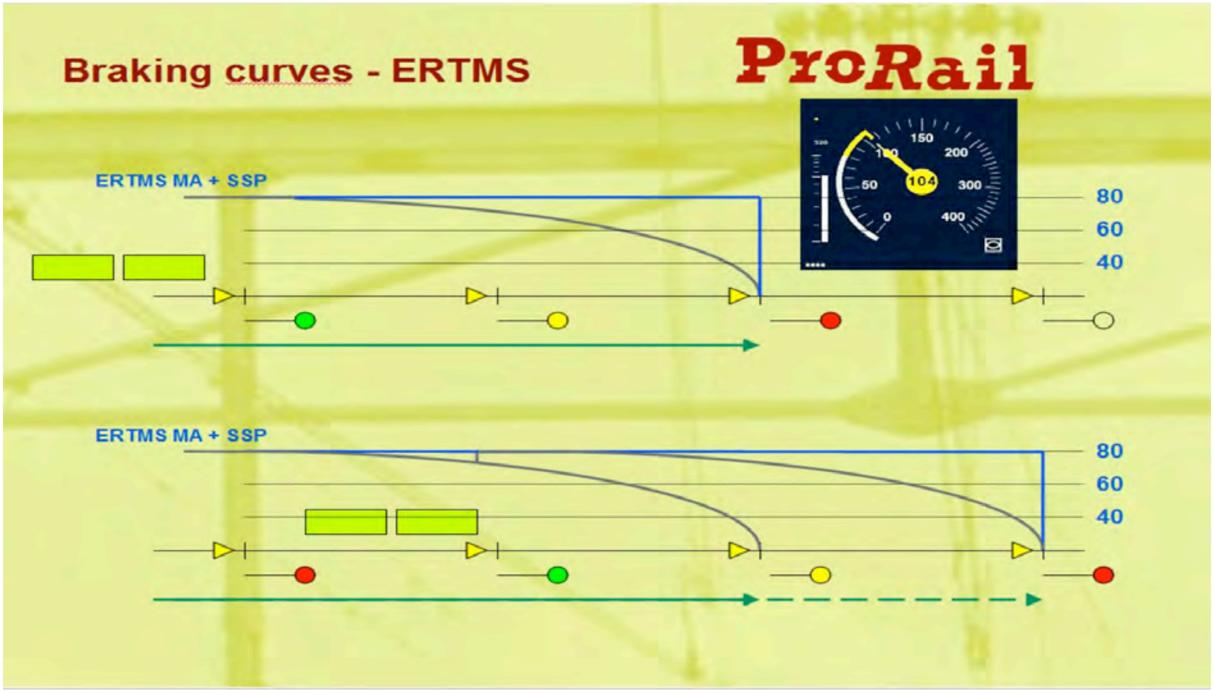
(Upper part of Figure 10) A train moves in the direction of a green signal. The next signal is yellow (slow down to advisory speed), followed by a red signal (stop). The train receives the ATBEG speed code related with the yellow signal. Only after passing the yellow signal, the ATBEG code will force the train driver to adapt his speed according to the ATBEG braking criterion.

(Lower part) In this case, while in the 'green block', the yellow signal changes to green, which means that the train can continue the route set via the ARI trigger (automatic route setting (ARS) or in Dutch: "Automatische Rijweg Instelling") with the old speed. The train keeps its maximum ATBEG(speed) code and does not have to brake.

In case of ERTMS, the situation is different (Figure 11).

ETCS underestimates human capabilities by applying more conservative safety criteria, hence a train driver has less margin for error (or correction of mistakes). This issue occurs under Level 1 and 2. Complex train movements, like shunting, are also difficult to address with ERTMS.

Figure 11. Braking curves with ERTMS



Source: Meyer, 2010.

Trackside ERTMS sends a movement authority (MA) until the end of MA (EoA) and a Static Speed Profile (SSP) to the train. SSP is a permanent speed restriction for a track section, sent from the track to the train. The EVC calculates the braking curves based on the train characteristics. Since these are such (brake lever in position G, low braking percentage) that a longer braking curve is necessary for a given block length, the braking curve will be shown on the DMI long before the yellow signal (upper part of Figure 11).
In the lower part of Figure 11 the impact of fixed points (where an MA update can be given) is shown. Like in case of ATBEG, the path of the train is extended (yellow-green change). However, the MA is only updated at the next signal. This bears the risk that the train driver has to brake while moving towards a green signal; braking occurs, but the MA is not shortened. In other words, the shorter braking curve is employed instead of the longer one. Braking is earlier and harder than with ATBEG.

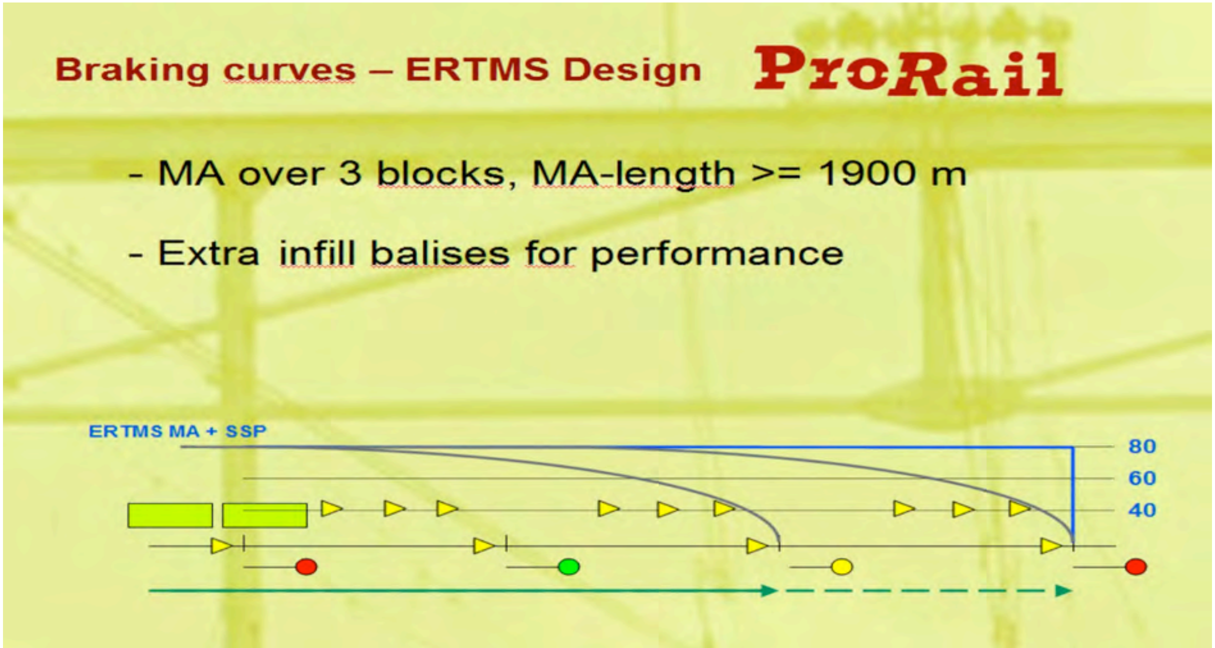
This is an example of a situation where the braking curve may conflict with the MA. MA is monitored by means of a section timer. A train driver should use the allocated time efficiently in order to continue swiftly from one section to another. If the train is too slow, then it may be put to a halt, which not only affects his train, but also subsequent trains.

Adaptation of the infrastructure

When designing the infrastructure, a braking distance of at least 1700 meters before a signal was assumed. In practice, ERTMS may start braking at 2500 meters (Van Zandvoort, 2009b), which is much too early.

Based on analysis of freight train braking curves, a decision was made that with Level 1 one MA has a standard length of 3 blocks (1900 meters).

Figure 12. Braking curves with infill balises



Source: Meyer, 2010.

This maximum variant minimizes the risk that a train receives a braking instruction while the signal in the next track section shows a permissive aspect. Also based on the braking curves, the maximum number of 3 [20] infill balises per signal was chosen, giving distances between signal and balises of 100, 400 and 600 meters (Klomp et al., 2008b, Figure 12). When passing a(n infill) balise, the train receives information about the state of the next signals, which are used to adapt MA and speed profile. If this MA is given for several

[20] Due to local requirements, at some locations, the ARI (automatic train path install procedure or in Dutch: "Automatische Rijweg Instelling" or "ARI") trigger is limited to two blocks, reducing MA length; a trade-off between capacity and performance.

blocks, then the MA will be divided into sections, each having its own section timer telling the train driver how long the MA remains valid. Infill balises are only read by a train running in FS mode.
Still, 1900 m may not be enough, because according to EBI the braking curve for long and heavy freight trains (based on a brake-weight percentage of 55% in G mode, a train length of 750 m) can have a length of more than 2500 m, which is very flat. The problem is therefore not solved completely.

Adaptation of train driver behaviour
Next to these technical measures, train driver training (see report DT 5.1) fulfilled an important role in improving operations. An example is the combination of operating modes G (freight or in Dutch: "Goederen") and P (passenger or in Dutch: "Personen") (Van Dort, 2009).

In future, a new set of parameters in baseline 3.0.0 may give a more acceptable braking curve.

More about the design choices
When designing the Port Line, many assumptions were made, which landed into the requirements list for building the infrastructure. To be mentioned are:
- rounding off of slope percentages in a safe manner (5%, also for flat sections);
- service brake intervention is allowed.

In order to change these settings, all balises and LEU's have to be reprogrammed, which would lead to (many) out-of-service situations.
To adapt the infrastructure to the real braking curves, section timers and OS-windows could be adapted. After consultation with Keyrail, no changes were made yet, except for the Botlek tunnel, because the impact on train scheduling cannot be quantified. Field tests have to show the need for such changes based on an analysis of the impact of ERTMS on train operations and scheduling (Van Zandvoort, 2009b). Tests and analyses should lead to a European standard for the braking curve of freight trains supervised by ERTMS.

Evaluation

Improvement of the braking curve of freight locomotives can only partially be achieved by the already mentioned infrastructure measures. A more structural solution should come from a new European standard. In the meantime, operators and infrastructure managers rely on the available ERTMS implementation, which functions suboptimally.

There is also a safety aspect involved. Although everyone involved appreciates a more efficient railway system, with more trains running at a reduced separation distance, nobody wants to get there by lowering the safety level. So, until the new standard is available and proven, the status quo will remain.

An unofficial norm exists, but the final baseline should first be ready, then certified and next installed in locomotives in order to start test runs. This process will take some time.

Intuitively, experts think that the new standard will help to improve operations, but the capacity gain has not been calculated.

3.5.3 International train paths – OSS

International coordination

International train paths are distributed via the organisation of European Rail Infrastructure Managers and RailNetEurope (RNE). Within RNE rail infrastructure managers from more than twenty European countries cooperate. In case of the Betuweroute, the link between the Dutch and German railway networks (including the Betuweroute) falls within the scope of the CREAM project.

National rail infrastructure managers are legally only responsible for national train paths. International train paths are agreed via cooperation between national infrastructure managers. Such cooperation should optimize transit times of freight trains (in corridors). Improved integration of train schedules and exchange of train drivers are among the tools available to support this goal.

For railway undertakings, the point of contact is the One-Stop-Shop (OSS). The OSS is a service desk providing access to data about available train paths, user charges, administrative issues, technical data of railway lines and terminals. It also deals with complaints from railway-related businesses. If a railway undertaking makes a reservation for an international train path with one OSS (in this case a single coordinating OSS), the responsible infrastructure manager should coordinate the whole process of capacity distribution of the international train path. The OSS's should reduce administrative requirements and improve safety of international train services via a common approach to safety.

Dutch experience [21]

An inquiry by the Dutch NMa Transport Chamber (NMa Vervoerkamer, 2006) among railway undertakings told the following:

- the international cooperation among rail infrastructure managers in the process of creation and distribution of train paths is not efficient enough;
- these managers are also not able to determine the demand for international train paths and are unable to provide (ad-hoc) train paths;
- if such train paths are reserved, they frequently are not available to the railway undertakings;
- it takes too much time to provide an answer to the path request and that the procedure is complex;
- in practice railway undertakings solve these issues themselves via their foreign branches and contacts, asking for separate national paths;
- railway undertakings also complain about discriminatory practices when asking for international train paths;
- one of the causes for inefficient train path distribution is the fact that the closure dates and the requirements for capacity requests are different in the countries involved. If there is a lack of capacity in one of these countries, the other countries should be informed. Next, a solution should be fiound to solve the issue. Aligning the closure dates is then a logical step. Pathfinder was developed to harmonize the procedure for path requests, but it is not linked with the capacity distribution module. That process is still taken care of manually by the respectively rail infrastructure manager.

Keyrail demonstration - OSS

In response to the demand for improvements Keyrail changed its way of dealing with international path requests. A major change is the moment when a train schedule is delivered. From 2010 onwards the following procedure is valid (Keyrail, 2010a):

- Receipt. RNE form, request sent to planning system (VPT/Donna), request via Pathfinder;

[21] Compare also chapter 5.

- Notification. Requests received before 10.00 AM are processed before 12.00 AM the same day. Requests received after 10.00 AM are processed before 12.00 AM the next day;
- Order processing. OSS informs the requesting company within 5 days whether capacity is available, then starts planning or looks into alternatives. If the request cannot be planned, then Keyrail offers 2 alternatives to the requesting company. This company has 3 working days to decide about acceptance;
- Train path delivery. Changes of train scheduling (in Dutch: "Wijzigingsblad") will be sent to the requesting company within 5 working days after closure. Changes to the Day Plan will be sent at most 7 days in advance to the requesting company (if requested at least 14 days before execution date).

  In all cases, train paths will only be definitive if a terminal slot is reserved.

Evaluation and outlook

To reduce transit times and increase reliability of international freight trains many things have to be improved. A major issue is institutional and organizational improvement. To be mentioned are better cooperation between the Dutch and German rail infrastructure managers, optimization of the way RCC staff in both countries guides trains through their systems, alignment of procedures and exchange of train drivers.

Next to these issues, there are many infrastructural and technical bottlenecks, in the Netherlands (see section 3.5.9), in Germany as well as in other parts of the major railway corridors (see section 4.4.4 for the north-south Corridor A). Until these are solved, it will be very challenging for rail infrastructure managers and railway undertakings to deal with the forecasted growth in freight transport by rail.

3.5.4 SPIN/Chain Management rollout [22]

Introduction

Punctuality is a key requirement in logistics. Research showed that punctuality on the Betuweroute was much lower than what Keyrail regarded as acceptable. There were too many irregularities in traffic due to

- limited options for cooperation among a growing number of competing operators;

[22] This section is written from the perspective of Keyrail. It includes information from the interviews with Mr. Schmidt and Mr. Sjoerdsma.

- lack of communication and cooperation regarding planning and changes in planning among inter alia RUs, terminals and operators; [23]
- lack of fulfilment and inefficient use of train paths by RUs, due to non-availability of locomotives and/or train drivers at the planned time.

Before Chain Management, each link of the transport chain only optimized its own operations. Actors were not able or interested in organizing their business in a way that is beneficial to all users of the Betuweroute. Keyrail was giving-in all the time, solving problems created by others.

Common perspective

Chain Management (in Dutch: "Ketenregie") started as a pilot project by Keyrail in order to improve punctuality on the Port Line. Improved punctuality helps to use available rolling stock more efficiently, to increase the quality of rail transport and to use rail capacity more efficiently. The latter is not only needed to handle existing traffic, but even more to keep up with the forecasted growth in rail transport and prevent grid lock (Keyrail, 2009a).

The scope of Chain Management is intermodal transport in the Rotterdam Port area (Maasvlakte-Waalhaven- Kijfhoek). Several meetings were organized by Keyrail with stakeholders to discuss punctuality and to create a sense of urgency.

An overall plan was developed consisting of the following:

1) A new operational model for the Port line developed by Keyrail, terminal operators, rail operators and railway undertakings. It provides an integral and realistic planning of terminals, train paths and yards at a tactical and a dynamic level. The model should show the planned use of capacity in terminals, (marshalling) yards and on the corridor (in this case the harbour line);
2) Improved organization (time table, terminal planning, co-operation between actors in the chain, duties and responsibilities);
3) The development of a new ICT system to support this operational model. The system became known as SPIN (in Dutch: "SpoorINformatiesysteem");
4) Management information generated by the ICT system:

[23] An example: a terminal expected a train to arrive at 14:00, while the shipper expected this train to depart at 13:00 from the same terminal.

a. reliability at specific points relevant for train scheduling (yards or terminals);
b. the extent to which standard causes are responsible for differences between planned and actually operated times;
c. a set of indicators concerning the quality and quantity of information exchange between actors in the chain;
d. statistics concerning other 'quick wins' in the Pilot Chain Management Port Freight Line;
e. SPIN is fed with data from an integral plan that is linked with the Day Plan from VPT 17. Replanning is possible based on the actual Day Plan;
f. the system should also act as a communication tool between Keyrail and the other partners in the transport chain. The system should act as an information base for all actors, providing access to information enabling them to optimize their operational processes - ETA, train scheduling, if it is possible to stick to a train path, staff planning, information concerning loading and unloading, terminal capacity planning, what to do with containers arriving 'too late', to deliver the concept and final wagon list on time, to check whether the train arrived on time and whether train and train driver did return on time.

Chain Management would enable Keyrail to
- communicate changes in train scheduling to the operators;
- tell what the different players in the chain have to do and when in order to optimize train movements.

In September 2007, preparation of the Pilot Chain Management started with a commitment by all relevant stakeholders, saying that improvement of the transport chain should be a common objective.
Key assumptions were the following:
- optimisation of the whole process;
- open communication to non-participants;
- no deterioration of performance outside the scope.

Involved actors had to start to think, decide and act from the perspective of the transport chain and no longer from their own perspective.
The Pilot involved the main terminals (ECT, RSC), RUs (ERS, Railion, Veolia), the operators (ERS, Hupac, Intercontainer) and the Port of Rotterdam.

Goals, logic and planning of the Pilot

The aim of the Pilot was to increase punctuality on the Port line by 20% in the short term.

During November-December 2007 an analysis of problems and potential improvements was finished. It came up with a list of *quick wins*:

- real time reservation of yard tracks via Keyrail;
- replanning with central coordination;
- operational rules for the whole transport chain;
- all parties will be connected to the Traffic Management Information System (ISVL);
- reduction of partial (on/off) shuttles (in Dutch: "opstapshuttles");
- joint planning of specific trains.

Operational rules (Ops)

The list of improvements was translated into a set of *operational rules* for the Port Line. These rules were accepted by the management of the involved companies.

The concept of integrated planning of rail traffic and terminal operations says that *only trains with a terminal slot* [24] *are allowed to use the shunting yard tracks of the Port line.* If a train running on the A15-trajectory does not have a terminal slot, it has to wait at one of the waiting tracks at Kijfhoek, instead of continuing in the direction of and finally waiting at one of the process tracks of the Maasvlakte-, Botlek- or Waalhaven terminals. If the process tracks were blocked by trains without a terminal slot, trains with a terminal slot could not be processed at these terminals according to planning. To prevent waiting at Kijfhoek, operators are stimulated to improve their operations, their communication with terminal operators and more in general prevent that the behaviour of their staff has a negative impact on other companies in the transport chain.

The ten operational rules (spread over 4 categories) are as follows (Keyrail, 2009a):

1) General. Integral planning of train schedule with terminal slot;
2) General. Agreements about terminal slots;
3) Normal process. To communicate information about the containers to be loaded and unloaded on time (#, container id, full/empty, DG);

[24] A terminal slot defines which activities should be carried out at the terminal and how much time is available for these activities (Keyrail, 2009a).

4) Normal process. To communicate wagon list and AZ-ZA [25], and the location of dangerous cargo;
5) Normal process. To communicate (dynamic) ETD as soon as possible;
6) Normal process. To communicate transport information on time;
7) Normal process. To assure that locomotives and staff are available before ETD;
8) Changes. To communicate changes to ETA and ETD as soon as possible;
9) Corrections. Replanning in case of deviations;
10) Corrections. Blocking trains will be shunted to another location.

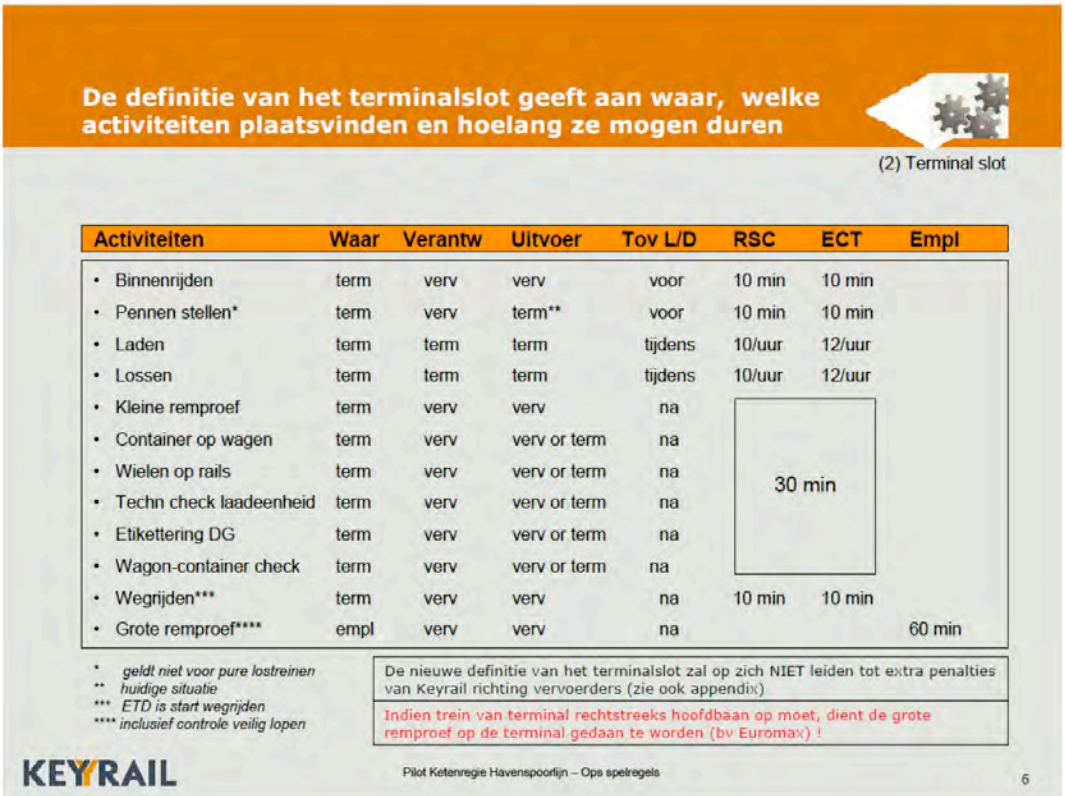
An example of the consequences of non-compliance is the following:
Ad 3) The operator should communicate the required information to RSC at least 2 hours before loading and unloading and to ECT at least 4 hours before unloading and 14 hours before loading. If container information is incomplete, then the operator has to communicate this issue at least 2 hours before arrival to RSC and the transport company. Containers with incomplete information are not processed at ECT, but transferred to RSC and parked there.
The train will stay at the yard until the terminal provides an alternative slot or the train can on his request be transferred to a next slot reserved by the same operator.
If a terminal slot is taken back, it can be used by other operators.

A complete overview with all the requirements and consequences of the operational rules can be found in Keyrail (2009b).

November 19, 2007 marked the start of the implementation. Participants in the Pilot had to learn to follow the agreed operational rules (Keyrail, 2009a). Cooperation was established via biweekly meetings with operational staff about operational issues and via regular meetings between directors.
April to May 2008 was used for a midterm evaluation of the Pilot. This led to the earlier mentioned definition of a 'terminal slot' (for the definition of a standard terminal slot, see Figure 13). Tighter rules were launched. A training was organized to support the change process (see report DT 5.1).

[25] This refers to the direction of the train. A = hinterland (in Dutch: "achterland"), Z = sea (in Dutch: "zee").

Figure 13. Definition of a standard terminal slot (in Dutch)



Activiteiten	Waar	Verantw	Uitvoer	Tov L/D	RSC	ECT	Empl
• Binnenrijden	term	verv	verv	voor	10 min	10 min	
• Pennen stellen*	term	verv	term**	voor	10 min	10 min	
• Laden	term	term	term	tijdens	10/uur	12/uur	
• Lossen	term	term	term	tijdens	10/uur	12/uur	
• Kleine remproef	term	verv	verv	na	30 min		
• Container op wagen	term	verv	verv or term	na			
• Wielen op rails	term	verv	verv or term	na			
• Techn check laadeenheid	term	verv	verv or term	na			
• Etikettering DG	term	verv	verv or term	na			
• Wagon-container check	term	verv	verv or term	na			
• Wegrijden***	term	verv	verv	na	10 min	10 min	
• Grote remproef****	empl	verv	verv	na			60 min

Note: The technical checks are also known as 'check before departure' or 'train preparation'.

With the start of the new Year Plan in December 14, 2008, Keyrail started with an integral planning and strict enforcement of the rules.

In March 2009, a decision was made to extend Chain Management to all users of the Port Line.

Chain Management will become a requirement in the Access Permit of the Betuweroute and as such becomes mandatory for all users of the Betuweroute. Next to that, the operational rules will become part of the Service Level Agreements (SLAs) of the terminals in the port.

Evaluation of the Pilot

Keyrail realised that 'we were good in adjusting, not in planning'. It was clear that the content of the operational processes had to be improved.

The Pilot has achieved the following:

- the average punctuality of all terminals increased from 73 to 85% in the direction of Germany and from 58% to 80% in the direction of Rotterdam (Railforum, 2009), despite a growth in traffic of some 30%. After the rollout all companies will be involved and higher figures are expected;
- a reduction of the costs in the logistic chain;
- participants have become aware that it is one decision making process;
- behaviour has improved, although not to the fullest extent;
- the chain has become more transparent. There is more information and it is shared with other participants. Mistakes and their consequences become visible to everyone. This is an incentive for improved individual contributions;
- 80-90 % of the problems identified at the beginning of 2007 have been resolved.

It became clear that the flexible train shuttle concept (in Dutch: "opstapshuttle") should be abandoned, because in this concept, a train stops at several points in the Port area, which means a more complex planning and lower reliability. Direct shuttles are favoured and shorter, feeder trains are used for the remaining traffic.

Remaining issues

Non-participation means that you do not get sanctioned if you make operational mistakes. This explains the rollout of Chain Management to all users of the Betuweroute. All rail users should participate and improve their operations.

The terminals perform less than expected. They do not make the right operational choices. Lack of staff is an issue, for instance at the ECT terminal, but there is also the fact that they do not want to say no to customers, even if their choices create a problem elsewhere in the chain.

Internal processes have to be analyzed in order to understand why participants decide in the way they decide. This is the most important aspect of Chain Management. Measuring of processes is important. It is also important to dig deeper when asking questions.

There is more transparency. Two years ago, this information was not available. But, the information is not always on time, due to focus on internal operations by participants.

There is a pressure on participants to cooperate, but the tools, like SPIN, do not motivate well enough. It is necessary to make the benefits more transparent.

The operational rules help to secure the achievements, especially in more difficult periods. This is why they are included in the Access Agreements.

Chain Management roll out decision

Analysis of the results of the Pilot showed that the operational rules were stable and fully implemented. The results were measurable and structural.

This led to the decision to start the preparation of a full-scale rollout of Chain Management. This took place between March and June 2009. This step was supported by communication, training and the development of two support systems (IP and SPIN).

In July 2009, the rollout started, demanding all terminal and rail operators to work according to the new operational rules.

Development of supporting systems; IP and SPIN

Two systems were developed: IP and SPIN.

IP or integral planning (in Dutch: "Integrale Planning") is an internal system developed for and owned by Keyrail. It supports and communicates integral planning for a certain period. This tactical tool was ready end of March, 2009. Integrated planning schedules are periodically updated according to a special procedure (Keyrail, 2009a). IP is not discussed any further in this report.

Integral planning means that the Year Plan will be tuned towards terminal planning. The Day Plan is deducted from the Year Plan or actual Change Leaflet including known changes (for example from the railway undertaking or due to maintenance).

The Day Plan may change due to insertion of an additional train, a change of planned train route or a cancellation of a train.

SPIN or rail information system (in Dutch: "SPoor INformatie systeem") is an operational (software) tool developed for Keyrail and Port of Rotterdam to support the operational rules.

SPIN consist of data input and output (presentation) modules.

Each category of users will have access to his own set of pages in SPIN. After login, a user has access to operational information (static and dynamic data about operations within the chain), to management information and user management. In addition to this, Keyrail has access to planning. SPIN is used by terminals, RU's, rail operators and Keyrail to enter, change and distribute data. It tells users when to provide which information or to act in a specific way. A user can apply certain filters to the input and output of data, in order to make his own overview. SPIN was ready in June 2009.

The management information pages deal with KPI (Key Performance Indicators or achievements), punctuality (with differences and their causes), norms to adjust planning by the actor. This information can be used to improve planning and execution, and to make cross relations, prepare statistic overviews, etc.

SPIN consists of the following main technical components:
- business processes and activities by the different actors (in Dutch: "bedrijfsprocessen");
- the different actors themselves (Keyrail, terminal operator, traction provider, rail operator, application manager);
- the integral planning of trains including the overview of trains and details per company;
- reporting/output (based on algorithms);
- data model.

A complete overview of the functionality of SPIN can be found in Droog (2009).

When SPIN was ready, data had to be typed in manually. This is a very time consuming process, especially if real ETA and ETD data have to be entered. Furthermore it was a repetition of data entry, because a lot of operational systems of railway undertakings and rail operators demanded the same information. This is why a connection with existing operational systems is discussed. This would allow (semi-)automatic input of data.

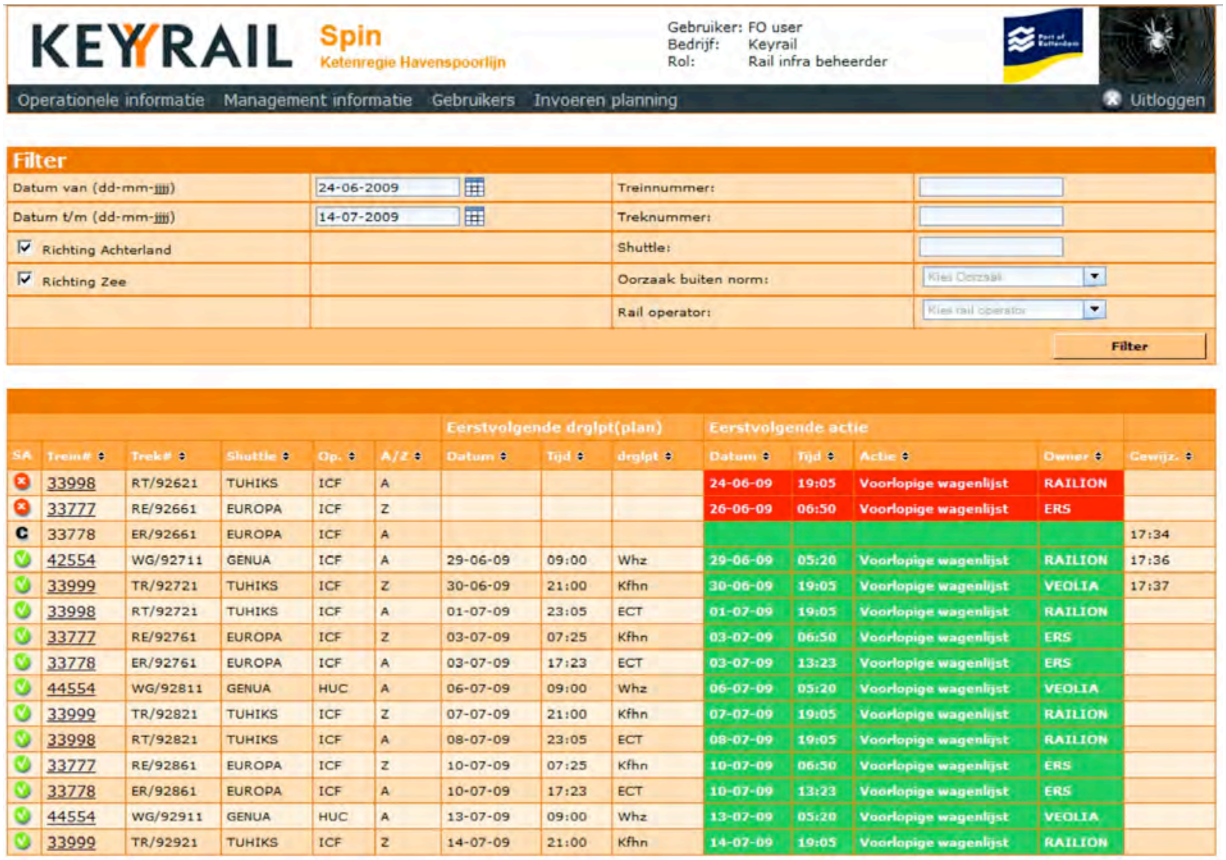
In the following figures, some examples of user screens are given. We will not discuss a complete sequence, as this is not an instruction manual.

All user screens have a similar layout. Each screen is divided into an input/filter section (upper part) and an output section (lower part).

Operations

Figure 14 gives an overview of the trains planned for a specific period in time (in this case 24-06-2009/14-07-2009) and for both directions (A and Z).

Figure 14. Overview of trains as seen by SPIN user Keyrail



						Eerstvolgende drglpt(plan)			Eerstvolgende actie				
SA	Trein#	Trek#	Shuttle	Op.	A/Z	Datum	Tijd	drglpt	Datum	Tijd	Actie	Owner	Gewijz.
	33998	RT/92621	TUHIKS	ICF	A				24-06-09	19:05	Voorlopige wagenlijst	RAILION	
	33777	RE/92661	EUROPA	ICF	Z				26-06-09	06:50	Voorlopige wagenlijst	ERS	
C	33778	ER/92661	EUROPA	ICF	A								17:34
	42554	WG/92711	GENUA	ICF	A	29-06-09	09:00	Whz	29-06-09	05:20	Voorlopige wagenlijst	RAILION	17:36
	33999	TR/92721	TUHIKS	ICF	Z	30-06-09	21:00	Kfhn	30-06-09	19:05	Voorlopige wagenlijst	VEOLIA	17:37
	33998	RT/92721	TUHIKS	ICF	A	01-07-09	23:05	ECT	01-07-09	19:05	Voorlopige wagenlijst	RAILION	
	33777	RE/92761	EUROPA	ICF	Z	03-07-09	07:25	Kfhn	03-07-09	06:50	Voorlopige wagenlijst	ERS	
	33778	ER/92761	EUROPA	ICF	A	03-07-09	17:23	ECT	03-07-09	13:23	Voorlopige wagenlijst	ERS	
	44554	WG/92811	GENUA	HUC	A	06-07-09	09:00	Whz	06-07-09	05:20	Voorlopige wagenlijst	VEOLIA	
	33999	TR/92821	TUHIKS	ICF	Z	07-07-09	21:00	Kfhn	07-07-09	19:05	Voorlopige wagenlijst	RAILION	
	33998	RT/92821	TUHIKS	ICF	A	08-07-09	23:05	ECT	08-07-09	19:05	Voorlopige wagenlijst	RAILION	
	33777	RE/92861	EUROPA	ICF	Z	10-07-09	07:25	Kfhn	10-07-09	06:50	Voorlopige wagenlijst	ERS	
	33778	ER/92861	EUROPA	ICF	A	10-07-09	17:23	ECT	10-07-09	13:23	Voorlopige wagenlijst	ERS	
	44554	WG/92911	GENUA	HUC	A	13-07-09	09:00	Whz	13-07-09	05:20	Voorlopige wagenlijst	VEOLIA	
	33999	TR/92921	TUHIKS	ICF	Z	14-07-09	21:00	Kfhn	14-07-09	19:05	Voorlopige wagenlijst	RAILION	

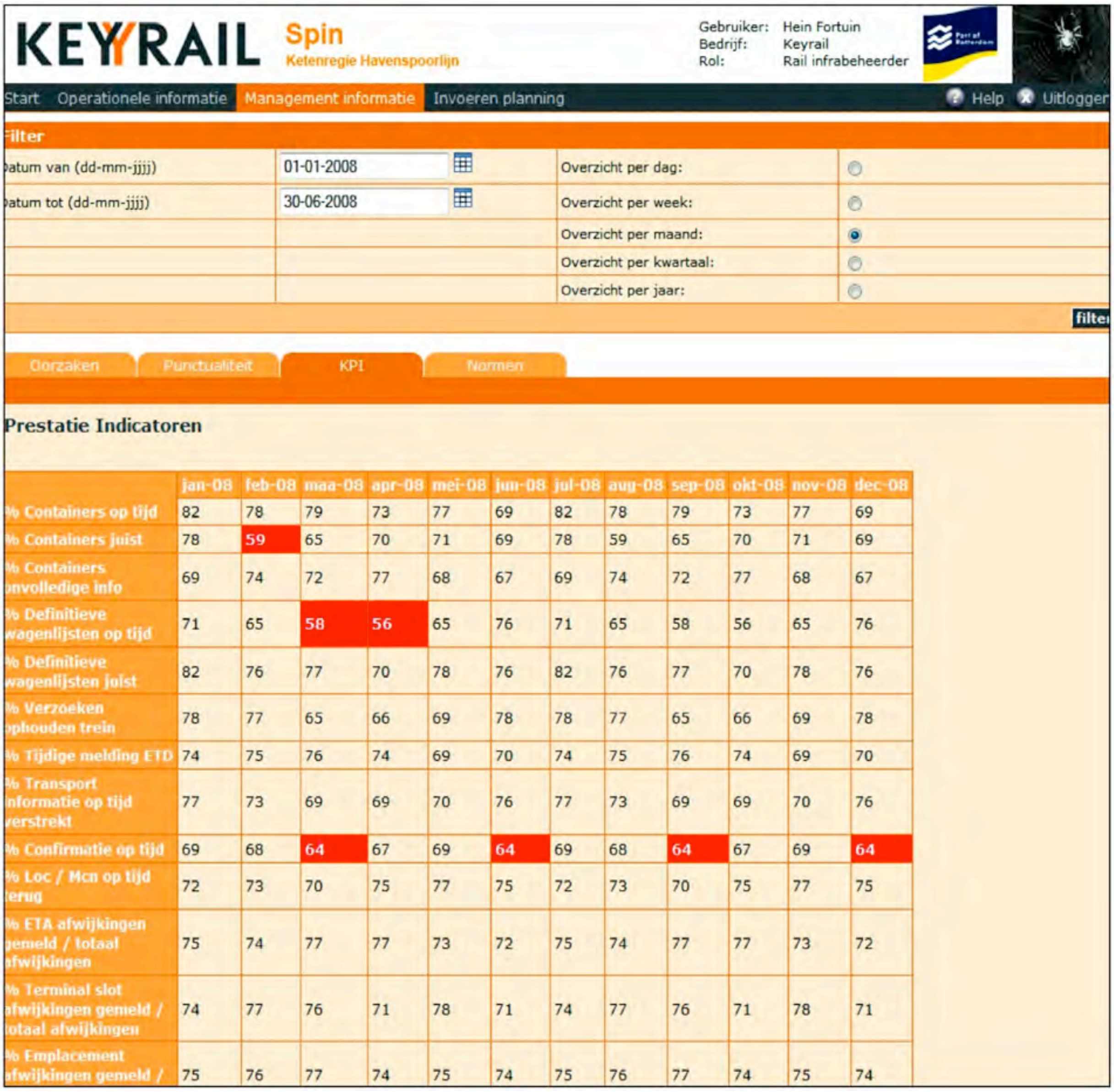
Source: Droog, 2009.

The top part of this screen allows filtering by period, train number etc. In this case only a period filter is applied and the results are presented in the bottom part of this screen.
For each train number we can see shuttle name, trek number, abbreviated name of the shuttle train, operator, direction of the train, planning (date, ETA, destination), next step (date, time, action, actor), rescheduling (time) actions.
Two trains in the top of the list have a problem. The operator did not provide the required 'preliminary wagon list' in time (yet). This situation is covered by operational rule no. 4 (required train information): without the preliminary wagon list, a train is not allowed to go to the terminal. The terminal slot will be taken back. The operator can ask for replanning, but this will only be considered if he enters the required data into SPIN.
The third row belongs to a train, which has been rescheduled, but no further information is shown on the screen. In case of the fourth and fifth row, the required information is available, but the trains are rescheduled. By clicking on a row, more information will be shown.

Management information

An example of Key Performance Indicators (KPI) is given in Figure 15.

Figure 15. An example of realised KPI in the first half of 2008

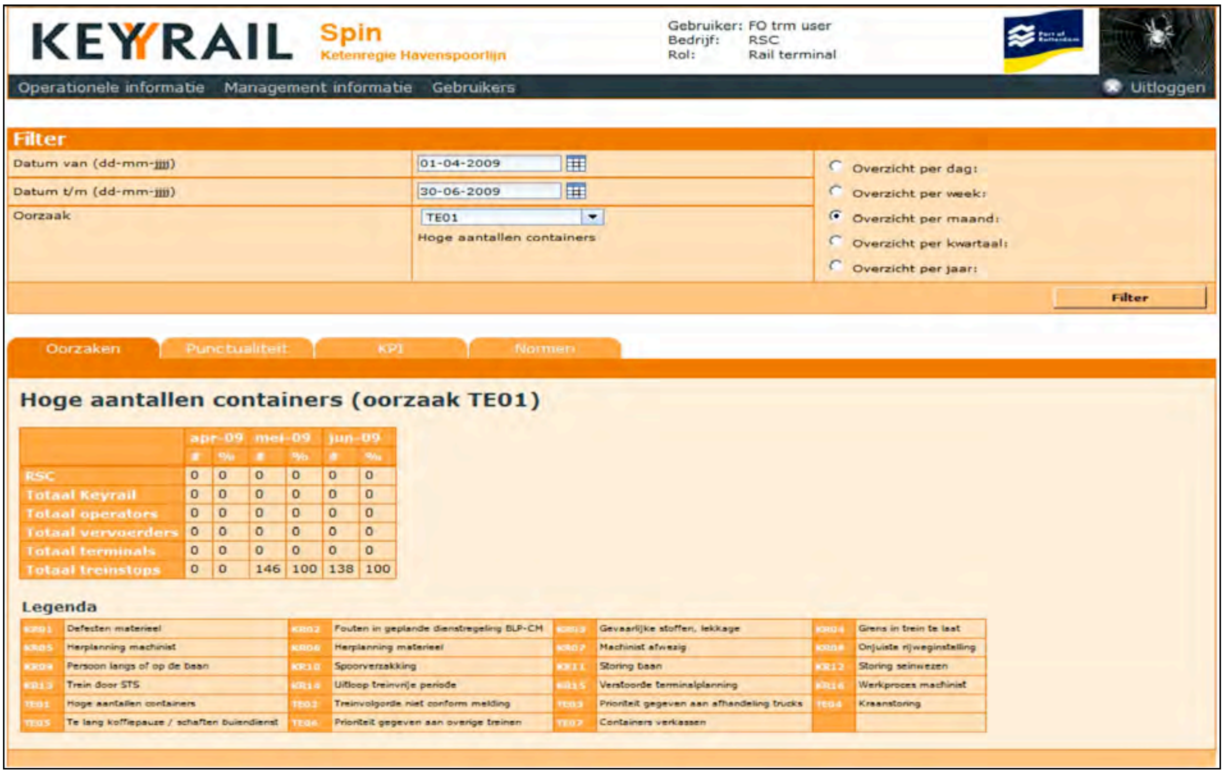


	jan-08	feb-08	maa-08	apr-08	mei-08	jun-08	jul-08	aug-08	sep-08	okt-08	nov-08	dec-08
% Containers op tijd	82	78	79	73	77	69	82	78	79	73	77	69
% Containers juist	78	59	65	70	71	69	78	59	65	70	71	69
% Containers onvolledige info	69	74	72	77	68	67	69	74	72	77	68	67
% Definitieve wagenlijsten op tijd	71	65	58	56	65	76	71	65	58	56	65	76
% Definitieve wagenlijsten juist	82	76	77	70	78	76	82	76	77	70	78	76
% Verzoeken ophouden trein	78	77	65	66	69	78	78	77	65	66	69	78
% Tijdige melding ETD	74	75	76	74	69	70	74	75	76	74	69	70
% Transport informatie op tijd verstrekt	77	73	69	69	70	76	77	73	69	69	70	76
% Confirmatie op tijd	69	68	64	67	69	64	69	68	64	67	69	64
% Loc / Mcn op tijd terug	72	73	70	75	77	75	72	73	70	75	77	75
% ETA afwijkingen gemeld / totaal afwijkingen	75	74	77	77	73	72	75	74	77	77	73	72
% Terminal slot afwijkingen gemeld / totaal afwijkingen	74	77	76	71	78	71	74	77	76	71	78	71
% Emplacement afwijkingen gemeld /	75	76	77	74	75	74	75	76	77	74	75	74

Source: Droog, 2009.

This (assumed) user, employed by Keyrail, wanted a monthly overview for the first half of 2008. The lower part of the screen gives the indicators (left column) and their 'score' in % (100% is max.). The cells with a red background indicate that the performance was below an acceptable (agreed) level.

Figure 16. Container screen as seen by terminal operator



Source: Droog, 2009.

In Figure 16, the terminal operator experienced a problem with punctuality. He liked to see a trend, in this case he chose a period of two months When looking into the causes, he used a filter for cause TE01 (high number of containers). In april, there was no problem, but in May and June there was. This high number increased the number of train stops. From the table no (direct) conclusions about the actor causing the problem can be drawn.

The use of SPIN is hampered by the need to enter data twice (manually). To make the interface with existing systems, an investment of more than 100.000 Euros is necessary per user. Not only these costs are prohibitive, but also the perspective regarding the availability of the interface. There should be a perspective for the market parties, e.g. that the system is ready in three months.

Experiences during rollout

The first observation is that the new group of users (see report DT 5.1) shows too little support for the operational rules. For them, it is also difficult to keep track with the companies who participated in the Pilot group. (New) users should experience a reward when they follow the rules. Changing behaviour takes time, this is a sector with rather solid traditions.

It turns out that the operators do not have the required information internally, while adjustments are common. Companies on their part do not recognize the data from Keyrail.

Operational rules have to be explained: are they real, do all ten rules apply at the same time? This is a phase in the process.

Planning becomes more important. Integral planning means that the information from the terminals has to be provided earlier. Discussion with ECT and RSC is needed. The management of terminal tracks is not done by Keyrail, hence they should cooperate as good as possible.

A punctuality score of 85% is good compared to the present 81%.

A task force (in Dutch: 'Kernteam integrale planning") is working on improvements. A test is in preparation in order to measure at the terminals.

New developments

From July 1, 2010, all operational rules are now in use.

Based on the experience gained sofar (see also chapter 5), a decision was made to change the scope of Chain Management for the time being. A limited number of trains (8) is monitored fully (trains from the first group of participants) and reports are made to optimize the parameters.

Shunting of blocking trains is also obligatory from this date. The procedure is as follows. If a train arrives too late at e.g., RSC Waalhaven, then the operator will receive a phone call asking him what to do: parking or shunting?

Shunting can be self-arranged. For instance, DB Schenker has a dedicated shunting loco. Otherwise, the operator may ask Keyrail to do this for him.

Legally the responsibilities are clear. Shunting will cost between 300 and 350 Euros.

Sofar, shunting has not occurred. If it happens, the first shunted train will be used as a test case helping to answer questions like: will there be a 'dispute', is there capacity, how fast will the response be?

Evaluation

Key achievements of Chain Management are improved punctuality, more focus and communication (for instance, participants discuss with each other on beforehand). Many problems could be solved, but additional work is needed (see also chapter 5).

Data exchange is vital for the success of Chain Management. Data entry is now a manual process and because the same data is also entered into other systems, it means double work, at least for the traction providers. The development of an interface between SPIN and the internal systems used by railway undertakings and terminal operators is crucial, otherwise SPIN will not be accepted as the system. In that case, it is likely that another system will be used, because there has to be a common and up-to-date information system supporting railway operations in the port area.

3.5.5 Chain management rollout Duisport

Introduction

In order to reduce transit times and improve punctuality, international freight trains should receive sufficient priority by rail infrastructure management and in particular local RCC [26].

Sofar, chain management has been a Dutch application. Its success stimulated Keyrail to think about an extension of Chain Management into Germany, in particular to include Duisburg, the commercial and transportation center of the Rhine/Ruhr region, Europe’s largest industrial conurbation. Thirty million people live and work within 150 kilometers from Duisburg (Duisport, 2010). Within Germany, Duisburg/Duisport is the key node for freight trains from and to the Netherlands.

The rail connection with Duisburg/Duisport is part of rail Corridor A Rotterdam-Genua (see section 4.4.4).

Requirements

Both Keyrail and DB Netz A.G. are aware of the importance of improved punctuality. There are regular meetings between the management of both companies and their experience is positive. At the operational level there is regular contact via a valuable contact person at the Dutch/German border in Emmerich, who speaks Dutch.

It is however important to consider the differences in approach concerning punctuality between the Netherlands (Keyrail) and Germany (DB Netz):

First, punctuality is measured differently. Keyrail uses the latest planning in its process of

[26] In workpackages 5.2 and 5.3 the issue of improved border crossing procedures has been elaborated, focussing in particular on the border crossings in the south-eastern part of the CREAM corridor.

replanning, but DB Netz uses the original planning of a train.

Second, Keyrail uses a time window of 0-3 minutes for measuring delays. In this period the train can enter or exit its system and changes to train scheduling are instantly made. DB Netz uses a period of 15 minutes, prolonging of which can be registered as a delay, but replanning will take another 20 hours.

Third, for Keyrail punctuality is a key parameter, hence information is readily available. DB Netz will only measure punctuality of trains if requested by another party.

Outlook

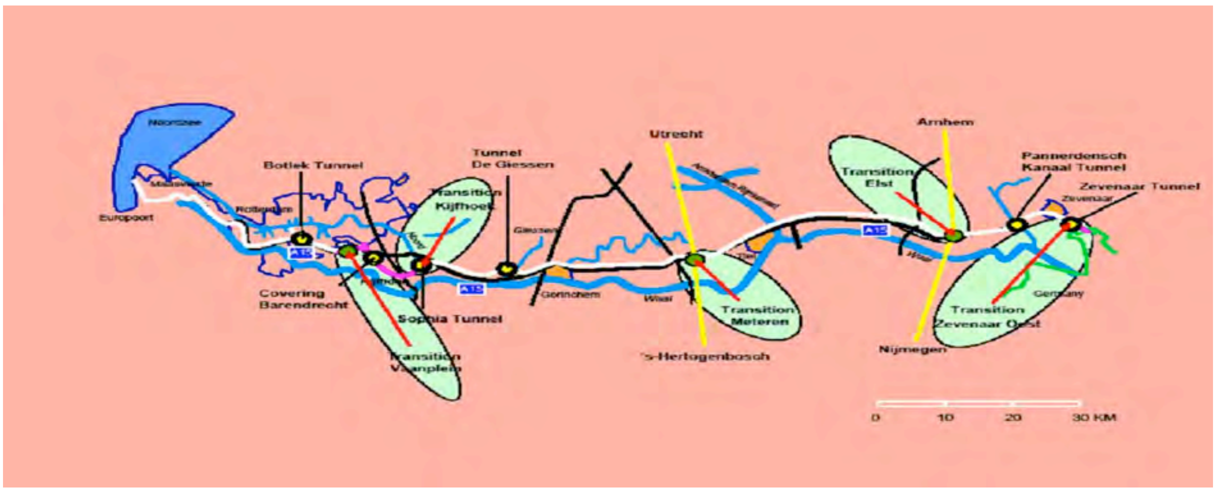
DB Netze is very interested in cooperation to improve the punctuality in the corridor Rotterdam-Duisburg (v.v.). Regular meetings between Keyrail and DB Netze took place already, both at the operational as well as the board level. Next (operational) meetings have to clarify common goals and how to deal with the difference in measuring punctuality between the Netherlands and Germany.

3.5.6 Sophiatunnel regime

Introduction

The Betuweroute has six railway tunnels (see also section 3.6.2). One of them is the Sophiatunnel, an eight kilometer long passage below the rivers 'de Noord', 'de Rietbaan', the 'Sophiapolder' and the highways A16 and A15 (see Figure 17).

Figure 17. A15-trajectory with connections to the main railway network



Source: Van de Ven, 2008.

This tunnel is partially built in a trench without a roof (in Dutch: "open tunnelbak") and partially built as a normal tunnel (in Dutch: "gesloten tunnel"). The tunnel is also the entrance/exit of the marshalling yard at Kijfhoek.

In tunnel design a compromise has to be found between tunnel length and gradient. The shorter the tunnel, the lower the cost, however, a shorter tunnel will also have a steeper slope (gradient). Track gradient should not exceed a specific maximum, otherwise upwards moving trains cannot master the slope, while downwards moving trains may either get trapped at the bottom of a tunnel while running at low speed or after a stop, or derail if the speed is too high or if the train makes an emergency stop. Gradients also limit the payload of a train. The acceptable gradient (%) will therefore co-determine tunnel length (next to spatial restrictions).

Signalling system

Tunnels are integrated into the signalling system. In the Netherlands special signals are used next to the normal main signals with green/yellow/red lights. They are only valid for heavy freight trains [27] passing tunnels, bridges and hilly terrain. These signals are known as the L/H regime (Bailey, 1995). If a slope is 5 ‰ or more, the use of L/H-signals is advisory.

An L-signal (in Dutch: "langzamer") is a signal (see Figure 18) in advance of a H-sign. Such a signal can be off (not lit) or on (lit). If lit, this signal tells the train driver that he is approaching a slope and that the main signal on the slope will show 'stop' (red light). If he would stop before the red light (like a passenger train), that would be 'uphill', which would make it difficult or impossible to continue the trip.

The L-signal has the same meaning as a yellow light of a main signal ('reduce speed to 40 km/h'). In this way the train driver can safely stop before the slope.

The L-signal is followed by a H-signal (in Dutch: "halt", Figure 19).

[27] The shipper and the train driver can choose whether they classify a train as a heavy freight train.

Figure 18. L-signal before rising slope

Note: the main signal shows green, but this is only valid for passenger trains.

Source: Van de Weerd, 2010.

Figure 19. H-signal before rising slope

Note: the main signal shows yellow, but this is only valid for passenger trains.

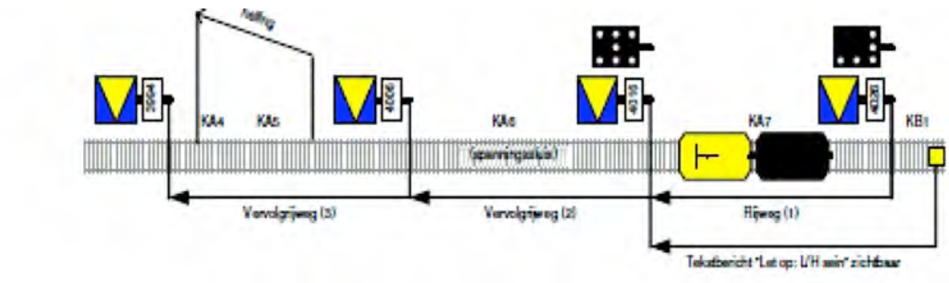
Source: Van de Weerd, 2010.

The H-signal is lit if the L-signal is lit. It tells the train driver where to stop his train, comparable to a red light of a main signal. It is shown automatically as long as a train would risk to be trapped. The H-signal is located at such a distance before a rising slope that when the H-light changes to 'off', the train driver can make enough speed to master the slope. The H-signal is also positioned in such a way that no part of the train will stay on a downward slope.

Instead of the L-H regime, also the X-G regime can be used. A blinking X-signal warns a freight train driver that he is approaching a lit H-signal. A G-signal (Freight trains, or in Dutch: "Goederentrein/G") is used to signal this special regime. A blinking X-signal indicates a speed reduction to 40 km/h. A fixed X-signal means 'halt before the signal'.
Train drivers have to obey the allowed minimum entry speed of a tunnel. This speed allows safe and swift passage of the tunnel. The entry speed is connected with the advisory speed for the bottom of the tunnel, in order to prevent overspeed and derailing.
Speed advice can be different depending on the direction in which a tunnel is entered, as the slopes may be different per direction.
The chance that congestion occurs, or that a train becomes blocked in a tunnel can therefore be manipulated by a clever location of the L- and H-signals in connection with block length (which can be shortened or extended). Their location is usually calculated by a model. It uses the inclination (‰) as input for a risk analysis of the particular slope (Wolbers et al., 2006). Each point on the slope receives a so-called 'slope letter' (alphabetic) (in Dutch: "hellingletter") corresponding with the %. The output of the model can be validated by field tests.
Calculations for the Sophia tunnel led to the conclusion that one set of L/H-signals per direction was needed.

Figure 20 shows a track section divided into four blocks, hence four MA's are needed to pass this section. While running in the first block (in Dutch: "Rijweg (1)"), the balise sends a message to the train driver that the L/H-signals are lit. After SMB 4016 (nr. 2 from the right) he receives a new MA for the next section (in Dutch: "vervolgrijweg") taking care of the passage of the voltage change over (VCO; explained in section 3.5.7.4), until SMB 4006 (nr. 3) etc. The slope (in Dutch: "helling") is located between SMB 4006 and SMB 3994 (nr. 4).

Figure 20. Train approaching voltage change over (center) and slope (left)



Source: Van Wilpe, 2008.

As can be seen in Figure 21, L- and H-signals are used in parallel to the SMB's of the ERTMS system. A warning about the status of L- and H-signals is also displayed on the DMI in the train cabin if the train is running on tracks supervised by ERTMS. When RCC sets a train path, relevant L- and H-signals are automatically switched on (Van Wilpe, 2008).

Sophiatunnel adaptation

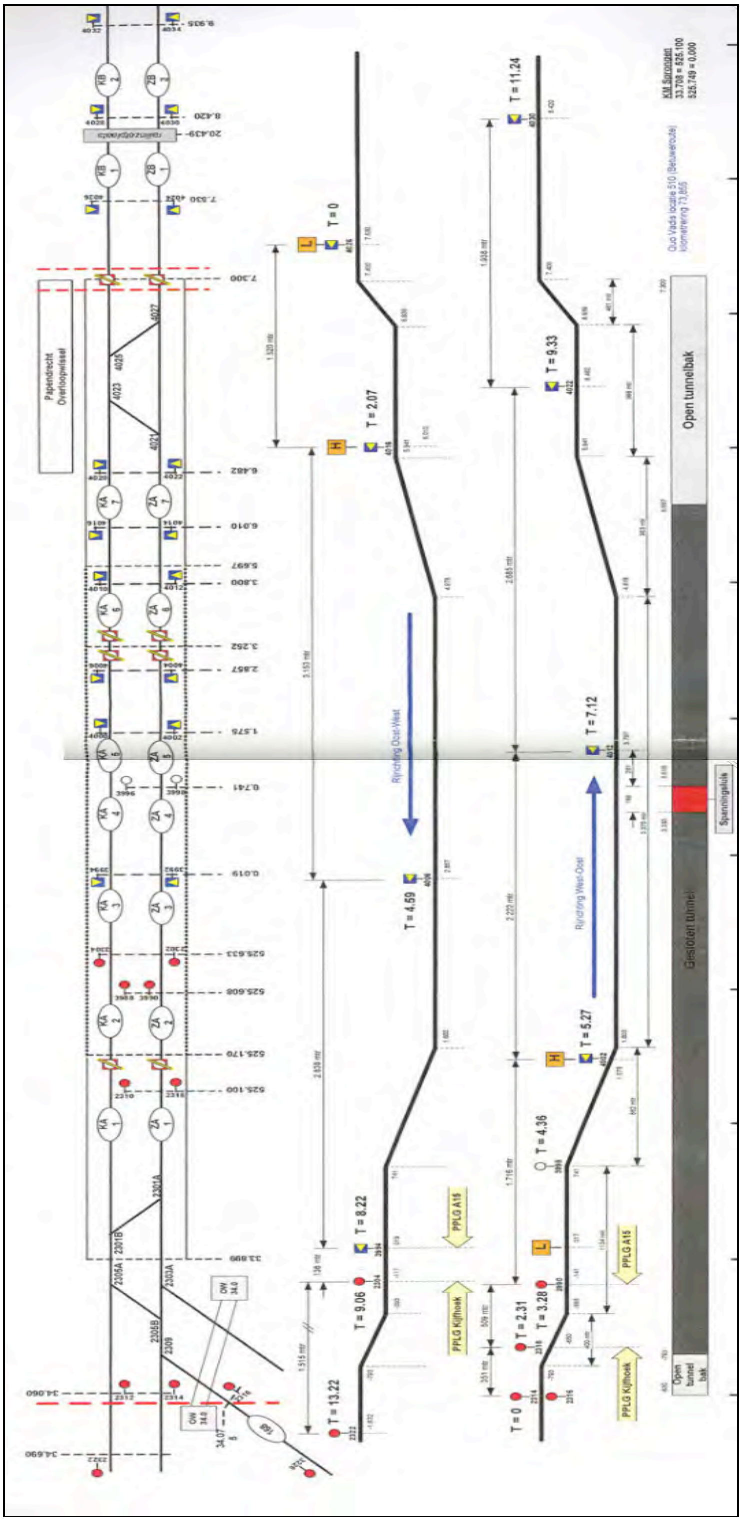
In case of the Sophiatunnel (Wolbers et al., 2006; Van Wilpe, 2008) the case is as follows:

- the tunnel is divided into block sections;
- these blocks are protected by ERTMS. SMB's show beginning and end of a section;
- the tunnel contains a VCO, where 1500 V DC and 25 kV AC sections come together;
- the tunnel has a 'stepped' slope;
- the entry of Kijfhoek is protected by a main signal and there are turnouts, which increase congestion risk for incoming trains.

In 2008, the safety agency IVW of the Ministry of Transport decided that only 1 train per direction would be allowed to be in the Sophiatunnel at the same moment in time because of the following reasons:

- risk of derailing of a train with less than optimal composition;
- likely teething problems of ERTMS;
- not yet available recovery scenarios for stranded trains.

Figure 21. Sophiatunnel track and signalling layout



Keyrail was forced to manage trains via integral train paths, so one train per path (= the full tunnel length). This *use restriction* meant that other trains had to wait outside the tunnel. Technically, 10 trains per hour per direction could be led through the tunnel. This number was also used in the requirements list of Keyrail (in Dutch: "Plan van Eisen") of its exploitation strategy for the Betuweroute. In practice, this number will only be realized with single locos and a functioning L-H signalling regime. The length of signalling blocks is such, that a lower number of trains of standard length per hour is realistic. In case of very heavy trains, like those transporting iron ore, this is even more valid.
After discussion, a plan to remove this capacity restriction was accepted by IVW (Van Herwaarden, 2009):

1) To change the signalling on the eastern side of the Sophiatunnel as follows: Disabling of L/H-signals. Connection between green light of signal 2318 with SMB 4012 showing 'out of stop'. This prevents braking on a downward slope. Capacity rises from 4 to 6 trains per hour per direction;
2) Recovery scenarios for stranded trains are developed by Keyrail after consultation with IVW.
   Next, the integral train path requirement could be abandoned.
3) Keyrail will prepare monthly reports for IVW in which the causes of stranded trains and solutions to tackle them are described. These reports will be evaluated together with IVW;
4) Keyrail will prepare monthly reports for IVW in which the causes of teething problems of ERTMS Level 1 and 2, and solutions to solve them are described. These reports will be evaluated together with IVW.

The following data was collected (Van den Berg, 2009):

- NID-train, loc type, EVC version;
- Train data (wagon master);
- NID_operational (train number included in train scheduling);
- Date/time of entry transition;
- Date/time of exit transition;
- Min, max, average speed.

Next to data collection, the following questions were addressed:

- Was ERTMS data entry correct (confirming information from wagon master): max train speed, train length, braking percentage?

- Where and when did transmission problems occur between train and RBC: at the ERTMS level or at the GSM-R level?
- Where and when did the train receive balise errors (linking inconsistency, no message, wrong message, default message (by balise/LEU))?
- Where and when did the train report other errors (such as EVC disturbances)?
- Where and when did emergency braking occur and what is their cause: SPAD, section time out, overspeed, train/infrastructure failure, input mistakes by train driver?
- Where and when did the train pass in another mode than FS?
- Where and when was the maximum speed in SR mode higher than the national value (default)?
- Which speed was achieved in tunnels, was there a speed reduction on downward slopes?
- Did any usage problem occur, ‘uneasy’ situations, messages?

A second adaptation of the signalling system involves a connection between signal 2318 and SMB 4002 to increase capacity. A decision about this adaptation is postponed to at least 2011, due to poor performance of RBC connectivity. That problem should be solved first before a decision about this second adaptation can be made.

Evaluation

If we look at the data about stranded trains, then at first glance, it seems that these are not a major problem. Van Zandvoort (2010) mentions a gradually reduced number of strandings, with about 0-1% of all trains facing this problem.

If we look into the logistic consequences, then one realises that even such a small number may create problems. A stranding may cause a block of a track section for 4-12 hours and if this happens 1-2 times per week, then the impact is more significant. If the number of trains increases, the number of failures is likely to increase as well.

3.5.7 Technical feasibility of long trains

Introduction

The length of a freight train is one of the factors influencing rail cost per tkm. Depending on the local situation, significant operating cost savings can be achieved by using longer trains (EU, 2008).

Long freight trains are uncommon in Europe, unlike the situation in the USA and Canada, where freight trains of 1000 meters or more are regularly scheduled. In Europe, technical constraints, in particular the length of signalling blocks, of tracks in stations and yards, and commercial/logistic requirements (lack of enough transport volume) prohibited the use of such trains in the past (see report DR 5.1 for a more general description). This is why train scheduling is designed around the standard 400-600 meters train length.

Scheduled tests

In 2008 several tests with longer trains have been carried out in Europe, including a test with such a train on the Betuweroute. On this line, trains up to 750 meters can be accommodated. The test was meant to reveal if 1000 meters was also feasible. This test was part of a study by DB Netz into the feasibility of 1500 meter trains.

Participants in the test were DB Netz, Keyrail, ProRail and DB Schenker.

On request from DB Netz, during the nights of November 29/30 DB Schenker train number 42790 and November 30/December 1, 2008, DB Schenker train number 42791, both with a length of 1050 meters and at most 2400 tons (excluding locomotive) ran between Oberhausen (Germany) and Kijfhoek (Maat, 2008).

Preparing the tests

Preparation involved train scheduling and RCC preparation.

a) Train scheduling meant (Van Driel, 2008 [28]):

- to schedule a no train period for the A15-trajectory for other trains during two complete nights (23:00-7:00 resp. 00:00-07:00). In order to reduce the risk for field staff accompanying the trains a WBI [29] was used issued;
- to block seven running tracks at Kijfhoek;

[28] Section 3.5.7 is based on Van Driel (2009) and the interview with Mr. van Driel.

[29] Instruction to secure a work location, ranging from limited access to a train free period (in Dutch: "Werkplek Beveiligings Instructie voor werkplekbeveiligingsklassen Buiten Dienststelling of Beheerste Toelating").

- to provide additional space by removing 4 other trains from the time schedule and by giving 2 other trains a slightly different path between Kijfhoek and Emmerich (Maat, 2008);
- to skip maintenance activities during the nights of 30/11-1/12 (00:00-8:00).

A train was composed of two wagons sets, which were merged to one test train before the test, resp. the test train was split into two parts after the test was finished (both at Kijfhoek).

Wagons with two axles were not allowed at all, while empty wagons were not allowed in the middle of the train [30]. In the middle of the train, one locomotive was located, making it easier to split the train, if necessary for whatever reason, before the end of the test.

b) RCC preparation

This involved the following:

1) For Oberhausen-Kijfhoek and Kijfhoek-Oberhausen:
   - the RCC officer responsible for the A15-trajectory put this line out of service after consultation with the local safety supervisor (in Dutch: "LWB" or "Leider Werkplek Beveiliging");
   - in case of a stand-still detection alarm, the RCC officer responsible for the A15-trajectory would contact the train driver in order to check if the train was still moving.

2) For Oberhausen-Kijfhoek:
   - the RCC officer at Kijfhoek blocked seven running tracks at Kijfhoek (sections IA, CB, CC, DC, DA and UA);
   - earlier than usual, the RCC officer responsible for the A15-trajectory (after communication with his colleague in Emmerich) set an integral train path between the Dutch/German border until section CC at Kijhoek.

3) For Kijfhoek-Oberhausen:

- the RCC officer responsible for the A15-trajectory is only allowed to set a train path for the 1050 meters train in the direction of Emmerich after permission from the RCC officer in Emmerich (in German: "Fahrdienstleiter Emmerich").

[30] Two-axle wagons usually carry less payload than four-axle wagons. Empty wagons are also lighter, which, especially in curves, may lead to derailment, because longitudinal forces are stronger than vertical forces, letting the lighter wagon behave like it negotiates a straight instead of a curved section.

VCO short circuit risk and mitigation measures

Before the tests were carried out, a number of risks were identified. A key issue were unwanted VCO connections.

A VCO (or Voltage Change Over, or in Dutch: "spanningssluis") is a section which separates two incompatible power supply systems from each other. The train can only be connected with one of the two systems at one moment in time. It enables a train to go from one power supply system to another. The train enters the VCO with power switched-off and pantographs down and then rolls through the section, after which the pantograph go up again and the engine can be restarted. The separations of catenary (voltage) and return loops (current) are made in order to prevent a connection between 1500 V DC and 25 kV AC power supply systems. If they would be connected, AC current could flow into DC tracks, compromising the train's detection system, while DC current into AC tracks could damage it's traction transformer.

The split in the catenary is very short, related with the small footprint of the pantograph. The separation in the track has a length of 750 meters, so well over normal train length (400-500 meters). VCO protection is designed around standard train lengths. With a longer train the DC-connection points (in Dutch: "DC-las") and the AC-connection points (in Dutch: "AC-las") will be connected. This will create a voltage drain, but this drain will decrease rapidly the further the locomotive is away from the DC-connection point. This means that the 250+ 'excess meters' should not have more than a marginal impact on the power supply systems.

To reduce this VCO issue, the following measures were taken:

1) a representative of the company responsible for the power supply systems monitored the train at the SMC. If necessary, additional protection measures could have been taken;
2) the test train ran during a long train free period. This reduced the load on the power supply system to a maximum of 250 Ampère at 25 kV AC;
3) traction voltage was reduced from 27.5 kV to 25 kV in order to reduce the impact of DC voltages on AC traction transformers;
4) train detection in tunnels is fixed at 750 meters, hence a longer train will trigger a warning. The procedure was to suppress or neutralize the warning. In case of a detected stand-still, the procedure was already mentioned above;
5) JADE current flows (in Dutch: "spoorstroomlopen") are not likely to cause train detection problems. After passage of a long train, RBC would act as if the section

was occupied, because RBC is set to 750 meters maximum. A specialist from Alstom could reset the system at RCC, if necessary;

6) since the train is longer than 750 meters, the OBU of the train might have asked for a new MA in order to proceed, which could then be given to a following train. This was impossible, because the test train was the only train on the whole A15-trajectory;
7) in case of technical problems, the test train might cause delays for other trains. This was also not possible, see 6);
8) the test might have been stopped earlier due to technical problems or a speed lower than the speed belonging to the train path, which might have interfered with the next scheduled train(s). This was mitigated by the 'in-the-middle' locomotive (a BR 189) which had a driver onboard, making it easier to split the train into two active sections, ready for removal (as regular trains) to Kijfhoek or Emmerich;
9) to mitigate the risk of a malfunctioning BR 189 locomotive on A15-trajectory, an additional BR 189 was available at Kijfhoek or Emmerich;
10) malfunctioning of ERTMS/RBC due to lack of connection or otherwise would have meant the end of a test. The train would then have been treated as a 'stranded' train, be split and removed, see 8), according to local legal procedures. In case of loss of connection with RBC, the second train had to wait until the first train left the A15-trajectory.

Results of the tests

During the test of November 29/30, 2008, the following observations were made:

1) Process operations:
    a) Scheduling. Train 42790 arrived with a delay of 5 minutes in Kijfhoek;
    b) RCC. No problems or messages about train detection;
    c) TTI. No warnings about stand-still. Train detection failed at Giessen Tunnel after the train left the tunnel;
    d) Infrastructure. The train arrived at section CC. There it was split and later on the two trains were sent to Rotterdam Waalhaven Zuid. Regular use of trains longer than 750 meters demands longer arrival and departure tracks in order to reduce the hindrance for other trains.
2) Train protection:

Alstom has monitored RBC communication with OBU and messages from track elements. There were no issues. Further analysis of loggings of the different systems was not seen as necessary.

3) TTI:

   - Train detection. It is necessary to adapt the software of train detection in tunnels. The existing detection systems either did not detect the train or failed. The automatic fire extinguishers rely on these detection systems. As a consequence, firefighting may start at the wrong location (or not at all);

   - Ventilation systems. The number of ventilation units is related with air resistance, which is co-determined by train resistance and train length. In case of longer trains, the ventilation systems need redesign and adaptation.

   During the demonstration, SMC staff was enlarged to compensate potential TTI problems.

4) Voltage change over:

   a) Until the VCO at Zevenaar no power supply issues have been recorded. At VCO Zevenaar, SMC SCADA system measured an excessive DC voltage in the traction transformer of substations Zevenaar and Tiel;

   b) During the trip it was decided that after passage of VCO Sophiatunnel, the train would raise its pantograph 300 meters after passing the VCO. Due to this no excessive DC voltages were detected. However, the DC monitoring system at substation Graafstroom was defect, so there was no measurement possible.

It was decided that the return trip (train 42791) was not a 1000 meters train. Train 42790 was split into two parts, which were moved to Zevenaar-Oost. At that point the two trains were combined to a 1000 meters train, ready to be tested on the German part of the test track.

Evaluation

The test with a long train was successful, showing the potential for longer trains, but also the technical constraints. In particular the length of VCO's, TTI, signalling blocks and parking tracks prevent the use of trains longer than the average 400-600 meters and maximum of 750 meters.

In order to use longer trains on a regular basis, adaptation of technical installations and infrastructure is necessary. This will increase investment cost. For new rail projects, provisions should be made to allow future use of longer trains.

3.5.8 Train scheduling in Q4 of 2009 [31]

Introduction

The fourth quarter of 2009 was a very important period for the Betuweroute. As discussed in section 3.3.9 (Figure 6), ATBEG was replaced by ERTMS on October 4, 2009, which means that from this date on only ERTMS equipped locomotives were allowed on the Port Line. Between October 4 and December 12, 2009, the 1500 V DC power supply was replaced by a new system supplying 25 kV AC. This also meant that the catenary had to be replaced. The Pernis-Maasvlakte section did not have electrical power supply before. Because of these activities, there was no electrical power supply, hence electrical locomotives could not be used on the Port Line in this period.

These changes meant a real challenge to all users of the Port Line, in particular because the conversion had been postponed several times. Many of them did not believe that it would finally happen and could be finished successfully.

Here we will focus on the special train planning (in Dutch: "Herplanning") for this period.

Complex planning

Due to the technical conversion of the Port Line, only diesel locomotives with certified ERTMS equipment could be used to haul trains in and out of the Port area in the fourth quarter of 2009. Electrical locomotives could only be used to generate additional power in a mixed diesel-electrical locomotive set, where the diesel locos had certified ERTMS equipment (and catenary was available).

Analysis learned that an intensive use of diesel locomotives would create several problems.

The first problem was that only a limited number of these special diesel locomotives was available. This was due to the late availability of fixed ERTMS specifications and the - as a consequence of the former - late availability of ERTMS locomotives. Next, such locomotives were not needed in large quantities after the conversion was finished. Series

[31] This section is based on the interview with Mr. P. Koolen and Koolen (2009).

189 electrical MSL with ERTMS became available in growing numbers, replacing diesel powered locos.

A second problem was the following. If electrical locomotives were used to haul freight trains on the A15-trajectory, then a change from diesel to electrical traction (or v.v.) was needed in order to enter or leave the Port Line. A change of locomotives takes time. Since it affects most if not all trains replanning is needed (in Dutch: "Herplanning") [32]. So-called 'planned stops' at Kijfhoek and IJsselmonde were included into the change leaflet (see report DR 5.1 for an explanation) for the fourth quarter of 2009.

A third problem was the additional demand for fueling at Kijfhoek. Non-ERTMS diesel locomotives used for ore/coal trains were no longer allowed on the Port Line. They could not refuel at Waalhaven or Maasvlakte (only allowed as non-functioning 'load', which is expensive), hence refueling had to take place at Kijfhoek. A railway fuel station was built at Kijfhoek to prevent additional movements of locomotives (in particular so-called 'triangulation', in Dutch: "driehoeken").

Initially, users demanded tracks at Pernis and Waalhaven to change locomotives. Because of a lack of space, Keyrail decided that they should use Kijfhoek and IJsselmonde. There, tracks had to be reserved for this process. At Kijfhoek these were available after a concentration of shunting traffic. As a result, locomotive logistics changed drastically (more kilometers per engine).

In the Directors meeting of March 26, 2009, this replannning process has been agreed. An agenda for the process has been made. Users could send their demands to Keyrail. Keyrail discussed the demands with the users. Keyrail analysed these demands and found solutions to fulfil these demands and solve the conflicts in discussion with the users. This included a procedure about how to manage parked locomotives (in Dutch: "overstand"). Keyrail had to develop a new, integral plan to deal with these challenges. This was operational from October 4, 2009. The process was complex and time consuming.

Evaluation

The change leaflet was functioning without significant problems. There was flexibility to carry out these changes. The reduction of traffic due to the economic downturn also helped in this respect.

[32] It would be called rescheduling (in Dutch: "Herverdeling') if only one or a few trains would be affected.

As a result of this replanning, the technical conversion did not reduce the capability of railway undertakings to fulfil the demands of their customers. After the conversion of the Port Line, railway undertakings were able to use electrical locomotives in most of the Port area. This means that they could use less locomotives, save on fuel cost, time to refuel and change locos. The environment also benefitted from the change from diesel to electrical traction. Especially the latest electrical locomotives (series 189) have a much higher traction power than diesel powered locomotives, allowing heavier and faster trains (important logistical benefits).

3.5.9 Removal of 1.5 kV and ATBEG sections

Introduction

With respect to traction supply and signalling, there are two conventional sections in the Betuweroute. There it crosses the main (mixed) railway network of the Netherlands. These sections are also known as change-overs or '1.5 kV and ATB isles' (in Dutch: "1500 V en ATB eilanden"). They are located in the western (Barendrecht Vork ←→ Kijfhoek-entrance of the Sophiatunnel) and eastern part (Zevenaar-Oost ←→ Emmerich) of the Betuweroute. These sections have the conventional 1500 V DC traction supply and ATBEG signalling systems instead of the 25 kV and ERTMS Level 2 systems of the A15-trajectory. This was a design choice, which is now in the process of being abandoned.

The corridor perspective

In January 2007 an agreement was reached between the ministers of transport of the Netherlands and Germany. It was formalized in a Letter of Intent, which mentioned the following (Steering Group, 2009):

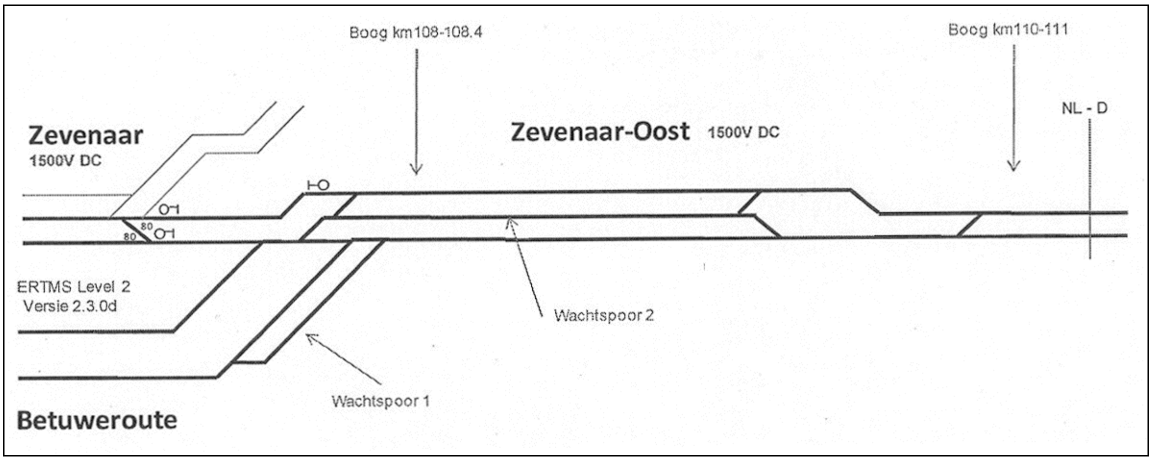
- A third track between the Netherlands and Germany in 2013 (Zevenaar-Oost ←→ Oberhausen);
- Introduction of ERTMS in the Netherlands and Germany in 2012;
- Extension of the German 15 kV AC traction supply system towards Zevenaar-Oost in 2009 (see Figure 22);
- A cost benefit analysis of replacement of Kijfhoek's 1500 V DC traction supply system by a 25 kV AC system.

ProRail is in the final phase of technical-economic studies, which investigate feasible technical options (variants) to remove the 'isles' and how much value for money they offer (also known as value engineering).

A. Zevenaar-Oost / German border existing traction supply systems

The existing situation is shown in Figure 22. The conventional mixed railway network is found in the top left part of the picture.

Figure 22. Existing situation Zevenaar-Oost / Dutch-German border



Note: Boog = curve, wachtspoor = waiting track

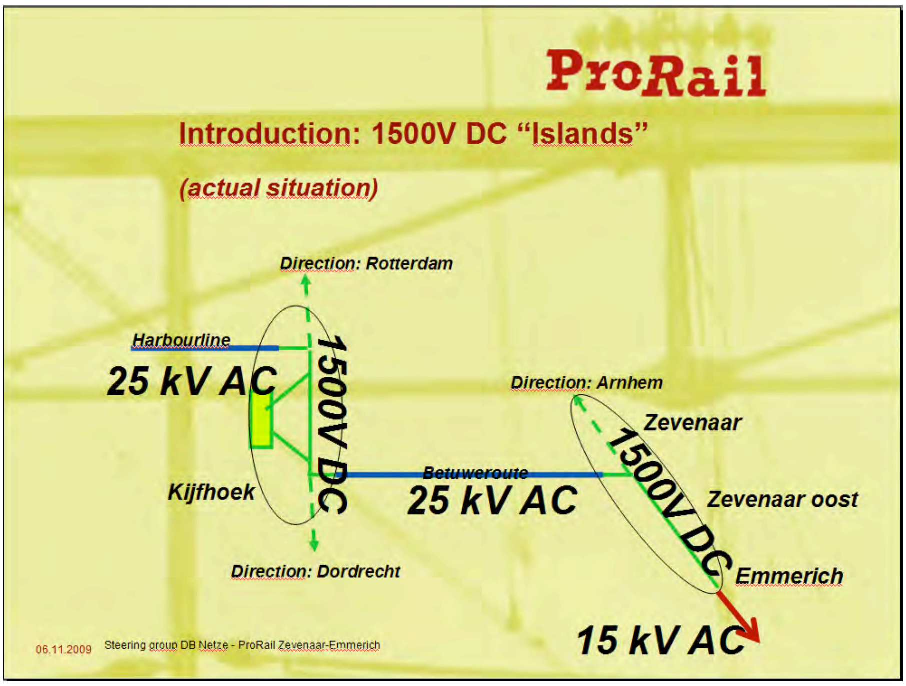
Source: ProRail, 2010.

Zevenaar is connected by domestic regional passenger services. International (bus-train) services are routed from Arnhem further south via Nijmegen/Venlo/Viersen/Duisburg etc. The only passenger services crossing the Dutch-German border are the ICE services connecting Amsterdam and Germany/Austria/Switzerland via Duisburg. These trains, known as ICE-3M, are four system trainsets (1500 V DC, 3 kV DC, 15 kV AC and 25 kV AC). They are equipped with all necessary conventional ATC systems. ETCS equipment will be installed in these train sets in future, as agreed between NS Hispeed and DB Fernverkehr. Then ERTMS is also installed inside the tracks.

The Betuweroute can be found in the bottom left part of Figure 22. It joins the conventional sections at Zevenaar-Oost. In Zevenaar-Oost there are 2 VCO's [33] (see the lower right part of Figure 23) and 2 changes of signalling system.

[33] VCO or voltage change over, for an explanation see section 3.5.7.4.

Figure 23. VCO's near Kijfhoek and Zevenaar



Source: Steering Group, 2009.

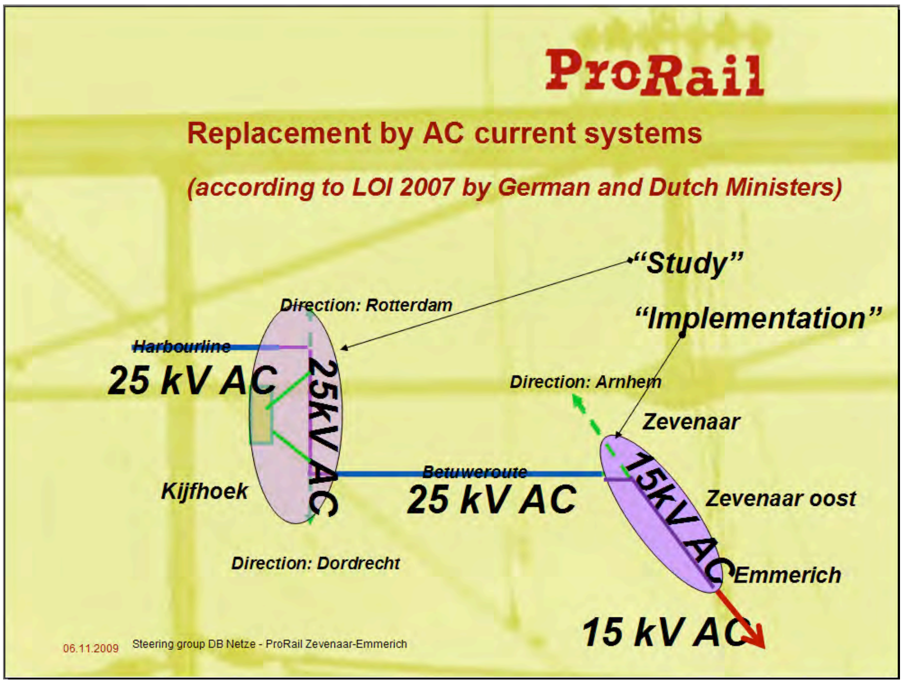
Seen from east to west, the number of running tracks changes from two to four. There are two 'waiting tracks' (in Dutch: "wachtsporen"). These are necessary, because freight trains coming from Germany have to cross passenger trains coming from Arnhem. Freight trains also need a space to park in case of overheated axles (after an alert from hot box detectors) and time for the removal procedure, without blocking the path of other trains (Van den Berg, 2010).

The picture is of course stylized, in reality there are several curved sections (a curve is "boog" in Dutch) and turnouts. Curved sections with a small radius and turnouts with a wide angle reduce permissible speed significantly, which goes along with a reduction of line capacity. Therefore the assessment, which we will be summarized here, dealt with the following issues:

- change of traction supply systems;
- change of signalling systems;
- future use of existing tracks in Zevenaar-Oost (including necessity of 'waiting track');
- where to build the third track (north or south side) and what to do with 'cross-traffic';
- replacement of specific turnouts;

- environmental impact and legal procedures in the Netherlands and Germany including differences.

Figure 24. Solution according to the LOI of 2007



Source: Steering Group, 2009.

Traction supply - alternatives options

Since 2007, this issue has been studied by ProRail and engineering consultant Movares. Later, railway undertakings NS Hispeed and infrastructure managers DB Netze and Keyrail became involved in the process.

In 2009, a list with nine alternatives was made, which were compared and valuated by these stakeholders in plenary sessions. The main outcomes were the following (Steering Group, 2009, p. 15):

- "extension of 15 kV into the Netherlands ('variant 3') scores dominantly low because of EMC problems and uncertainty over timely acceptance of new systems;
- extension of 25 kV until the Dutch-German border ('variant 2') scores low because of a new voltage island in the Arnhem-Emmerich section;
- as long as the Kijfhoek section will not be changed to AC, a change of the Zevenaar section has no advantage;

- advice to the Ministry of Transport of the Netherlands is in favour of 'variant 1+' (remaining 1500 Volt section in the Netherlands);
- this Ministry wants reactions on variant 1+ and variant 2."

This outcome was presented to NS Hispeed, DB Schenker NL and D, ACTS, Keyrail, DB Netze and the Bundesministry. The result was confusion (why deviate from the LoI of 2007?) and difference of opinion. Consultant Railistics prepared a positive business case for the elimination of both the Zevenaar and Kijfhoek 1500 Volt isles for the Ministry of Transport in the Netherlands.

Conditions to be met

Any solution should fulfil the following criteria (Steering Group, 2009, p. 16):

- "reliable and safe systems;
- minimise EMC influence on Dutch systems for train detection and ATB, acceptable for Dutch and Germany authorities;
- feasible, affordable within budgetary limitations".

Necessary agreements

According to the Steering Group (2009, p. 17), the following should be agreed on:

- "Feasibility of 15 kV alternative, or mitigation of negative aspects in 25 kV alternative
- Agree on investment costs
- Common planning for VCO, ERTMS, 3rd track on Zevenaar-Emmerich
- Financial agreement on investments on both sides of the border, including extra block signal, faster switch-over at Emmerich, S-curve, and interface to new interlocking/ESTW in the Netherlands."

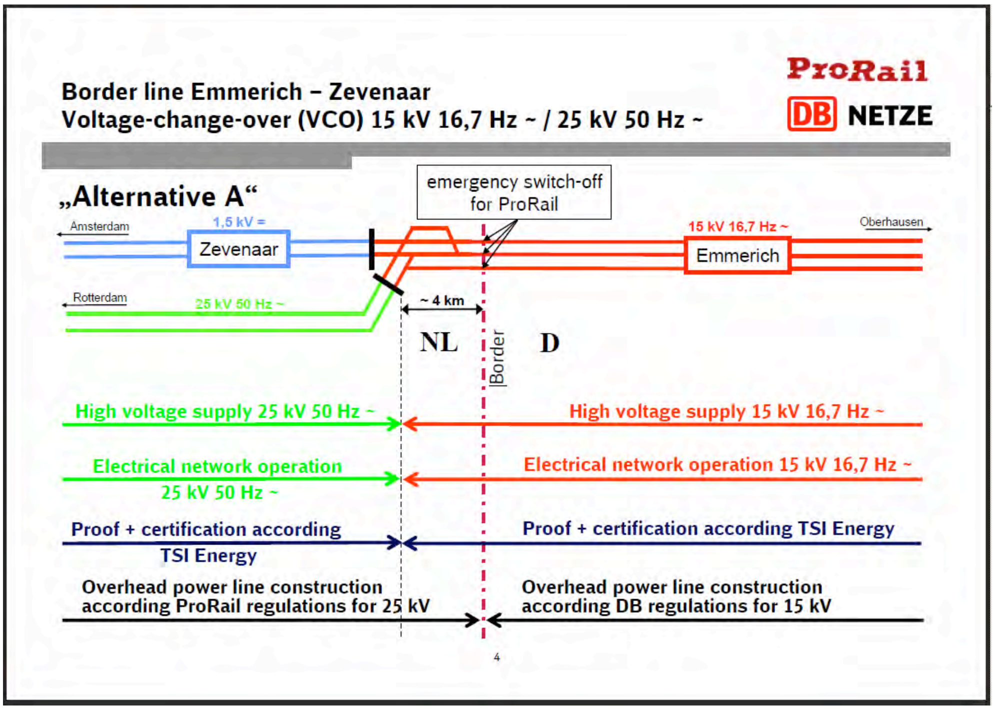
Joint feasibility study

The large number of variants was reduced to three, which were further analysed by means of a joint feasibility study in 2010 (ProRail, DB Netz AG, DB Energie GmbH Bilateral working group, 2010): alternative A, B short and B long. We will discuss these alternatives.

Alternative A

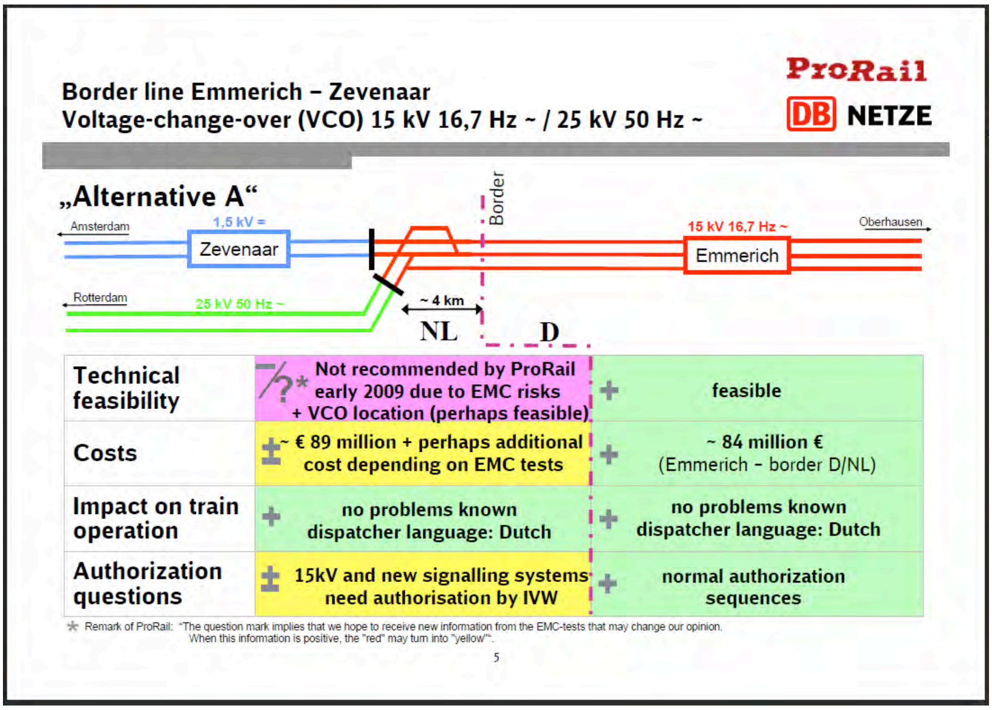
In this alternative, the 1500 V DC isle is removed by extending the German 15 kV AC network into the Netherlands (Figure 25).

Figure 25. Alternative A, voltage change



This alternative introduces a new traction supply system in the Netherlands. There are some technical uncertainties, because the pros and cons of 15 kV AC have never been investigated by the Netherlands (EMC, location and isolation of VCO's, see Figure 26).

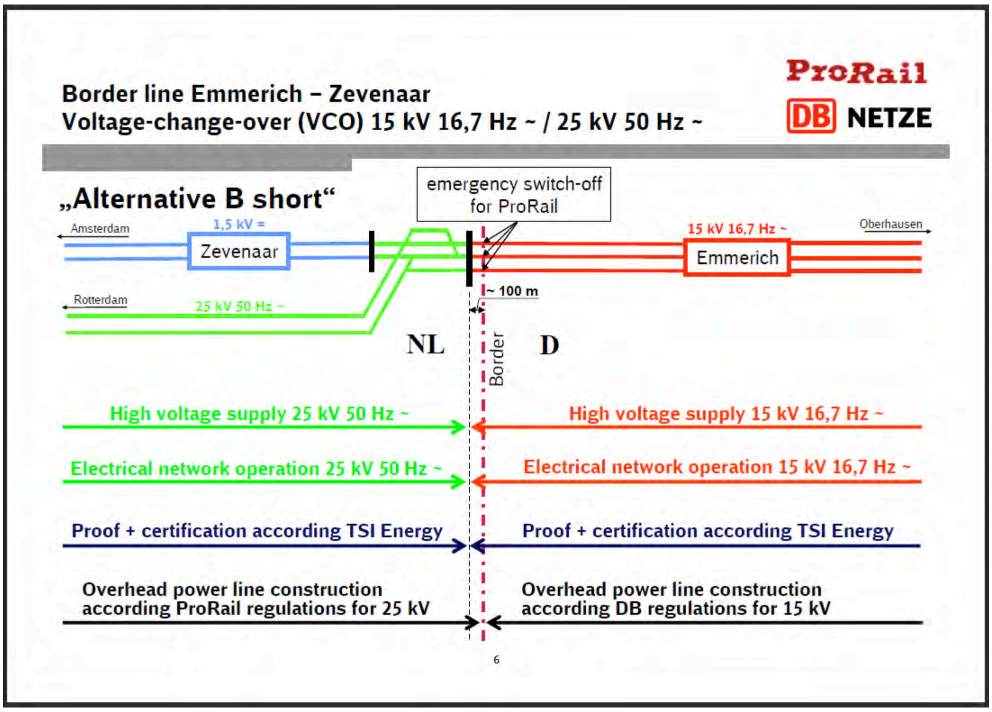
Figure 26. Assessment of alternative A



Alternative B short

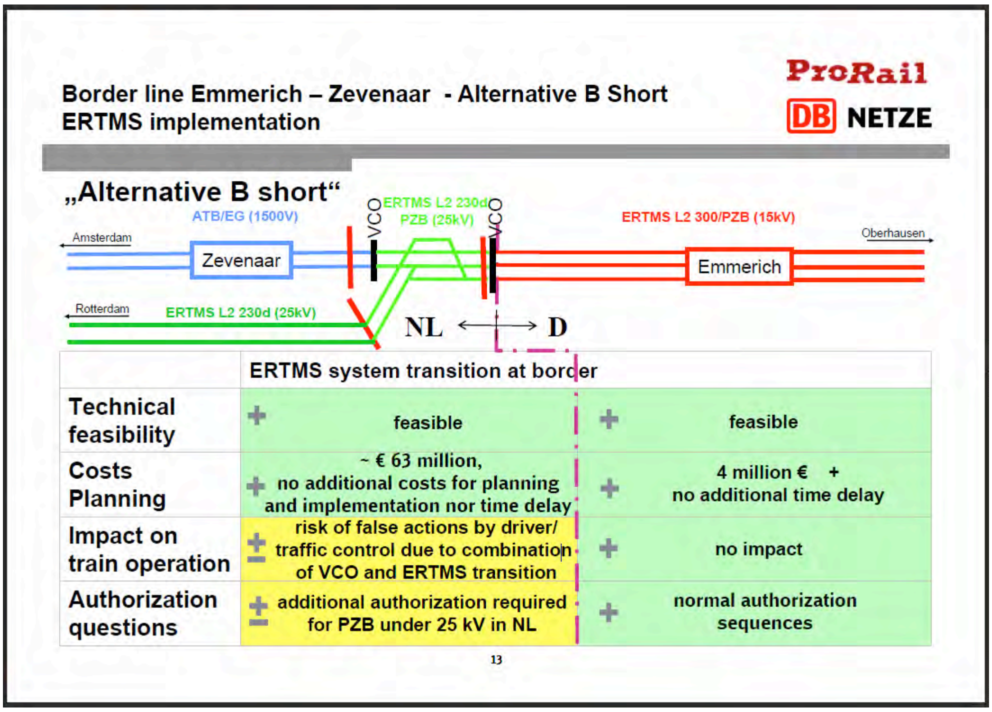
In this alternative, the 1500 V DC isle is removed by extending the 25 kV AC network until the Dutch-German border (see Figure 27).

Figure 27. Alternative B short



As a consequence, ICE trains have to pass an additional VCO over a short distance. By combining voltage and signallng transition sections a train driver has to monitor two systems closely and becomes confused. Experience shows that a freight train driver concentrates on the signalling system and forgets to change the voltage (Figure 28). An ICE passenger train driver may not only pass the VCO with power switched off (free flow), but can also make a mistake regarding which voltage system to adapt to later on. ICE trains detect such driver failures however, so there is no real technical risk (short circuit), but a potential logistic issue (delay).

Figure 28. Assessment of alternative B short



<u>Alternative B long</u>

The 1500 V DC isle is removed by extending the 25 kV traction supply over the Dutch-German border over a distance of 5 kms (see Figure 29).

Figure 29. Alternative B long

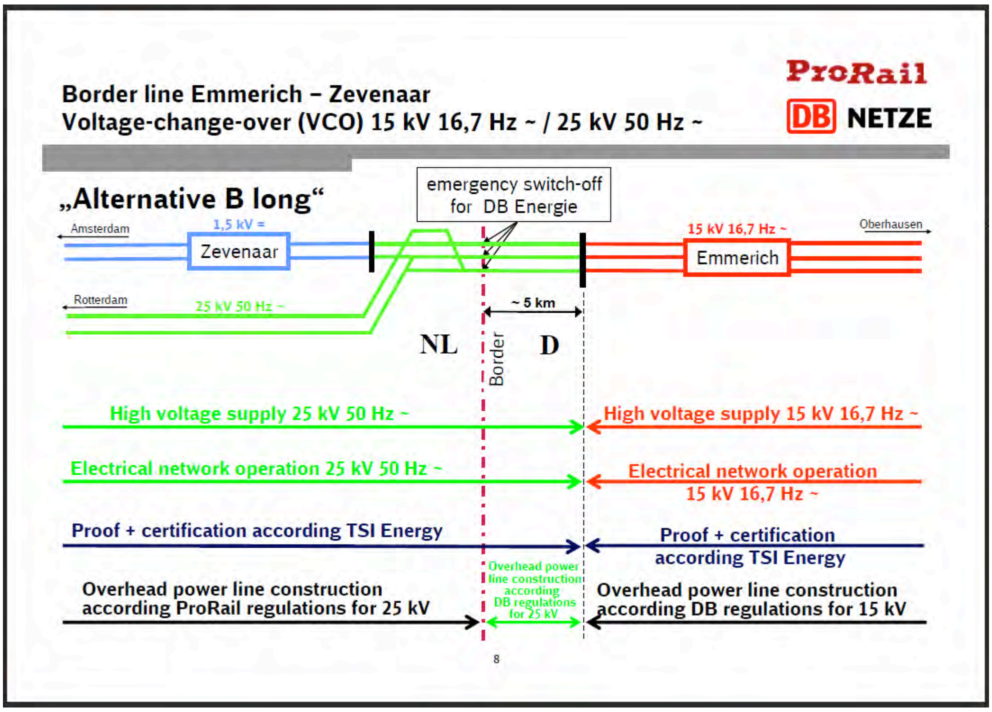
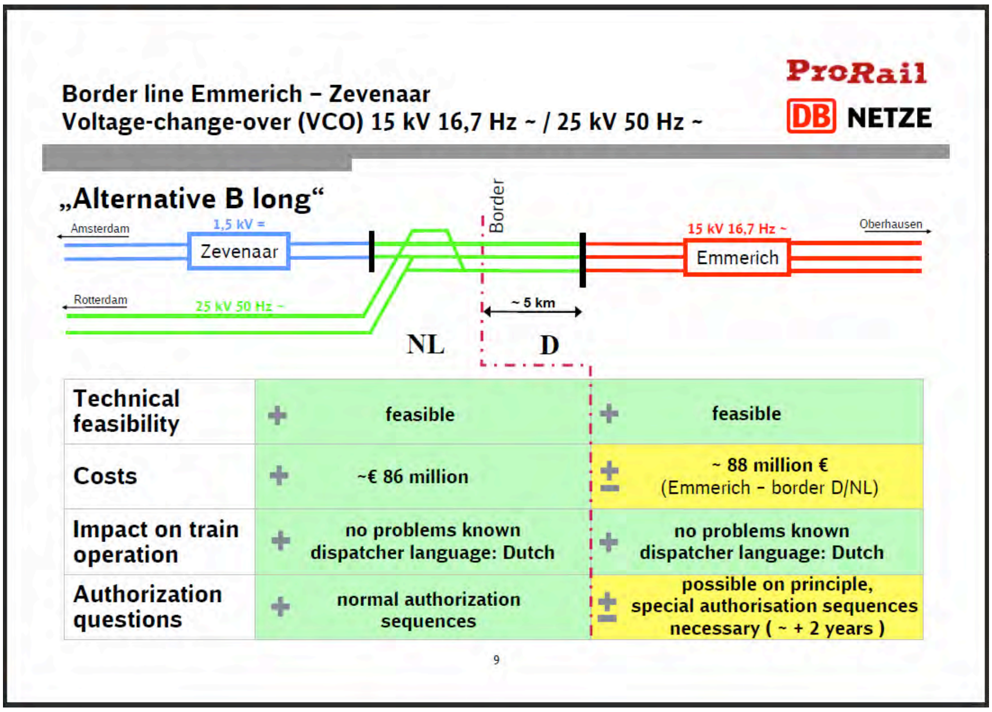


Figure 30. Assessment of alternative B long



The final comparison of these three alternatives is presented in Figure 31.

Figure 31. Comparison of traction supply variants

Border line Emmerich – Zevenaar
Voltage-change-over (VCO) – Comparison of variants

ProRail
DB NETZE

Alternative / Aspect	„A“		„B short“		„B long“	
	NL	D	NL	D	NL	D
Technical Feasibility	−/?	+	+	+	+	+
Costs Planning	±	+	+	+	+	±
Impact on operations	+	+	±	+	+	+
Authorization	±	+	+	+	+	±

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It follows that alternative A scores least, while alternatives B short and B long seem to offer a better perspective. Alternative B short scores a bit lower in terms of operations, while alternative B long scores a bit less on costs, planning and authorization. None of these issues is regarded as a real problem, however.

B. Zevenaar-Emmerich signalling system – existing situation

The 1500 V DC system is now connected with the ATBEG system. As explained in report DR 5.1, 25 kV and ATBEG are not compatible. As a consequence, ERTMS stops before Zevenaar-Oost. Across the border, PZB (also known as Indusi, an Intermittent train protection system) is installed. This is the standard solution for lines where the maximum speed stays below 160 km/h (in some cases its successor LZB (offering continuous train protection), is installed on these lines in order to increase capacity). PZB and LZB are cab signalling systems, like ERTMS.

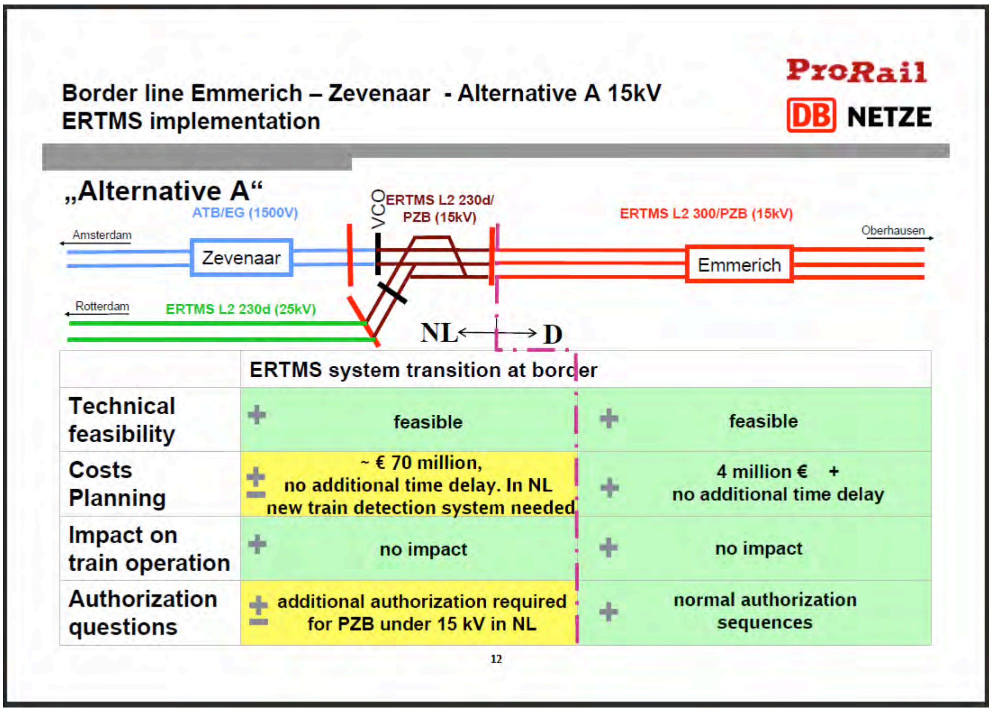
Signalling system/ERTMS alternatives

In this case, there are four alternatives: Alternatives A, B short, B long with system interface near the national border and B long with system interface near the VCO.

Alternative A

In this case, the Dutch ERTMS Level 2 baseline 2.3.0 d is extended from the Betuweroute until the Dutch-German border and the German PZB system is extended over the border to include Zevenaar-Oost. Both ICE and freight trains have to pass a section where ERTMS is installed as an overlay on PZB. In Germany, ERTMS Level 2 baseline 3.0.0 [34] will be installed as an overlay on PZB. There is an ERTMS system transition at the national border (see Figure 32).

Figure 32. Alternative A and assessment



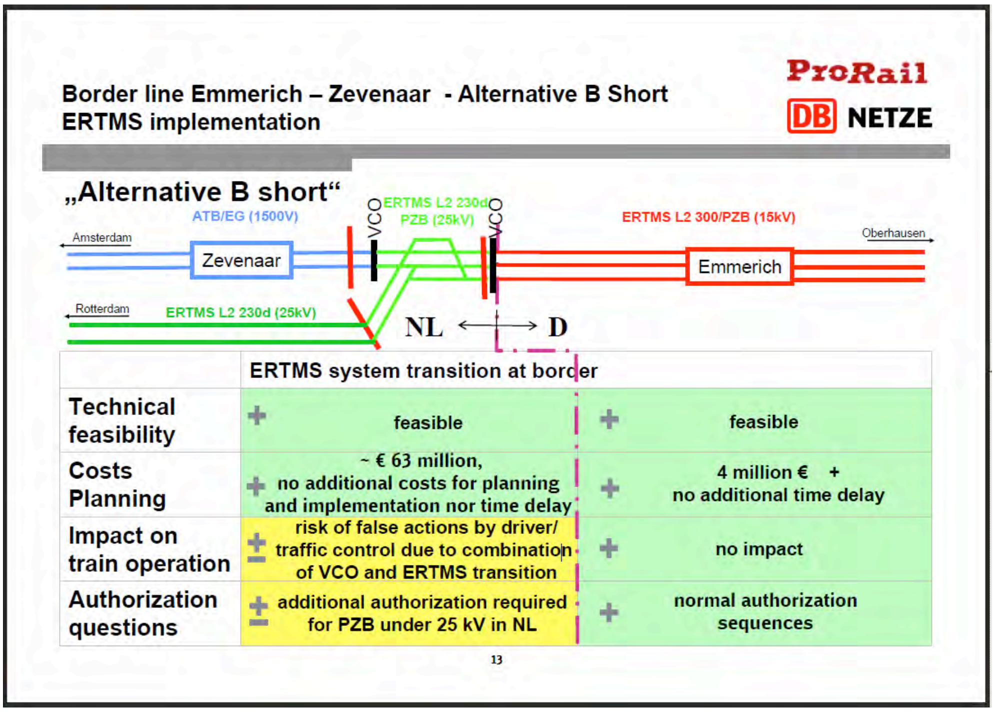
In Alternative A 15 kV and PZB are installed on Dutch territory, which demands an official authorization. Technical problems are not expected. Planning is also not affected.

[34] Baseline 3.0.0 is still work in progress.

<u>Alternative B short</u>

Here the 25 kV AC system from the Betuweroute is extended until the Dutch-German border. ERTMS Level 2 baseline 2.3.0 d is installed as overlay on PZB (see Figure 33).

Figure 33. Alternative B short and assessment



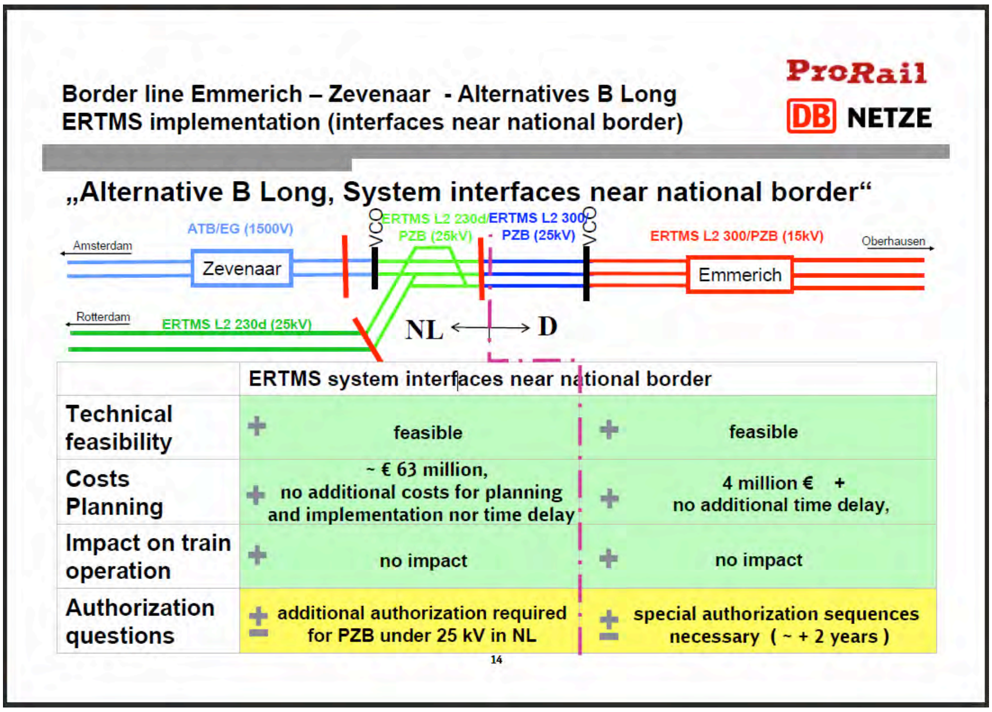
ERTMS will be installed in the ICE trains (agreed between NS Hispeed and DB Fernverkehr), so PZB could be removed, but a decision was made to keep PZB as fall-back option in case of ERTMS failures and for locomotives without ERTMS (Van den Berg, 2010).

From the assessment of this alternative it follows that there is the risk of false actions by driver/RCC. There is also an authorization issue with PZB and 25 kV. There are no technical or cost issues.

<u>Alternative B long with system interfaces near national border</u>

Compared to the B short case, an additional 25 kV section is installed inside Germany until the next VCO and then the 15 kV section starts. The ERTMS system interface is located at the Dutch-German border. This alternative requires special authorizations, but no additional issues are likely to emerge (see Figure 34).

Figure 34. Alternative B long with ERTMS interface near border and assessment



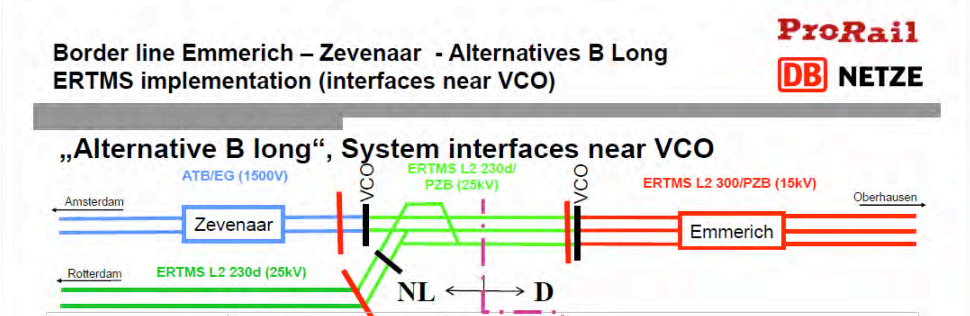
	ERTMS system interfaces near national border	
Technical feasibility	+ feasible	+ feasible
Costs Planning	+ ~ € 63 million, no additional costs for planning and implementation nor time delay	+ 4 million € + no additional time delay,
Impact on train operation	+ no impact	+ no impact
Authorization questions	± additional authorization required for PZB under 25 kV in NL	± special authorization sequences necessary (~ + 2 years)

<u>Alternative B long with system interfaces near VCO</u>

In this alternative, 25 kV is extended into Germany. As a consequence, the VCO is also shifted into Germany. The ERTMS system interface is located at the Dutch-German border. The ERTMS system interface is located near the VCO.

This alternative is quite complex and received a lot of remarks amongst others because the system interface is not located at the physical border (see Figure 35).

Figure 35. Alternative B long with ERTMS interface near VCO and assessment



	ERTMS system interfaces near VCO	
Technical feasibility	+ feasible	+ feasible
Costs Planning	± ~ € 63 million, major consequences for planning + implementation, time delay > 2015	– ~ 10 million € + repayment ~ 1 million € time delay > 2015
Impact on train operation	± risk of false actions by driver/ traffic control due to combination of VCO and ERTMS transition	± risk of false actions by driver/ traffic control due to combination of VCO and ERTMS transition
Authorization questions	± additional authorization required for PZB under 25 kV in NL state treaty necessary	– special authorization of Dutch CCS system by EBA, state treaty necessary

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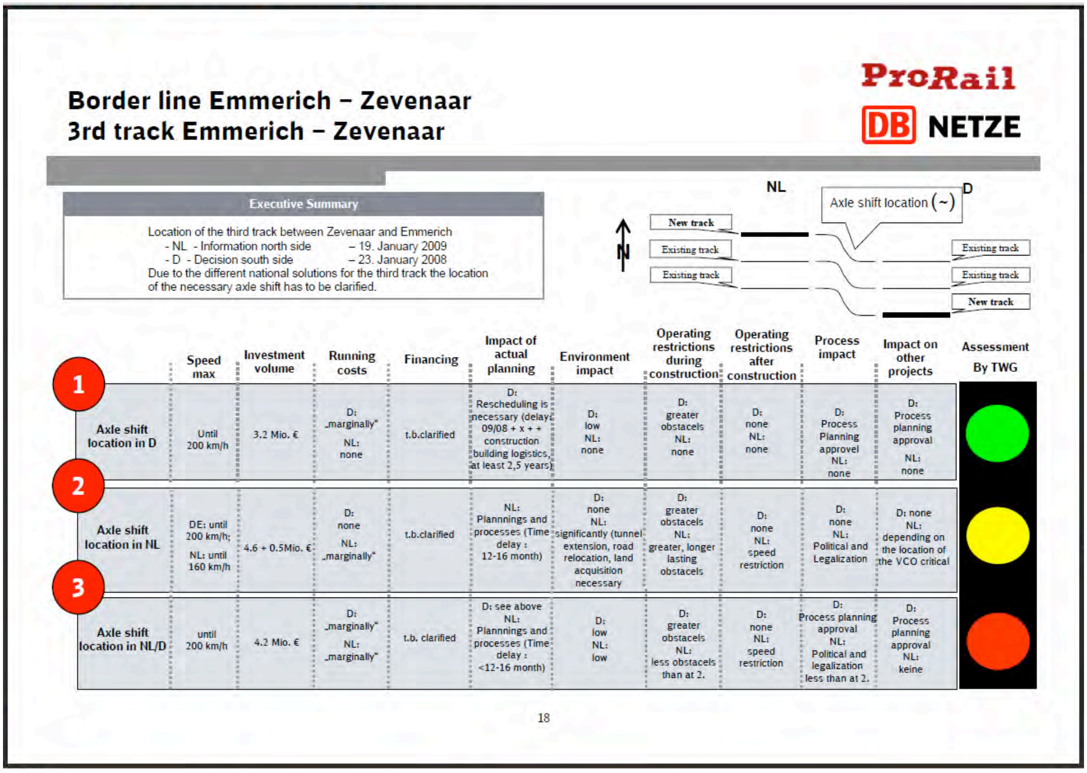
C. Zevenaar-Emmerich third track - axle shift

Although the third track issue is not part of the workpackage description, it is an integral part of the solutions and very important for the Netherlands and Keyrail. This explains why we will elaborate this point as well. Initially the idea was to keep the waiting track at Zevenaar-Oost. Building an additional running track would imply building an additional fourth track, which was too expensive and not acceptable for the city of Zevenaar. It created a conflict with its spatial planning objectives for the area; it is developing a living area nearby. The fourth track was then abandoned from the discussion. If necessary, trains can wait on one of the running tracks or in Germany (Van den Berg, 2010).

If three tracks are connected to 2x2 tracks (or vice versa) and there is bi-directional traffic, it is logical that tracks will have several functions. The situation becomes more complicated, because the Netherlands and Germany are likely to choose a different location for the third running track, because of spatial and environmental/liveability requirements. The Dutch will most likely build this third track on the north side of the existing tracks, while Germany is likely to choose the south side. This means that trains cannot stay on the same track, but have to change (‘shift’) from one track to another at a certain location. This point is called the axle shift location (see the right upper corner of Figure 36).

Figure 36. Axle shift issue and assessment



Analysis showed that the axle shift location does not impact the alternatives A and B long.

We can now present the final assessment by this Bilateral Working Group (Figure 37). The alternatives received the following comments from the users of this railway section (see Figure 38).

Figure 37. Conclusion with all alternatives

Border line Emmerich – Zevenaar
Conclusion

ProRail
DB NETZE

Alternative	A				B short ~ in D				B short ~ in NL				B short ~ in NL / D				B long ERTMS interfaces near border				B long ERTMS interfaces near VCO			
	VCO		ERTMS		VCO		ERTMS		VCO		ERTMS		VCO		ERTMS		VCO		ERTMS		VCO		ERTMS	
Aspects	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D	NL	D
Technical Feasibility	?																							
Costs Planning																								
Impact on operation																								
Authorization																								
Total valuation	NL ?		D		NL		D		NL		D		NL		D		NL		D		NL		D	

Remark: Location of axle shift has no impact on alternatives „A“ and „B long“ !

= +
= +/-
= -

21

Figure 38.Opinions and suggestions from railway undertakings

Border line Emmerich – Zevenaar
Opinions and suggestions

ProRail
DB NETZE

Alternative / RU	A	B short	B long
NS Hispeed	Preferred alternative for NS Hispeed	NS Hispeed rejects 2 VCO's; only acceptable with 'green wave' (cannot be guaranteed)	Not acceptable; NS Hispeed rejects 2 VCO's
Dutch Freight RU's	Ok for Freight RU's	Ok for Freight RU's	Ok for Freight RU's
DB Fernverkehr	Preferred alternative	Not acceptable because of 2 current system changes in short distance	2 current system changes should be avoided
German Freight RU's	Ok for Freight RU's	Ok for Freight RU's	Ok for Freight RU's

= +
= +/-
= -

23

Alternative A is acceptable for all involved, with B long second and B short the least preferred option. The negative remarks by the passenger operators could be expected given the previous explanation.

The Bilateral Working Group itself can be regarded as a process innovation. Technical and operational solutions are now discussed in an integral between the Netherlands and Germany. In Germany, such an integration usually does not take place.

Position of Keyrail [35]

Keyrail's aim is to separate the signalling and traction supply borders. Traction supply is a legal issue (related with liability). Signalling is a national issue. Consequently, the national border should be the ERTMS system border and the traction supply border can be a few kilometers into Germany, between the border and Emmerich. For Keyrail, "Alternative B long with ERTMS interface near border" is the preferred solution.

In the present discussion a technical working group has to evaluate logistic variants. The group makes a cost calculation, without sufficient understanding of the logistic consequences of specific choices. This is where things go wrong.
Another factor is that the technical discussion is based on a Requirements Specification (in Dutch: "Programma van Eisen") from 2005, which is not relevant for the present situation anymore.

Decision-making and planning [36]

On January 14, 2010, the Netherlands and Germany have agreed to choose Alternative B long: 5 km with 25 kV on German territory, ERTMS Level 2 + PZB, third track, north extension in the Netherlands, south extension in Germany, axle shift via an S-curve in Germany and waiting tracks. The total investment will amount Euro 156.2 mln., Euro 149 mln. will be paid by the Netherlands, the remainder by Germany.

Since the total budget for Zevenaar and Kijfhoek was originally only Euro 155 mln., the Dutch Ministry of Transport demanded an assessment of the projected costs. A value engineering approach was chosen, in which the functional requirements of the project were analysed in terms of costs (including indirect costs) and value. The same was done

[35] This section is based on the interview with Mr. van Dort (September 2010).
[36] Van den Berg, 2010.

with alternative solutions. A result of this analysis was a reduction of projected project costs towards Euro 118 mln. This result was then sent to ProRail in order to prepare the next steps.
With respect to planning, the project plan has to pass the Dutch and German planning process, which make it reasonable to expect that the project is finished by the end of 2015.

D. Kijfhoek-Barendrecht case [37]

Introduction
The reasoning behind this project was that locomotives without 1500 V DC and ATBEG should be able to enter the Rotterdam Port Line. This project is part of the same international political agreement as the one concerning Zevenaar. Both projects are linked, because it does not make sense to remove one barrier, while the other one stays in place.
The case of Kijfhoek is much more complex than the case of Zevenaar. Kijfhoek has a large marshalling yard, but marshalling has become less important over time in favour of direct trains. Next to that, the plan for the new Maasvlakte II includes a large railway yard, which in fact replicates the one at Kijfhoek (partially). Kijfhoek is used as a buffer, where trains are (temporarily) parked before they are sent to the terminals in the Rotterdam Port area. Kijfhoek can also be used to wait for an international pathway to the European hinterland. These developments have led to a discussion about the future of Kijfhoek.

Decision-making and studies into alternatives
In case of the Port Line, decisions regarding ERTMS and 25 kV AC were regarded as joint decisions. In case of Kijfhoek, this approach has been abandoned: ERTMS will be installed and 25 kV later. In the meantime further research will be carried out (Van den Berg, 2010).

With respect to conversion from ATBEG to ERTMS, the experience gained during the conversion of the Port Line allows the conclusion, that this is a straightforward exercise,

[37] This section is mainly based on Projectgroep Opheffen Eilanden (2009).

which will have foreseeable operational consequences. Locomotives with ATBEG will no longer be able to enter Kijfhoek. This implies a change of locomotives.

ERTMS

In phase 2A of the project, five main variants and 4 subvariants have been studied. Decision criteria were: technology, functionality, realisation, management and maintenance, cost of building and investment, risks and planning.

The Ministry of Transport has decided in favour of the minimum 'variant 0-- (min/min)', which says that ERTMS Level 1 will be installed on the two eastern running tracks, as an overlay on ATBEG, and ERTMS SH on all tracks of Kijfhoek, again as an overlay on ATBEG.

The reasons for choosing 'variant 0--' are the following:

- locomotives with ATBEG only can still reach their destination without the need for additional equipment or detours;
- locomotives with ERTMS only can use the running tracks from the Sophiatunnel onwards into the Port. If they are guided towards Kijfhoek, they automatically change to Level 1 SH mode (train drivers don't have to make an additional stop to change from FS to SH mode). But if they go from the yard to the FS tracks, they have to stop in order to do a 'Start of Mission', which takes time and capacity.

In case of the other variants, ERTMS would be installed on several process tracks etc. This would also have increased the investment costs. Since we are dealing with a temporary situation – valid until all locomotives with 1500 DC and ATBEG have been replaced by locomotives with 25 kV and ERTMS, a temporary and cost-efficient solution is the best option. Variant 0 scored best and was therefore chosen as the preferred alternative.

With this choice the project entered a new phase (called 2B). The scope of the project has been extended with an additional ERTMS Level 1 section on the three connecting track sections in order to fully eliminate the 'isle' instead of decreasing the 'isle'. For the project Kijfhoek-Barendrecht the installation of ERTMS has an estimated cost of Euro 19.2 mln. (Van den Berg, 2010). According to the latest planning, Kijfhoek-Barendrecht and Zevenaar-border should be ready at the same moment – by the end of 2013.

Some minor issues have to be solved. One is that the existing traffic management system VL and the planning system of Keyrail do not register whether a specific locomotive only has ERTMS or also ATBEG. This may lead to the situation that a locomotive is given a path which leads it into ATBEG tracks. Such disturbance of train scheduling reduces capacity. Adaptation of both systems is then a logical requirement. The second issue is the cost of converting the tracks. In case of the foreseen two times single track conversion, the cost is higher than in case of two tracks at once conversion. The higher costs should be compensated.

25 kV AC

A full conversion is regarded as the optimal solution by the railway undertakings and Keyrail. It is an expensive option, because it will cost Euro 250-350 mln, which is way beyond the amount budgeted for the two 'voltage isles'.

To see whether it is possible to invest less, but still fulfil the technical and logistical requirements, various alternatives are being studied, ranging from full to partial conversion. Partial conversion would imply a change of the turnouts, as part of Kijfhoek would be separated from the rest of the rail network. Cost savings are possible by a partial conversion.

Technically, partial conversion seems nearly impossible. Additional VCO's are necessary, but they can't be built at the necessary locations. Demands regarding EMC are very high. Interlocking, detection and transitions present complex issues. Converting two tracks inside the Barendrecht tunnel and keeping one 1500 Volt DC track in parallel is very difficult and probably unacceptable for fire fighters etc. Converting only one arrival/departure bundle at Kijfhoek in relation with the A15-trajectory is not acceptable for railway undertakings. They don't want an additional stop to change locomotives, instead of direct trains.

The latest idea is to study in-between variants, according to which the running tracks will receive 25 kV in a cost-effective way and in relation to ERTMS. ProRail is responsible for the infrastructure-technical studies and Keyrail for a study into the international logistic consequences of the way 25 kV will be installed.

The logistic study is partially related with a logistic study carried out by the Ministry of Transport with respect to the developments in the Rotterdam Port area. This study, the Integral Exploration Port Area (in Dutch: "Integrale Verkenning Havengebied") is an analysis of how to optimise logistic processes of Traffic Management VL, Keyrail, terminal operators and railway undertakings in the Port Area. As a result, waiting times and buffer capacity should be reduced.

If the results of the value engineering session are realised, then there is enough budget to convert Kijfhoek to ERTMS, but for 25 kV there is no budget left.

Overall evaluation

In case of Zevenaar, decision-making is now reaching its final stage. If a final agreement is signed, it is not likely that the realisation of the Dutch part will face obstacles, but the German part is dependent on planning procedures, which also include community participation. There is also budgettary uncertainty. This makes synchronization of the Dutch and German projects a challenging issue.

In case of Kijfhoek, a partial conversion might satisfy politicians, but the railway undertakings and Keyrail would not be satisfied. With respect to ERTMS decision-making is nearly finished, but 25 kV is a very challenging issue.

As mentioned earlier, the projects at Zevenaar and Kijfhoek are related, so both bottlenecks have to be removed before the benefits of conversion can be reached.

3.6 Safety and Environment

3.6.1 Introduction

In section 3.6 the following three demonstration activities are described:

- Tunnel Technical Installations (TTI) - in section 3.6.2;
- Hand Held Terminal (HHT) - in section 3.6.3;
- Safety at Kijfhoek - in section 3.6.4.

3.6.2 Tunnel Technical Installations (TTI) [38]

Introduction

There are six (semi-) tunnels in the A15-trajectory [39]. In the original specification of the Betuweroute less tunnels were included. As the decision making process unfolded more

[38] This section includes information from the interviews with Mr. Runge, Mr. de Mol and Mr. van Dort.

tunnels were added in order to reduce the impact of the railway line on the environment and liveability. This enabled acceptance by the province of Gelderland, whose rural landscape would become intersected. Due to the tunnels, the cost of the infrastructure rose considerably (see report DR 5.1).

Following a series of very serious tunnel fires, which showed that firefighting in tunnels is very difficult and dangerous, safety regulations for tunnels became much stricter throughout Europe. As a result, existing tunnels were renovated and design of new tunnels had to fulfill the new requirements.

In each tunnel some forty-two Tunnel Technical Installations (TTI) were installed. TTI are used to manage accidents, to maintain tunnel integrity and reduce the impact of accidents on the environment.

The installation of TTI increased complexity of tunnel design, which already had to incorporate the new ERTMS technology. Optimisation occurred not on a system level, but at the level of individual systems. This led to many individual decisions, which from a systems perspective were suboptimal. An example is the installation of a VCO inside a deep tunnel, like the Sophiatunnel. The logistic consequences of such individual optimisations were not properly investigated beforehand.

Complex decision making [40]

The decision to install TTI instead of the conventional stand alone systems in tunnels was a late one. It was a change of the scope of the project. TTI were new to designers and engineers – the technology did not exist. This made tunnel redesign necessary during the building phase. TTI were built-in after the main tunnel hardware was already in place. So, TTI were not a result of integral engineering. TTI became one of the factors delaying finalization of the infrastructure.

To understand why this complex technology was developed and installed in this way, it is necessary to look deeper into public decision making and how it influenced engineering.

Local politicians in the Netherlands, in particular mayors, determine to a large extent what happens within their municipality. They can to some extent block or slow-down (implementation of) decisions made by higher governments. In this case, mayors used the approval of building applications to force The Hague to the limit of what was

[39] The Pannerdenschspoortunnel, the Sophiaspoortunnel, the Botlekspoortunnel, the tunnels at Zevenaar and Giessen, and the semi-tunnel at Barendrecht.
[40] Van Klink et al., 2010.

technologically feasible. Local politicians are responsible for local consequences ('no impact'), while decision makers in The Hague (Ministry of Transport) use the typical probabilistic (or practice-based) approach of engineers regarding safety ('minimal impact'). What also happened was that local governments and agencies like water managers copied the requirements of other public bodies, regardless whether the local situation required them. This led to a long list of requirements for TTI and as a consequence additional subsystems.

There was no open and transparent communication between these two government layers. In order to prevent further delays, the Ministry in The Hague accepted local demands. Neither the commissioner, nor the tunnel designer/builder had the political will or technical knowledge to withstand these local demands. The Project Bureau Betuweroute (PoBR) also stopped with communications halfway the project, instead of counteracting local fears and discussing the consequences of too stringent safety requirements for the design.

The discussions with local decision makers and the high load of permits to be acquired were a real burden in the design and building period.

Changed scope of firefighting

The scope of fire firefighting was also changed. The initial scope was to maintain tunnel integrity by cooling the tunnel walls. This required installation of conventional fire retarding panels. Sprinklers were regarded as optional fire extinguishing instruments. Later in the process, the scope was extended towards full-fledged firefighting.

Since firefighting was regarded as too complex (and dangerous) for conventional firefighting with humans operating inside the tunnels, firefighters should manage fires from the outside, relying on automatic systems. In buildings sprinklers fulfil this role. Reasoning that tunnels were similar to buildings and ships, the design and installation of sprinklers would be straightforward and costs would be reasonable, decision makers made sprinklers mandatory in the so-called Green Booklet with general safety requirements for the Betuweroute.

There the complications started, because the technical feasibility and costs of sprinkler installations for (railway) tunnels had not been proven elsewhere. The developers soon discovered that these assumptions were incorrect.

Next to that, the future user of the tunnels was not in the loop of decision making.

We may conclude that the decision to make sprinklers mandatory and primary firefighting systems was a high-risk decision.

Design and installation [41]

The contract with the supplier of TTI equipment was awarded to the lowest bidder, a mandatory practice given EU regulations. The change of scope introduced an 'unknown' technology to the scene, which was an argument for the 'cheap' supplier to claim more money. Changing the contract would lead to more delays and legal consequences. Hence, a decision was made by NS-RIB/ProRail to negotiate with this supplier. This increased the equipment costs [42] significantly. The development risk of TTI was in this way shifted from the supplier to the commissioner [43].

It is difficult to interpret a failure warning, because the man machine interface (MMI) was developed without previous experience. MMI design was a response to incidents, not to other (more common) situations.

The many layers in TTI make management and in particular changes of the system complex.

Design of fire extinguishing installations

Again wrong assumptions were made:

1) 'The way to extinguish fires in buildings and ships is also valid for freight trains'. This is not correct. First, freight trains may consist of wagons transporting chemically re-active substances. Sprinklers use water, but in case of chemical fires, use of water may worsen the situation, including the risk of explosions. In case of chemical fires, (expanding) foam is a much better fire extinguisher than water. A compromise was found by using a mix of water and chemical additives. After use, a chemical residue remains that cannot be released into the normal sewage system (or canals). In case of fires due to small pools of flammable material in the track bed also chemical waste remains. These toxic substances have to be treated in a more stringent way. As a consequence special basins (in Dutch: "vloeistofopvangkelders") were needed below the tunnels. Second, physical parameters of tunnels are different from those found in buildings and vehicles. Hence, firefighting demands a different approach;
2) 'The same fire protection system can be used in all five tunnels'. In practice, each tunnel needed a special design. The way to operate TTI is also different for each tunnel.

[41] Van Klink et al., 2010.
[42] The project budget was increased by 104 million Euros in the second half of 2003.
[43] The same happened with the high-speed line Amsterdam-Antwerp (see Stoop et al., 2007).

The tunnels were designed for electrical locos, even though at that time, mainly diesel locomotives were used to pull freight trains. Although multi-system electrical locos are replacing diesel locos, they are still used on the Betuweroute.
Diesel engines emit hot gases, which can be detected by gas and temperature detectors. In this way a fire alarm can be triggered, after which the train can be put to a halt and recovery procedures are initiated. To prevent this, RCC staff has to increase ventilator speed. Due to the use of diesel locos, maintenance frequency had to be increased as well.

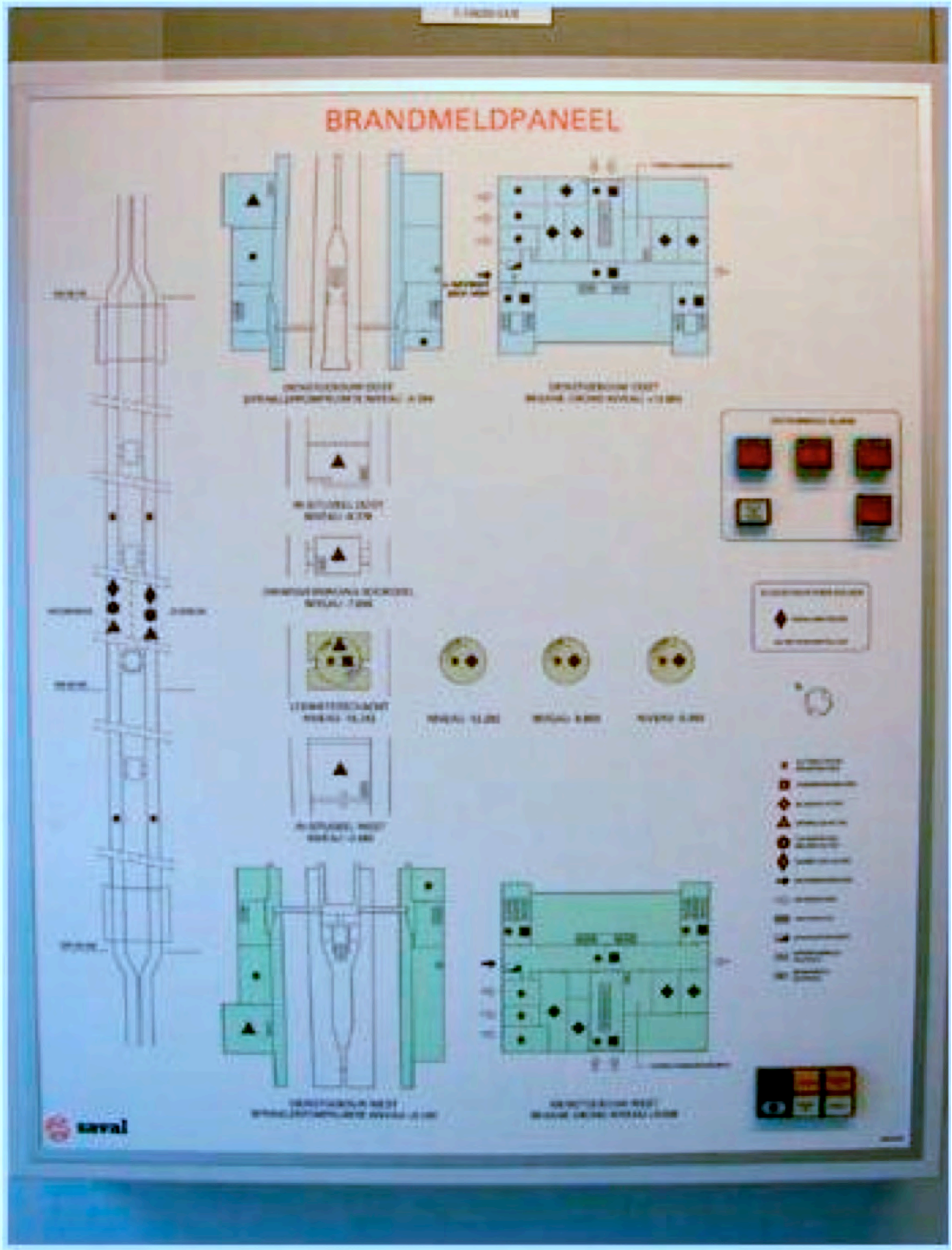
The actual technical design increasingly deviated from the initial design.
In 2001, aware of complexity and increased cost, Ministry of Transport dpt. DGG made an attempt to reverse the decision to use sprinklers and replace them by a large ventilation system. This attempt failed, because sprinklers were mentioned in the building permits, while the mayors were not convinced that ventilators provided at least the same level of protection as sprinklers. The mayors argued that the Ministry would be treated as a normal firm with respect to the building permits, in other words, there is nothing to negotiate as long as the effectiveness of ventilation systems is not proven to be at least as good as that of sprinklers (which still had to be proven).

TTI functionality

TTI consists of the following subsystems (NIFV/Nibra, 2010):

- fire alarm and debarking (in the tunnel buildings and the tunnels);
- firefighting by means of gas;
- LEL (lower explosion limit) detection (gas);
- temperature measurement (with string detector);
- train stand-still detection. This is the key detector to trigger the other processes;
- cameras;
- axial ventilation systems (in Dutch: "langsventilatie");
- overpressure ventilation systems;
- multi-section sprinkler installations and foam generators (using 3% AFFF);
- hydrants (water pumps and dividers);
- exit indicators (for staff);
- installations to remove liquids;
- back-up power supply (generator).

Figure 39. A fire notification panel at Pannerdensch Kanaal tunnel



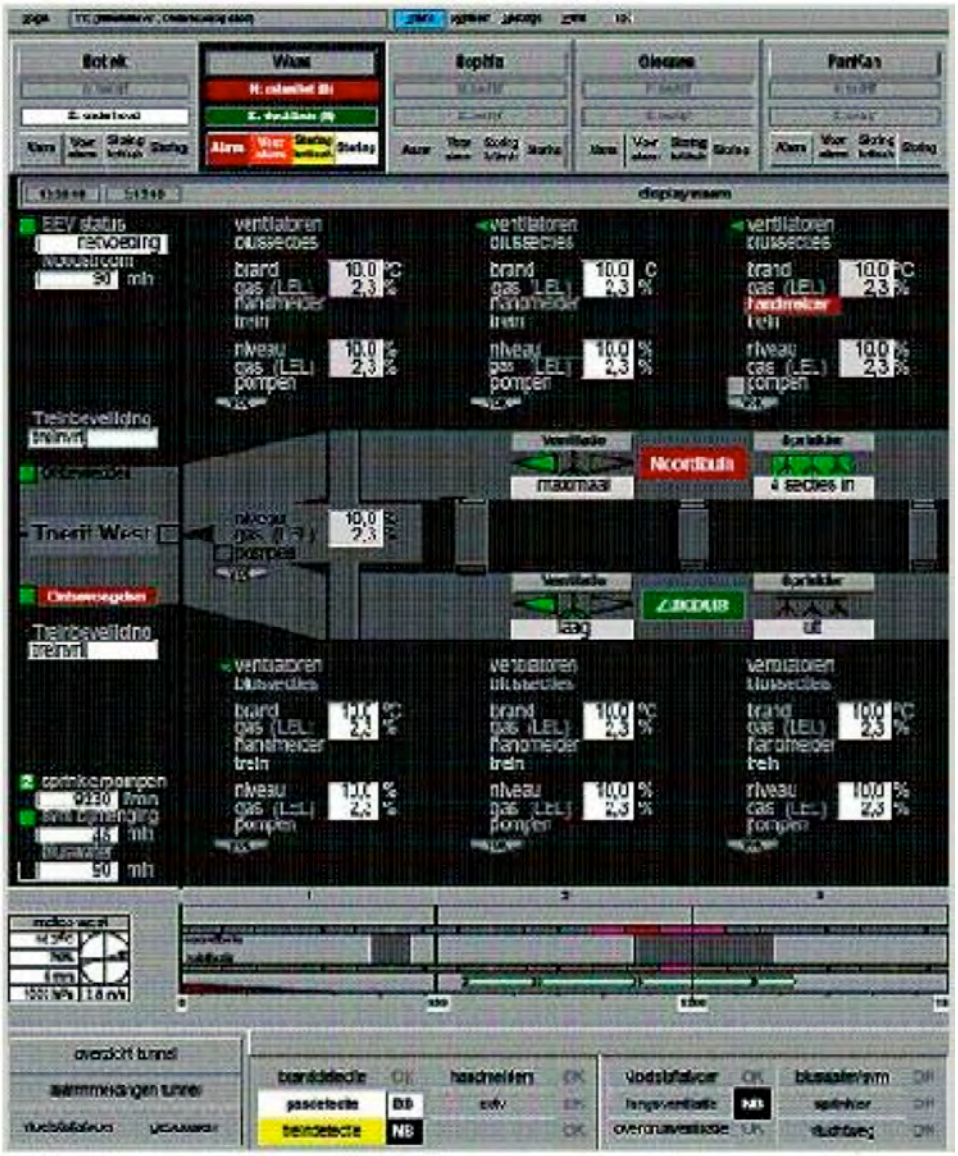
Source: NIFV/Nibra, 2010.

TTI modules are linked via a computer network. A data link connects a tunnel to a server and operators at SMC Rotterdam (Kijfhoek).

TTI functionality is based on detection-reaction cycles (to be explained below), which were developed by means of scenario analysis of accidents with freight trains.

The status of a TTI and the detection-reaction cycles can be monitored (see Figure 40) and managed by an operator in the tunnel command centre (TCR). This information is also available at SMC (Rotterdam) and at ProRail RCC.

Figure 40. Example of TTI screen at TCR, SMC and RCC



Source: NIFV/Nibra, 2010.

An alarm is automatically sent to the central emergency room (in Dutch: "Gemeenschappelijke meldkamer" or "GMK") of the firefighting agency in Gelderland-Zuid. A special procedure starts, which involves ProRail, Keyrail, local and regional firefighting agencies and local municipalities.

Examples of detection-reaction cycles are the following:

1) Firefighting

A detection device (a so-called 'thermo string') monitors temperature. In case of an accident, temperature may rise to an unacceptable level. If the train stand-still detection is also activated, then sprinklers and axial ventilators are switched on in the detection zone. Both systems are meant to reduce the temperature of the tunnels walls, wagon load, the air and the water sprayed by the sprinklers. To control the water level in a tunnel (caused by the sprinklers), fluid pumps are activated (NIFV/Nibra, 2010).

2) Water inflow protection

Two tunnels, the Sophiatunnel and the Pannerdenschspoortunnel are located below rivers. They intersect the natural water barrier (dykes). In case of water flowing into the tunnel, the polder land on both sides may become inundated. To prevent this, special water barriers [44] are installed.

In case of flooding in one tube of a tunnel, the purpose is to clear both tubes as soon as possible using the following strategy (Van Wilpe, p. 225):

- trains that can be stopped before entering a tunnel. RCC will first check whether the train driver can stop the train before the tunnel (in order to prevent 'lock-up' of a train). Next, RCC will reduce the MA until the next SMB and recall the train path (procedural measure). The latter is a measure to prevent that a train will receive a MA after the alarm is cleared;
- trains inside a tube, and trains that cannot be stopped before entering a tube. They will be guided through the tunnel by setting a connecting train path and by issuing a MA.

[44] The Sophiaspoortunnel (a) and the tunnel below the Pannerdensch Kanaal (b) have adjustable water barriers, which can be closed in certain alarm situations. It takes 12 (a) resp. 7 (b) minutes before an automatic closure process is started. This period can be used to remove the train or to allow the train driver time to escape via a special exit procedure. There is a local emergency button that can be used to bypass this automatic process.

After clearing one tube, the water barrier will close automatically, powered by large hydraulic systems. Next, this procedure is carried out for the second tube. Signals will be set to the 'stop' position and the automatic path procedure (in Dutch: "Automatische Rijweg Instelling" or "ARI") will not be able to use planning rules. Relevant train drivers will be informed by RCC via GSM-R about the situation. After the situation is stable again, RCC will reset the systems to the normal situation.

Local operation is possible. For instance, the fire brigade can change the functioning of TTI if necessary to support their work.

TTI Testing and validation
Since the TTI did not function as an integrated system, testing and validation could not be carried out for a complete system, instead subsystems were tested in a kind of ad hoc way. A partial RAMS validation was carried out by means of a theoretical calculation.

In case of the sprinklers, their water supply system was 'made to work'. When testing, the standards for firefighting in buildings have been applied, because there are no standards for railway tunnels.

Remaining issues
After installation, TTI did not fulfil the expectations of Keyrail. Analysis of the situation by the TTI Taskforce (May 2009), Horvat & Partners (June/July 2009) and Keyrail (Korlaar, 2010) concluded that there were too many system failures and too many out-of-service periods. As a consequence, maintenance was very labour intensive and maintenance costs were higher than expected.
TTI are infrastructure elements and as such governed by asset management. Given these issues, it can be argued that asset management was inadequate (Korlaar, 2010).
Next to dealing with the causes of the failures, professional maintenance was necessary to provide sufficient availability of the tunnels: Keyrail is able to fulfil the demands by shippers, keeping in mind a proper balance between costs and benefits.

In case of the Betuweroute, RAMS [45] requirements were developed via an academic exercise. No overall RAMS exists, only RAMS for subsystems are available. Subsystems fulfil RA in a reasonable way, but not M, while S is not fail safe.

[45] RAMS = Reliability, availability, maintainability and safety (EN 50126).

It is difficult to make a prediction about the impact of operator failures.
RAMS requirements had to be modified. In particular, the number of disturbances (in Dutch: "Treindienst Aantastende Onregelmatigheid" or "TAO") should be reduced from 60 to 20/year (-66%) and the number of out-of-service periods (in Dutch: "Trein Vrije Periode" or "TVP") should be reduced from 375 to 300/year (-20%). Maintenance costs should be reduced by at least 1.3 mln Euros/year. TTI should fulfil legal requirements.

To achieve these goals, a plan consisting of two phases was prepared.
In phase 1 (quick wins and study into additional improvements) the following results should be achieved: less disturbances, a higher availability and better process management. A budget of 4.8 mln. Euros would be necessary for this phase. This investment should help to
- improve understanding of system specifications;
- develop new RAMS specifications;
- make an additional adaptation of TTI;
- develop a proposal of how to involve governments (how to discuss safety systems).

In phase 2 (additional improvements and changes) the following results are aimed at: lower maintenance costs, less disturbances and increased availability. In this phase, TTI should be finally transferred to Keyrail. Strategic management should become possible.

The aim is to reduce the number of maintenance companies. One main constructor, Asset Rail, will become responsible for TTI. Due to its wider scope, Asset Rail can organise a group of maintenance workers, which is multidisciplinary and it can also plan their activities better, which helps to reduce the out-of-service periods.
With the transfer of the Betuweroute from ProRail to Keyrail, Keyrail became the prime initiator of the process of improving the TTI.

A list of measures was made to improve the functioning of specific TTI systems. It included a time-planning and cost overview (Korlaar, 2010). Due to the additional investments, the yearly investment costs should be reduced from 6.8 mln. Euros in 2009 to 5.0 mln Euros in 2015.

Evaluation

Decisionmaking regarding the Betuweroute was rather problematic. Public decision makers had little knowledge about the requirements TTI had to fulfil.

Changes to TTI were made during the realisation phase, and earlier decisions were changed. A small change of the scope of the project led to a complete technical redesign. This was the result of fear by decision makers, amplified by the media and not sufficiently balanced by information from technical experts.

The user of TTI was not in the loop of decision making, while he should have had the best knowledge about the actual requirements TTI had to fulfil. The builders did not have enough knowledge about these requirements, nor had the commissioner (the Ministry of Transport). The developers had problems to communicate their story to the locals. Planning was top-down, which did not help either.

TTI have to fulfill relatively simple functions. While these systems are functionally dependent, there was no overall system design, allowing them to work together (not even a system providing all information). TTI subsystems were developed as stand alone applications and then 'knitted together', not connected by a common interface. This makes operating TTI complex.

Instead of going for the best technical solution(s), somebody should have asked: is what we have achieved sufficient at the planned date (mid 2007)?

In future, design of comparable installations should include user requirements.

Like in many other cases, maintenance of systems is a problem after the system is finished. With respect to firefighting, also some lessons can be learned. The fire brigade received a basic instruction. Despite regular drills, fire fighters do not see the systems too often. Hence, in case of a real incident with a lot of time pressure and stress, fire fighters need support from SMC to operate the TTI.

Finally, TTI systems contribute to safe running of trains, but they can never lead to a stranding of a train.

Outlook

A taskforce was set up consisting of ProRail, Keyrail and the Ministry of Transport. It will focus on the question which functionality is now needed from the perspective of the primary process, which is running trains. The taskforce will prepare a proposal saying which systems are needed in that case.

3.6.3 Hand Held Terminal (HHT) [46]

Introduction

Railways are the safest means of transport. Railway safety involves all activities in and around the track, including maintenance. During maintenance activities "the track must always be in a safe condition for approaching trains and the safety of the track maintenance crew must be ensured." (Esveld, 2001, p. 349) Detailed procedures exist to protect maintenance workers (see ProRail, 2007).

At the operational level, responsibility for safety is *shared* between RCC staff, maintenance crew and train drivers.

To protect a working zone, rerouting or rescheduling of trains is common practice. RCC will lock the respective working zones, while approaching trains are prevented from entering a working zone by so-called 'border measures' (in Dutch: "grensmaatregelen"), i.e. local safety measures and supervision by local safety staff. This should create a safety net around maintenance workers. RCC systems are fail safe, but RCC operators can by mistake set a train path (signals and turnouts) into a working zone. Working zone protection can also fail if the local safety measures are not carried out in the prescribed way or if a train driver makes a mistake (e.g., overlooking a signal). As a consequence, maintenance workers may get injured or killed or a train may derail etc. [47]

The number of maintenance workers killed or injured is very low, but every accident is regarded as one too many. In the past decade, safety requirements have therefor been increased by the Ministry of Transport. On running lines, working within the clearance gauge or next to sections where trains can pass has become much more restricted (by running at reduced speed, safety distances/shielding) or even no longer allowed. In the latter case, also parallel tracks will be out of service during maintenance involving only one track. This reduces line capacity. At the same time, demand for line capacity increases, due to growing traffic volumes. This puts more pressure on the time available for maintenance.

[46] This section includes information from the interviews with Mr. Rook and Mr. Runge.

[47] Accidents can happen also after the work is done, in particular if maintenance staff doesn't follow the procedures (completely), for instance if equipment or people stay in the zone (too long).

The HHT

The increased safety requirements and the implementation of ERTMS and 25 kV have led to the decision by ProRail, Alstom, Strukton and Intraffic to develop a tool which makes it much safer and easier for local maintenance staff to take *exclusive* instead of shared responsibility for their local working zone.

In 2008 this tool, the Hand Held Terminal, a remote control unit, was introduced. It is an integral part of the ERTMS safety system. Both ERTMS and 25 kV made it necessary to develop a new safety regime for the Betuweroute instead of the regime used on the conventional railway tracks in the Netherlands.

The HHT has three main functions:

- to protect the working area of maintenance workers;
- to enable local control working zones including signals and turnouts ('engineering possession');
- to provide information about the status of a working zone, turnout or user.

The HHT allows six main commands:

- transfer/acceptance of the ownership of a working zone;
- give/take of a working zone;
- lock/unlock of a working zone;
- change position of a turnout;
- lock/unlock of a turnout;
- show status of working zone, switch from local control to RCC or from one local controller to another.

We cannot describe the full functionality of the HHT in this document, but will give a short example instead.

Before maintenance work starts, a running zone has to be changed into a working zone. On the A15-trajectory [48] a combination of conventional practice and the HHT is used.

The procedure starts with a request from RCC (in Dutch: "Treindienstleider" or "Tdl") to the Process Leading system. RCC and the local safety officer (in Dutch: "Leider Werkplek Beveiliging" or "LWB") contact each other by phone and make and sign a special contract document describing the work to be carried out, the conditions etc. (in Dutch: "werkcontract" or "WECO"). Maintenance workers receive instruction via the conventional

[48] The HHT is not used on the Port Line.

documents called WBI (in Dutch: "werkplek beveiligings instructie") before the work starts.
Now the working zone has been defined, it will be marked by entry and exit marker boards showing the number of the working zone. Tdl releases control of the working zone to the LWB. LWB uses the HHT to take over the working zone. This changes the status of the working zone and triggers automatic 'border measures'. Access control and control of turnouts and signals is now exclusively in the hands of local safety officers (LWB, or in case of several sections, there can be one or more LLV's (in Dutch: "Leider Lokale Veiligheid") certified to use the HHT. LWB or LLV becomes 'owner' of the working zone via the Handheld Terminal (HHT). This step is comparable to the use of conventional short circuit tool (in Dutch: "kortsluitlans"), which is not allowed on the A15-trajectory (see report DT 5.1). The sections are mechanically and electronically disconnected (turnouts are set to divert traffic and ERTMS is used to control the braking curve of incoming trains; SPAD is impossible).
In a working zone, one or several locks can be set by the LLV('s) responsible for the working zone. Local control can be transferred to another LLV or LWB.
Via a HHT LWB/LLV can communicate via GSM-R with the BEV21 ERTMS system. Local control is always supervised by BEV21.
The HHT enables communication with RCC staff, enables exclusive local control of installations (track sections, set or lock turnouts) and provides status information.
After the work is done all locks have to be removed (each by its original owner) before the working zone status can be changed and the zone is given back to RCC and the working zone(s) become part of the running network again. Only then, commercial trains are allowed to enter the area.
The HHT is part of the safety management system (in Dutch: "Veiligheidsmanagement-systeem" or "VMS") of ProRail. The HHT is a powerful tool, but in terms of safety it is only a means to communicate with BEV21. A local officer can never reduce local safety. The HHT, together with new procedures for working on infrastructure help to establish the necessary conditions for safe working on tracks. HHT fulfils the highest safety standards (SIL 4).

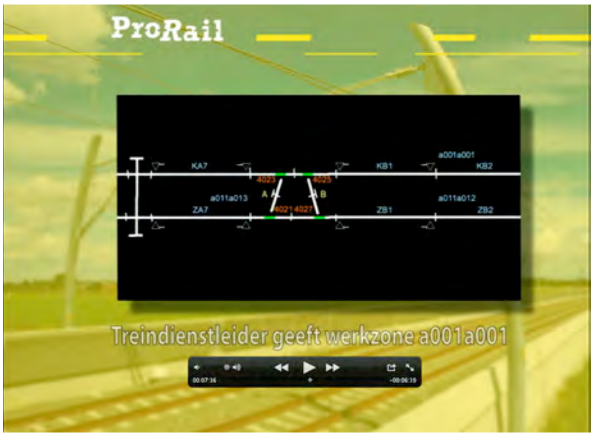
The pros of the HHT are the following (ProRail, cd):

- The system allows only two states for RCC and LWB: a section is either in use or out-of service;

- Explicit transfer of responsibility for the working zones between RCC and LWB. Supervisors (RCC/Tdl) cannot overrule local control (and v.v.);
- Each action by LWB (such a changing the points of a turnout) is immediately visible at the monitor of RCC (Tdl);
- HHT prevents working in situations where safety relies on personal observation (in Dutch: "Persoonlijke Waarneming" or "PW"). Out-of-service periods are such that capacity loss is minimized.
- Computer control replaces physical isolation measures and (partially) communication between track maintenance crew and RCC (Tdl);
- HHT is a personalized instrument, a special access code is needed to use the unit;
- LWB takes border measures and gets full control over local working zones and the turnouts inside the zone;
- Points inside the working zone can only be set by the LWB.

Figure 41 gives an impression of what RCC staff sees. Figures 42-43 show HHT displays.

Figure 41. RCC (Tdl) screens (left) and change to working zone (right)



Source 41-44: ProRail, cd.

Figure 42. To lock points

Figure 43. To lock (left) and unlock a working zone (right)

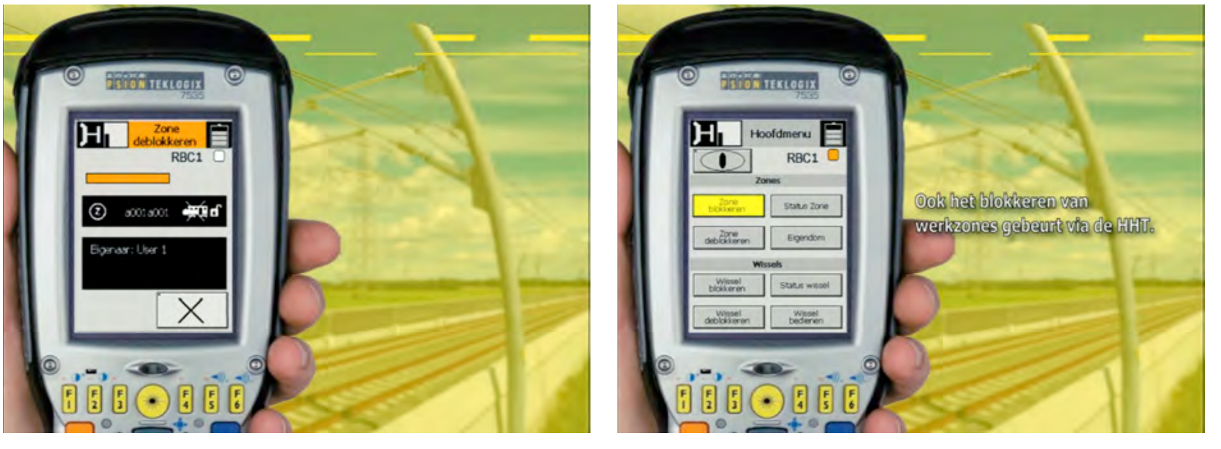
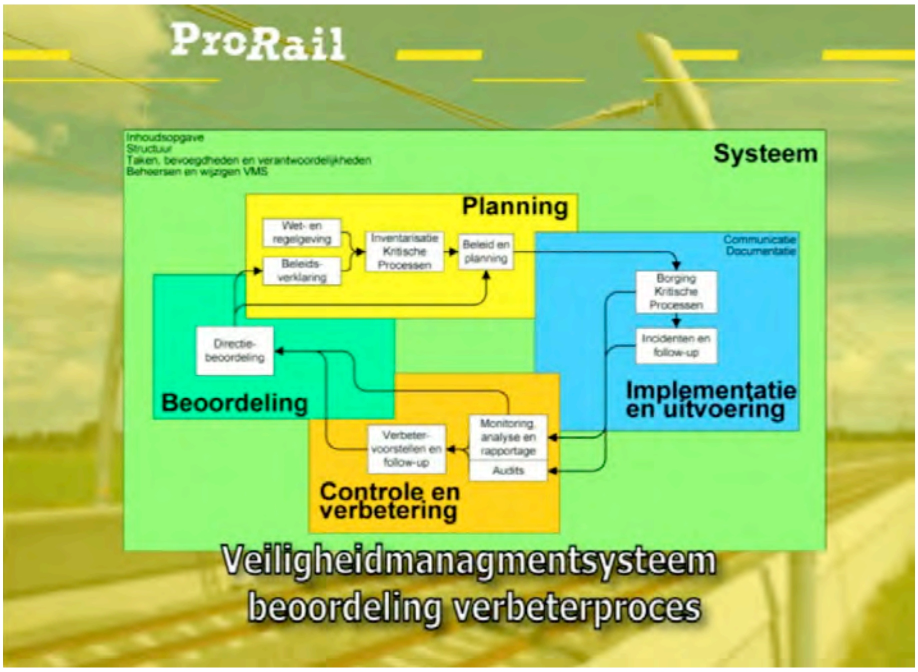


Figure 44. ProRail Safety Management system (VM)



Evaluation

Between January and December 2009 an evaluation of the operational usability of the HHT took place. The main conclusions from this evaluation are the following (Runge, 2010):

- the A15-trajectory is divided into a small number of very long sections, which implies that maintenance affects a large part of the A15-trajectory, much larger than necessary for the work itself. The advice would be to adapt the infrastructure by reducing these zones as much as possible and to find a more flexible way of combining the individual working zones;
- the zoning of the A15-trajectory is not always the same as the zoning of the catenary. Also in this case a larger than necessary part of the line is out-of-service in case of maintenance;
- working zones are visualized on site by special marker boards. In practice, these boards can disappear. To prevent this, proper fixing is necessary;
- staff using the HHT has adapted in a positive way to the HHT. The special training (see report DT 5.1) has contributed to this. The adaptation process should be managed properly in case of future implementations of safety systems;

- for the implementation of the HHT a handbook was developed. The construction company made a complementary implementation scenario. This procedure should also be used in case of future implementations of safety systems;
- the screen layout of the HHT makes it sometimes unclear, especially in case of larger working zones, which zones are actually out-of-service. In practice no problems occurred, yet, but a future upgrade of the HHT should include an improved layout;
- there are only few turnouts on the A15-trajectory. In case of a failure of a turnout, a relatively large area has to be taken out-of-service. When a failure of such a turnout (allowing switching from one track to another, hence the Dutch name "overloopwissel") occurs, it is necessary to lock the parallel track as well. This is another reason to adapt the zoning of the Betuweroute.

We can elaborate a bit on the zone length. For maintenance, a section of 5 km will be blocked, while 500-600 m is enough space for maintenance trains. Next to the already suggested reduction of the zone length (by increasing the number of turnouts), there is also the opportunity to benefit from technological development. Short circuit devices (see Report DT 5.1, section 4.3.4) were abandoned from the A15-trajectory because of safety concerns; installation and removal means entering unprotected track or removing protection, while working in a hazard zone. However, if the latest generation of short-circuit devices is used, (in Dutch: "zelfsignalerende kortsluitlans" or "ZKL" 3000, see Figure 45), then a much shorter length of track can be taken out of service.

Figure 45. Semi-automatic short circuit device, installation (left) and fixed

Source: http://www.railpedia.nl/display/test/ZKL+3000.

A ZKL can be permanently installed and switched on and off from a distance. This means that maintenance workers do not have to enter the rails before and after maintenance, which reducing safety hazard.

In practice, the use of the HHT is limited to specific situations:

- for single track maintenance (BDSL) and failures only;
- contrary to initial assumptions, turnouts are not managed via the HHT. RCC still manages locking and unlocking, which creates mixed management of a working zone. This is not in line with the idea of a clear separation between RCC and local safety staff. But, this way of working is the most practical and no accidents have occurred, yet.

3.6.4 Safety at Kijfhoek

Introduction

Kijfhoek is an industrial area of 50 hectares at the edges of the municipalities of Zwijndrecht (south), Barendrecht (north) and Hendrik-Ido-Ambacht. It is also close to the municipalities of Heerjansdam and Ridderkerk (see Figure 46). It became operational in 1975.

Over time it has become the central marshalling yard for the Netherlands, replacing sites at Feijenoord, IJsselmonde, Rotterdam-Noord Goederen, Amsterdam-Rietlanden, Watergraafsmeer, Amersfoort, Onnen en Zwolle (Wikipedia, 2010). Kijfhoek is connected with the national and international east-west (Germany and beyond) and north-south rail corridors (Belgium-France-Spain).

Next to a shunting area, there are also tracks were single locomotives, wagons and complete trains can be parked (temporarily or for a longer period of time), including those with ADR labelling (better known as 'dangerous' goods, such as (petro)chemicals and (acid) gases). Keyrail, DB Schenker and Strukton have buildings where operations and administrative activities are carried out, close to the tracks. Maintenance company Strukton also has work sheds and storage locations for construction material like turnouts, track and cables. Separated by a road and a small canal, there is an industrial area with firms in other branches of industry, including a discotheque (relocation is under negotiation). In order to prevent the spread of polluted water to the surrounding area, the canals at the perimeter of Kijfhoek can be isolated from the surrounding water system.

Figure 46. Kijfhoek and its neighbours

Note: This map shows plans for business (re)development and living areas. Barendrecht is not shown in the map, but is located left of Kijfhoek, on both sides of the railway line. Source: Werkplein Drechtsteden, 2010.

Next to a shunting area, there are also tracks were single locomotives, wagons and complete trains can be parked (temporarily or for a longer period of time), including those with ADR labelling (better known as 'dangerous' goods, such as (petro)chemicals and (acid) gases). Keyrail, DB Schenker and Strukton have buildings where operations and administrative activities are carried out, close to the tracks. Maintenance company Strukton also has work sheds and storage locations for construction material like turnouts, track and cables. Separated by a road and a small canal, there is an industrial area with firms in other branches of industry, including a discotheque (relocation is under negotiation). In order to prevent the spread of polluted water to the surrounding area, the canals at the perimeter of Kijfhoek can be isolated from the surrounding water system.

Figure 47. Kijfhoek shunting yard seen from Zwijndrecht

Source: Google.

This shunting yard has facilities for firefighting. There is also a building of the local fire brigade with cars and equipment next to the Zwijndrecht gate. The yard is crossed by two fly-overs for freight trains and a road bridge. Parallel to Kijfhoek lies the main railway line connecting Rotterdam with the south of the Netherlands and Belgium. This line is mainly used by passenger trains (see Figure 47, right).

Risks related with freight transport by rail; External safety

Rail is a very safe means of transport. Nonetheless, incidents and accidents can happen due to mechanical failure (in particular axle failure), wrong handling by staff (moving, shunting, opening/closing of valves, etc.) or others (vandalism, removal of parts) and environmental conditions (ambient temperature, wind).

As a consequence of such events or conditions, fluids or gases may leak, causing fire, explosions, pollution etc., the impact of which may be felt in- and outside Kijfhoek.

The risks of transport and handling of hazardous goods are to some extent known and preventive measures ensure that in most cases such events either do not happen or are limited to a very small area with only minor damage or injuries.

In risk analysis a distinction is made between area-related risk and group-related risk. Area-related risk refers to the chance that a person, being continuously and unprotected at a certain location will die as a direct consequence of an accident with hazardous goods near a risky activity. A limit of 1 per million is regarded as a limit for this kind of risk. Group-related risk refers to the chance that a group of people dies as a direct consequence of an accident with hazardous goods. Risk calculations are based on assumptions, which make the outcome of such analyses relative and uncertain. Risks can be managed to some extent, but not removed, hence there is never 100% safety, things can go wrong and in some cases, in a terrible way, as experience in other countries has shown.

Governance structure [49]

In the Netherlands, safety regulation goes far beyond the requirements of other countries. In total there are five monitoring agencies and dedicated sector laws, including the decision regarding external safety of installations or Bevi (in Dutch: "Besluit externe veiligheid inrichtingen"), a document regarding norms for the transport of hazardous goods (in Dutch: "Circulaire Risiconormering vervoer gevaarlijke stoffen"), which will

[49] Legal and institutional issues are not among the primary demonstration activities of DA 5.1, hence a short summary suffices.

become part of the decision regarding transport routes external safety or Btev (in Dutch: "Besluit transportroutes externe veiligheid").

The provincial (primary) and local governments (secondary) are responsible for external safety. They are advised by the regional fire brigade and the regional Environmental Department (Milieudienst Zuid-Holland-Zuid). In the Rijnmond area (with 15 municipalities) the Environmental Protection Agency for the Rotterdam Area (DCMR) operates. It acts as a policeman and policy advisor.
ProRail, the owner of Kijfhoek has a permit from the province of South-Holland, which covers all activities at Kijfhoek. It deals with safety and environmental issues (pollution, noise). The latest revision of this permit took place in 2009. It gives the province a better insight into what happens at Kijfhoek. This helps to improve risk analysis.
In the past the permit was based on a maximum number of wagons per freight category (e.g., Cat 2.). What to do if the maximum is reached? Moving wagons to another location, means moving hazardous goods over an additional distance, while the location does not have proper facilities. Hence, to manage risk, it was better to leave the quantitative categorization. Now a so-called risk contour is used, a circle on the map around Kijfhoek. A quantitative risk analysis (QRA) was made based on a prognosis of transported volumes and population density in a reference year. Outside the risk contour safety for the people and the environment is at a very high level.

The revised permit for Kijfhoek is based on (MZHZ, 2007) an analysis of

- the present institutional and physical situation and the desired future situation;
- the necessary changes and their impact on the environment.

The permit is related with the volume of hazardous goods passing through Kijfhoek each year. It allows ProRail (Keyrail), hence rail operators flexibility (no reduction of transport capacity), while maintaining safety at the highest level possible. It allows a faster assessment of violations of the permit and who is responsible in case of violations (MZHZ, 2007; Province of South-Holland, 2009).

Owner ProRail has developed a plan to deal with calamities at Kijfhoek (in Dutch: "Calamiteitenplan Kijfhoek") in line with the Environmental Law (in Dutch: "Wet Milieubeheer' or WM) and the Decision on Labour conditions (in Dutch: "Arbeidsomstandighedenbesluit).

ProRail is working on a contract with the surrounding municipalities dealing with enforcement (in Dutch: "Omgevingsconvenant"). This contract provides transparency, allowing a better analysis of the spatial development opportunities: where to allow which activities given specific risks.

Local governments lack the expertise regarding safety, spatial planning and law. It would be a good idea to join them into safety regions. As a result more coordination can be established and expertise can be clustered.

Keyrail and safety management at Kijfhoek [50]

Keyrail management treats external safety as a key issue. It has analysed the handling of trains at Kijfhoek. This has led to several risk mitigating actions. One of them is a dedicated pushing system (in Dutch: "doordruksysteem") that reduces the risk of collision and derailing of wagons. In the past, it could happen that a wagon, while rolling down the shunting hump for some reason did not reach its destination (one of the classification tracks), but stopped earlier. When the next wagon was released, it could collide with its predecessor(s), which is rather problematic in case of hazardous goods (risk of leaks and explosions). Now, wagons are managed in a controlled way, which also helps to increase the efficiency of the shunting process (repositioning is no longer needed). The noise of shunting was also reduced. Next to the pushing system, each shunting track has a special rail braking system. This also supports safe handling of wagons.

Kijfhoek has a fire brigade, which can support external fire brigades, such as those from the municipality of Zwijndrecht.

Transport is not a local issue, hence transport safety should be managed at least at a regional or even higher spatial and institutional level. In the Netherlands freight trains usually pass built-up areas. If an accident with wagons carrying hazardous goods would happen, in a worst-case scenario a complete city could be affected. There has been a discussion about shifting freight to a limited number of rail corridors, the so-called 'Basisnet Goederen'. It is difficult and not cost-effective to reroute trains away from built-up areas. Bypasses and tunnels cost large amounts of money.

There is a so-called safety platform, in which municipalities participate. It has developed scenarios and procedures e.g., concerning bypass routes in case of calamities. This is a response organisation, comparable to the one for the high-speed line between Schiphol

[50] This section contains information from the interview with Mr. Sjoerdsma.

and the Dutch/Belgian border. In that case, it deals inter alia with safe removal of injured people.

The perception of safety is a point for discussion. Rail transport has a very good safety image, rail is very well organised, but the requirements are increasing. The same will happen in future with barge transport. As a result, more expertise is needed.
Accidents can happen, but it is important to decide which of them ask for anticipatory action.

To improve transparency, adequate information is needed, such as a wagon list and a schedule of departing trains. Such information can be put on a website. Officers from a municipality or the fire brigade may log in to get an overview of relevant data.
Statistics about accidents are collected. At least as important are statistics about near-accidents, because these are the cases that people may learn from. Operators, contractors etc. should communicate such issues. Good behaviour should be supported.
Inspections by the Inspectie Verkeer en Waterstaat (IVW) agency of the Ministry of Transport and the fire brigade carried out in April and June 2009 indicate that rail operators do not check the state of wagons carrying hazardous goods parked at Kijfhoek. This is not in line with the regulations regarding transport of hazardous goods by rail (VSG/RID). These regulations demand continuous or regular supervision in order to monitor leaks. The agency also found shortcomings with respect to labelling of wagons (Inspectie Verkeer en Waterstaat, 2009). Rail transport is by definition unaccompanied transport, so it may be difficult to find a solution to this problem. But, it is clear that one should be found. Otherwise, there is a constant leak in the safety system.

Next to monitoring of rolling stock, regular inspections of the infrastructure are necessary. In the philosophy of Keyrail there should be a safe margin in the quality of the infrastructure. The quality should never be below a specific level.
Risk analysis of infrastructure parts is vital. For each part the safety risks are known.

The quality of the wagons should be high. The Dutch chemical industry has developed safety criteria, which are monitored. Wagons from abroad may be problematic with regard to monitoring criteria, but also with respect to theft. There are cases, where valves were stolen (copper parts). Also maintenance may be below the Dutch standard.

Safety relies on procedures, activities and equipment. To maintain the required level, maintenance and testing is required. Staff should receive regular training. There should be swift communication. The Year Plan includes time for training, both virtual and real. It is important to cooperate and put everything on paper. So far, several training sessions have been organized.
These are steps towards what the Zwijndrecht fire brigade calls an integral safety philosophy. It integrates prevention, preparation and repression. The present restriction to external safety is inadequate in its opinion.

Firefighting - IJsselmonde
During the conversion of the Port Line, IJsselmonde became an important point in train logistics. Locomotives were changed here. This meant that trains had to stay for a short period close to a living area. The local government had the intention to reduce the scope of the permit, which meant that the functionality of IJsselmonde was reduced to an unacceptable level. A way out would be that for a period of four months a dedicated fire brigade would be appointed. The legal 'battle' continued until the highest court (the Raad van State), which issued a decision. For several months a dedicated fire brigade was installed. It is typical that a moving train is not perceived as a risk, contrary to a shunting locomotive.

3.6.5 Evaluation

Rail is a very safe means of transport. Nonetheless, incidents and accidents can happen due to mechanical failure (in particular axle failure), wrong handling by staff (moving, shunting, opening/closing of valves, etc.) or others (vandalism, removal of parts) and environmental conditions (ambient temperature, wind).
Transport of hazardous goods by rail is related with important external risks. There is risk management at Kijfhoek, which should help to prevent incidents and if they occur, mitigate their impact both locally and in the wider surroundings. Procedures, regular training of staff, together with safety awareness and regular inspection are important tools to maintain a high level of safety.

3.7 Experience with the maintenance concept [51]

3.7.1 Introduction

At the start of its operations, Keyrail assumed that the subcontractors responsible for the realisation of the A15-trajectory finished their work turnkey. If this was the case, then railway undertakings would be able to immediately use the Betuweroute. Maintenance would be carried out to preserve the then existing infrastructure quality. Reality turned out to be rather different.

On January 1, 2008, a baseline measurement was carried out. Analysts of the collected data concluded that the quality of the infrastructure was below the acceptance level of ProRail, as stated in the RAMS requirements. As we already explained in report DR 5.1 (p. 16/108), among the problems was an unfinished ERTMS implementation, which severely reduced availability and capacity of the A15-trajectory.

So, in stead of starting a normal maintenance sequence, Keyrail was forced to start *renovating* the rail infrastructure.

3.7.2 State-of-the-art

In report DR 5.1 we explained that according to its contract with Keyrail, Strukton should develop itself from a traditional contractor to a maintenance manager.

Keyrail gained initial experience with the way Strukton carried out this (internal) transition process and concluded that Strukton had to improve substantially.

It was clear that Strukton needed more time to adapt to a situation in which it was not told by a commissioner when, how, where and for how much money it should carry out maintenance, but instead become responsible, together with Keyrail, for the fulfilment of a maintenance strategy and as such start behaving as a manager of maintenance projects instead of a contractor. Strukton should be able to inform and advise Keyrail.

Time has progressed, which allows additional evaluation of Strukton's transition process and its impact on the maintenance activities.

3.7.3 Evaluation

This evaluation focuses on the following:

[51] This section is based on the interview with Mr. Rook.

- Removing the backlog. Strukton and Keyrail made a lot of effort to raise the quality of the infrastructure. This effort came at the expense of the contract;
- Dealing with failures. There have been issues with transformers due to EMC, but these transformers were highly redundant. JADE (high-frequency) on the Port Line had bugs related with weather conditions. Hot boxes also had bugs. The 25 kV switches on the Caland bridge tripped. The impact of these and other failures on operations cannot be determined, yet, probably their impact is minor. Keyrail records all data, including function recovery times;
- Dealing with external conditions. Strukton was also reorganized in this period. As a result, knowledge left the company;
- Dealing with subcontractors. Subcontractors carry out work for different commissioners. Their staff is not (yet) able to easily switch between different maintenance regimes;
- Database. Process-related information is sufficiently available in the information system. This refers to measurement and failure data. But, there is no reference level, as we are just at the beginning of the lifecycle. It is not clear if more data is necessary either;
- Experience with condition dependent maintenance (based on visual inspection or measurement). Maintenance of new systems with which no previous experience exists feels like aiming at a running target;
- Negative consequences of a D&C contract. In general good infrastructure design reduces maintenance. The Betuweroute was built under a D&C contract, which means that the responsibility of the building company ends when the project is finished. Following conventional practice in the EU, the cheapest offer is awarded the contract. This stimulates short-term thinking or ‘cheap building’. The designers have not given enough attention to maintenance, which was out of their project scope. A key result of this practice can be seen in track geometrical positioning. Analysis of rail track data by Keyrail led to the conclusion that there was an extreme, much more than expected, soil movement (‘settling’). Contrary to the high-speed line between Schiphol and Antwerp, the substructure did not consist of concrete slabs, but ballasted track was used. Ballasted track has lower building costs, but demands regular maintenance, while concrete slabs are to a large extent maintenance free. Hence their lifecycle costs are lower (Esveld, 2001). Using heavy freight trains on rails supported by a rather flexible

substructure means that much more track position recovery is needed. The additional costs should be paid by the Ministry of Transport;

- Relation between traffic intensity and maintenance. Interestingly, experience showed that an increase in the number of trains does not (automatically) mean that more maintenance is needed;
- Safe working practices. Higher safety standards preclude working on a single track section if the parallel track is in use. As a consequence, both tracks have to be put out-of-service in most cases.

Maintenance is partially the responsibility of Keyrail (regular maintenance) and ProRail (renovation). This division is rather artificial. Yearly cost of maintenance are between Euro 7 and 8 million euro.

3.7.4 Outlook

Many assumptions of Keyrail and the contractors regarding maintenance turned out to be wrong. Currently time is used to collect and analyze data.

Due to the circumstances the focus of maintenance has changed. Instead of being organized according to a predictable sequence, maintenance is now less organized, giving it an ad hoc character ('shoot from the hip'). It is important to find a smart way of dealing with this.

It is likely that the maintenance planning changes over time. Instead of once per week, it is technically feasible to reduce maintenance activities to once per month or even less frequent in future.

As already discussed in our evaluation of the HHT, the small number of turnouts on the A15-trajectory leads to relatively large out-of-service areas. This topic is under investigation. It is not unlikely that additional swiches will be built in order to reduce section length and enable a more flexible use of the Betuweroute.

4. Demonstration of the economic implementation plan

4.1 Introduction [52]

Keyrail has a five-year concession to manage the infrastructure of the Betuweroute. ProRail remains the owner of the Betuweroute. Keyrail's goals and ambitions are outlined in a business plan.

Railway undertakings are not obliged to use the Betuweroute. Freight trains have four options to cross the Dutch/German border: via Emmerich and the mixed railway line (Utrecht-Arnhem), via Emmerich and the Betuweroute, via Venlo and the Brabantroute (Dordrecht-Breda-Eindhoven), and finally via Bad Bentheim (Utrecht-Amersfoort-Deventer-Enschede). Traffic via Bad Bentheim is not affected by the availability of the Betuweroute (yet) because rerouting via the Betuweroute would lead to longer transit times [53], but for the other two routes, the Betuweroute is a real alternative.

Railway undertakings are allowed to use the Betuweroute after signing an Access Agreement with Keyrail. The Business Plan and the Access Agreement are the main elements of the economic implementation plan for the Betuweroute. All operational and commercial activities are carried out in the framework of the Dutch Law on rail traffic and transport (in Dutch: "Spoorwegwet"). The way lawyers see the railway world tends to some extent be different from the perspective of those who actually work in railway operations and management, which tends to complicate matters for those involved in railways.

4.2 The business plan

4.2.1 Introduction

Keyrail's business plan has three aims:

- optimal use of the capacity of the Betuweroute (4.2.2);
- become the 'partner of choice' in rail freight transport (4.2.3);
- reach break-even in 2014 (4.2.4).

[52] Chapter 4 includes information from the interview with Mr. van der Nat.
[53] If the connections at Meteren and Elst become operational, then there will be an impact.

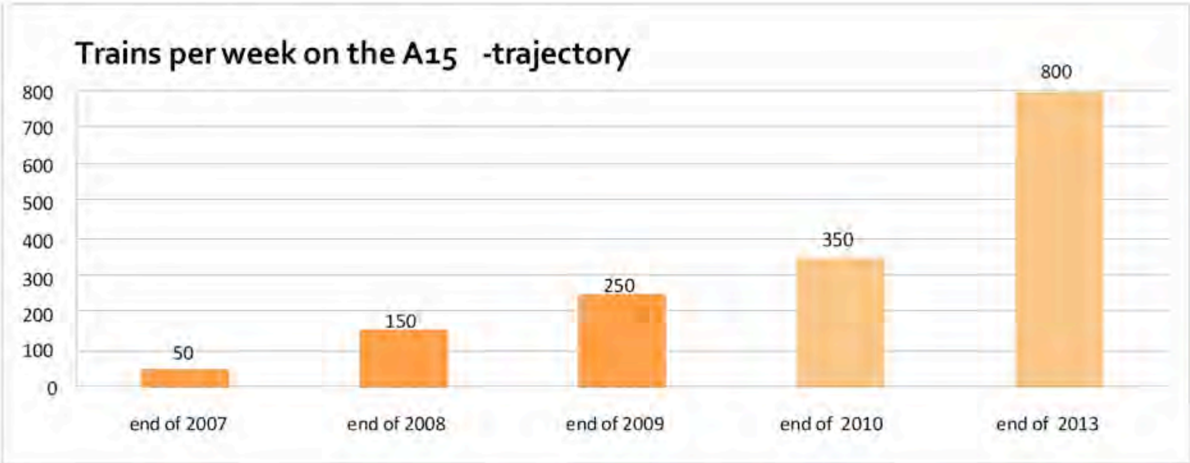
4.2.2 Optimal use of capacity

General perspective

Turnover (gross income) is determined by the number of trains multiplied by the user charge for each kilometer. More trains guarantee a higher income for Keyrail. The user charge is fixed within the 4-year (2007-2011) period governed by contracts between Keyrail and the railway undertakings. This means that Keyrail can increase gross income only by attracting a higher number of trains (in this period). This explains its 'focus on volumes'.

The development of traffic volume since 2007 is presented in Figure 48.

Figure 48. Trains/week A15-trajectory 2007/2010-2013



The actual number of trains stayed behind the forecasted number of trains due to

- technical problems on the A15-trajectory – lack of locomotives equipped with ERTMS and insufficient train-track integration. The initial forecast was 'a bit too positive';
- the impact of the financial crisis in 2008-2009.

The business plan underwent changes during the summer of 2009, taking care of the drop in volume. The latter means a set-back by one year compared to the original volume forecast.

More traffic is expected due to

- the opening of the connection in Meteren, providing access to/from the Port of Amsterdam;

- the availability of sufficient locos equipped with ERTMS;
- growth of transport of coal and ore and rerouting of coal and ore trains via the Betuweroute instead of the Brabantroute. Coal wagons run in block trains between Rotterdam's Maasvlakte with the terminal of Europees Massagoed-Overslagbedrijf EMO and receivers in Dillingen (Germany). Diesel locos are used to haul wagon sets in and out of the terminals. This means that the long haul locomotives, increasingly electrically powered, have to be parked nearby. Capacity has increasingly become scarce, due to the growth in traffic, the number of terminals, railway operators and railway undertakings. It is difficult to find space to park locos (see also Keyrail, 2010b). With many railway undertakings, it is more likely that locos from one traction provider may block access for other traction providers etc.

From July, 2010, DB Schenker replaced triple diesel loco sets by pairs of two electric 189 series locomotives. These locomotives have recently been equipped with automatic couplings. Such couplings remove the need for (reserve) coupling cars, hence parking space for such cars. Instead, locos can be parked there.

Claims by operators, some of which were also conflicting, and the urgency to find a solution, induced Keyrail to declare Maasvlakte East loco location as (one of the) 'excessively used areas' (in Dutch: "Overbelastverklaring"). Keyrail made process arrangements, carried out a capacity analysis and prepared a plan to increase capacity for loco location Maasvlakte-Oost (Keyrail, 2009d, e). It is clear that such changes are dependent on the actual layout and options of the infrastructure. Criteria like the length of tracks, catenary etc. are relevant here.

Keyrail actively approaches shippers, operators and terminal owners. It is import to realise that the commercial power of railway undertakings is very limited.

If we restrict ourselves for the moment to supply factors, then rail infrastructure is one of the factors limiting growth of freight transport by rail. Rail passenger- and freight transport are growing, competing for train paths on the mixed traffic routes in the Netherlands and in Germany. With respect to cross-border traffic, the 3rd track in Germany is essential to prevent gridlock. It is part of the Rotterdam-Genua corridor, which should be finished in 2015. Construction of this 3rd track may be delayed due to the German (federal) budget situation.

The rail market is in flux. Due to the economic crisis, small companies are taken over by the big European players. DB Schenker has a market share of 70% on the A15-trajectory. Although big players dominate the rail freight market, young companies can take their chances, as they are usually more flexible and closer to the customer.
Twelve companies signed the Access Agreement 2010-2011. This is a small number compared to the seventy railway undertakings in the port of Hamburg, which is considered as a 'rail port'.

Economic incentives

Quality of service agreement (in Dutch: "Prestatieregeling")

The Access Agreement (Keyrail, 2009d) contains a quality of service regime, performance targets and consequences of non-compliance. It consists of five rules:
I. Adequate response to requests for trains paths – no monetisation. Each quarter of the year Keyrail and the railway undertakings will discuss performance;
II. Reduction of the number of changes in already distributed train paths – monetisation from February 1, 2010. There is a bonus-malus regime for each change, both Keyrail and the railway undertakings may have to pay;
III. A more regular ('disciplined' departure process – indirect monetisation, consequences to be found in rule II. or V. Stricter compliance with what has been agreed and measurement of actual performance;
IV. Punctual shift from Keyrail's network to other networks - monetisation from February 1, 2010, the 'cap' will be adapted to the performance. A variance of 3% of the agreed time is acceptable. 89% of the trains should achieve the 3 minute time window;
V. Reduction of the number of cancellations (of trains by the railway undertaking and train paths by Keyrail) - monetisation from February 1, 2010, excluding 'acts of God'. The party causing the cancellation has to pay a fee, related to the kind of change.

'Unfinished infrastructure' means a cut in fees

The infrastructure of the A15-trajectory and the Port Line is not completely finished and even where it is finished, the technical installations show unforeseen and uncommon failures. As a consequence, railway undertakings are faced with logistic and commercial issues and additional costs. For instance, the cost of non-commercial stand-still is about Euro 250, which is higher than the cost of a single train path (NT, 2010). As long as this remains the case, they receive a rebate on the user charges. Keyrail and the operators agreed to analyze the situation headed by an independent mediator.

The fee structure itself is a transparent regime, information is public, all customers receive the same treatment. The fees for use of train paths, quality of service penalties, cancellation of train paths etc. will in total be not higher than 5% in 2010. This is called 'capping the tariffs' or 'cap'.

For example, the fee for parking could be 80.000-100.000 Euros without 'cap', but is only 19.000 Euros with 'cap'.

Support regime

To mitigate the impact of the financial crises and economic downturn in the past two years, a support regime (in Dutch: "Stimuleringsregeling") was designed for users of the A15-trajectory. Keyrail made an agreement with the Ministry of Transport to reduce the rail user charge for two years (2010-11). Railway undertakings need time to shift to the A15, and this incentive may help them.

Parking trains on the Port Line

Keyrail is implementing a policy for parking and longer stay of trains. Following this plan, it divides its yards into tracks for running (process), parking and longer stay of trains (rented tracks; Keyrail, 2009c). For process tracks customers pay the normal user charge. In addition to this, they also should pay for parking and longer stay.

Before 2009, parking fees were included in the Track Access Agreement (in Dutch: "Toegangsovereenkomst'; Keyrail, 2009d), but no bills were sent to customers.

In the Track Access Agreement 2010-2011 a regime with step-wise growing parking and renting fees is introduced (in Dutch: "Ingroeiregeling"). Fees are differentiated according to the type of yard (for instance: Kijfhoek is a D-location and Maasvlakte and Waalhaven yards are A-locations, which are the most expensive). The fee structure is the same for all customers.

The procedure is as follows:

- Keyrail registers parking in terms of minutes and prepares a report for each customer;
- Then these minutes are monetized and a bill is sent to the customer.

In 2010, customers will feel the impact, Keyrail expects 'hard talks' with its customers. In order to make the change easier, the B, C and D locations are exempted in 2010. In

2011, also for B locations fees have to be paid [54]. In all cases introduction starts with a major rebate on the fee, which is gradually reduced until the moment when the full price has to be paid. Even at 100%, the fees are much lower than in Germany. The parking fees flow into a parking fund, which is used for small investments, for instance to buy cameras. The Ministry of Transport also contributes to this fund.
It is important that customers understand and accept the reasoning behind the fees. Such fees are normal in other countries. Rotterdam port is the beginning and end of the Betuweroute, hence customers tend to use the opportunity to park their trains according to their individual logistic needs. But, more parking means less efficient use of infrastructure and a lower income from running trains.
Fees are effective. In the past, maintenance was carried out on the tracks, wherever the customer liked to carry them out. After the fees were introduced, wagons needing maintenance are sent to Hungary.

Renting tracks on the Port Line
Some yard tracks can be rented for a longer period of time. Before the start of the Year Plan 2010-11, a railway undertakings is allowed to rent tracks from Keyrail. He requests specific tracks, which are then granted before the start of capacity allocation in the Year Plan. If granted to him, the railway undertaking undersigns a rental agreement with Keyrail (Keyrail, 2009c), which grants exclusive access to the tracks by this railway undertaking. The agreement specifies the renting conditions, including allowed activities, prevention of damage and pollution and access by Keyrail. On rented tracks, light maintenance of rolling stock is allowed. There are also special tracks for more complex maintenance activities.
The fee for renting depends on the usability of the tracks.
Rented tracks are excluded from capacity allocation in the Year Plan. The procedure is specified in the Access Agreement (Keyrail, 2009d, Appendix 4).

Electrical power supply
Provision of electric traction energy is not a standard service by Keyrail. For a limited period of time, Keyrail has decided to act as a provider. The arrangement is comparable to the one for rented tracks.

[54] More details of the fee system can be found in Keyrail 2009d, Appendix 4. Unlike the DR 5.1 report, we will not be more specific, as the fee scheme is not fully introduced and apt to change.

A test with electricity contracts (including traction energy) was held in 2010. Keyrail sent the bill to the railway undertakings.
Organisations KNV Spoorgoederenvervoer, Keyrail, DB Schenker Rail Nederland, ERS Railway, ACTS Nederland, Captrain Netherlands and Rotterdam Railfeeding have established a buyer's organisation (called Coöperatieve Inkoopvereniging Elektriciteit Betuweroute or CIEBR) (infrasite, 2010). Since July 1, 2010 CIEBR buys e-power on behalf of its members. They are allowed to use electricity bought by CIEBR.
Main benefits of CIEBR and electrical power are

- that Keyrail is relieved from this task;
- stimulation of the use of e-traction, which contributes to a more sustainable rail freight transport;
- that operators become aware of the long-term costs of using electricity to power their locos.

4.2.3 Become the partner of choice

In order to attract and keep its customers satisfied, it is important for Keyrail to add value to the operations of its customers. Amongst others, this is done by tailor made services and a fast response time.

4.2.4 Break even in 2014

To become a financially healthy company, Keyrail (and its partners) should
- operate in a cost efficient way;
- optimize maintenance;
- optimize organization and processes.

The break even point is reached when 653 trains per week use the A15-trajectory. According to the latest forecast this will be in 2014.
In terms of investments, asset management is the highest investment category. In order to secure this investment, the infrastructure should be used and maintained as intended by Keyrail.

4.3 Evaluation and outlook [55]

The pricing mechanism is a potentially strong instrument. Customers try to survive in a market with strong competition and fluctuating demand (2008-2010). Profit margins hardly allow users to pay fees in addition to the user charges, let alone to pay fines if they 'violate' the rules. Until the 'cap' on the fees is removed, their impact will also be limited.

The bonus-malus regime helps to change behavior. It is difficult to change the mentality due to the conservative culture in rail transport.

Keyrail has to grow in its role. Customer relations should be good and stay that way. Keyrail is very customer orientated. At the same time, customers should change perception regarding:

- costs: the real cost of using the infrastructure and services should be paid (by their commissioners via contracts);
- planning: this has to become more strict. Problems have to be put on the table. Then they can be analyzed in depth in order to see where the chances for optimization can be found.

There are still some questions, for instance: when is the market ready for these incentives? Is a more dynamic approach by Keyrail necessary? How should Keyrail manage capacity (direct or indirect approach)?

Amongst others, terminal capacity is expensive. Therefore, like other links in the chain, also terminal capacity should be used as a scarce resource.

How should Keyrail improve accessibility of the terminals? Via a bonus-malus (indirect) or via shunting (direct)? Terminal operators tend to argue that the other parties in the chain are responsible for capacity bottlenecks. Thanks to more transparency (Chain Management) the (negative) impact of their own optimization efforts on capacity has become much more visible. Changing their behaviour asks for better communication and possibly also (better) contractual arrangements between Keyrail and the terminal operators.

[55] This section also includes information from the interview with Mr. Sjoerdsma.

4.4 ERTMS Corridor A: Rotterdam-Genoa

4.4.1 Introduction

The corridor known as ERTMS Corridor A (see Figure 49), TEN-T Priority Project No. 24 and RNE C02 is a north-south connection between (Zeebrugge-)Antwerp/Rotterdam-Duisburg-Basel-Milan and Genova(/Lyon (RNE C05)). In other words, the corridor connects the North Sea with the Mediterrenean Sea (Ministers of Transport, 2010) [56].

Figure 49. ERTMS Corridor A

Source: Brugts, 2009.

This corridor has the highest rail freight volume among the ERTMS corridors. Forecasts indicate that rail freight in Corridor A may nearly double by 2020 (Programme

[56] We will focus on the Dutch-German part of this corridor.

Management Group, 2007). The question is whether the rail system is ready for such a growth?

In the past, the (simple) idea was that liberalisation and harmonization would create more competition in railways and that competition would make railways more market-driven and hence offer a quality of service competitive to road only transport.

Next to the fact that liberalisation also has downsides [57], there are many other obstacles which limit the market potential of railways, let alone the opportunity "to shift a considerable share of the trans-Alpine goods transport to the more environmentally-friendly railways." (Ministers of Transport, 2007, p. 2)

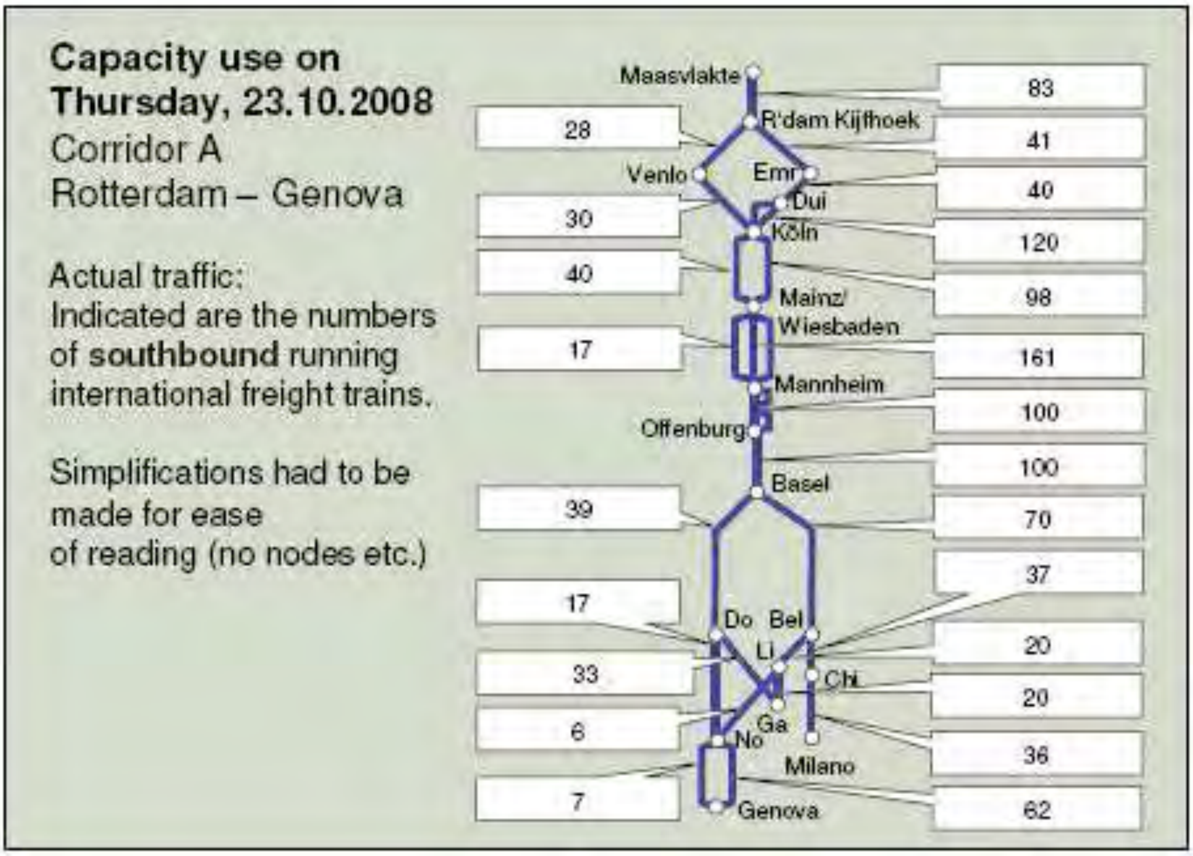
In particular, high quality services cannot be offered without sufficient capacity and quality of rail infrastructure. Capacity depends on many variables. For the whole corridor an inventory is in progress, based on the following parameters (IQ-C, 2010b):

- maximum inclination
- loading gauge
- train length
- line class
- axle load
- meter load
- train weight
- train speed
- power system
- number of tracks
- language used (for operations)
- planned ETCS equipment (SRS, level).

An earlier inventory based on traffic intensity is presented in Figure 50, while the known and forecasted constraints are shown in Figure 51.

[57] For instance, restructuring of short distance or single wagon services may lead to a modal shift from rail to road.

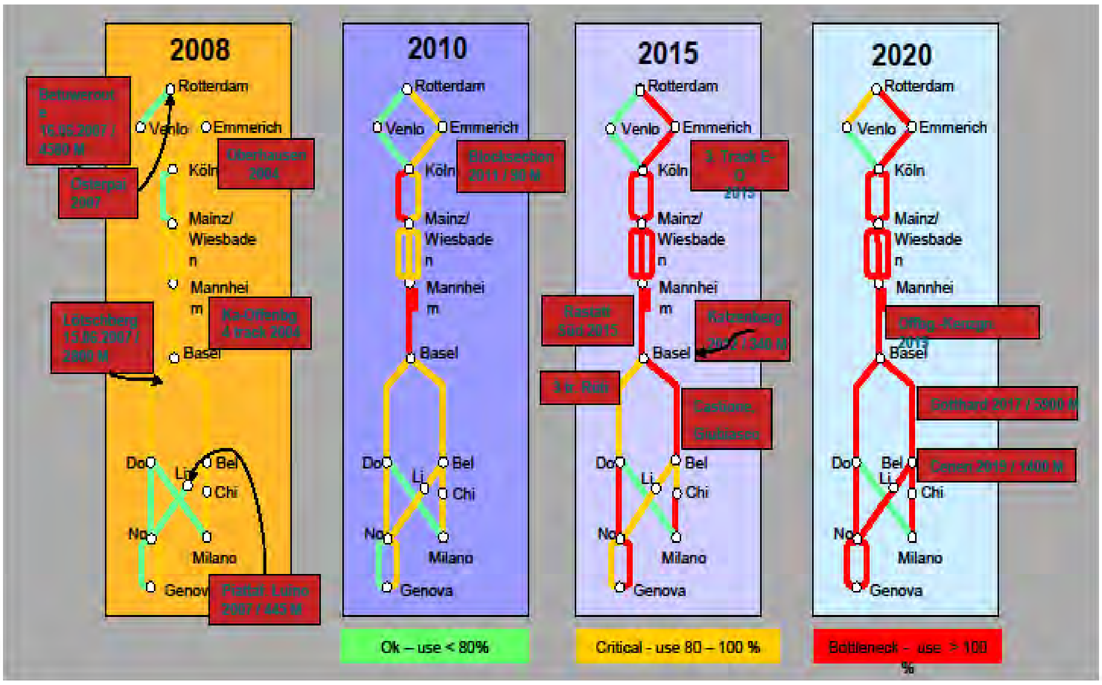
Figure 50. Corridor A traffic measurement 2008



Source: IQ-C, 2008b.

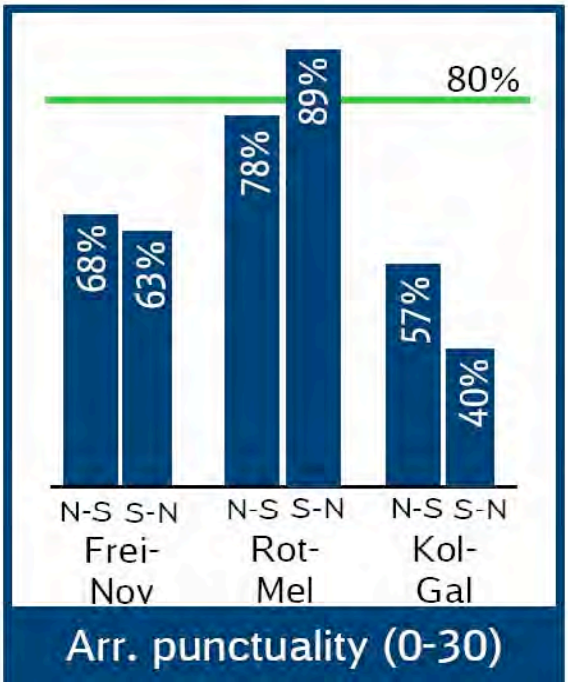
Figure 51 shows that capacity will become scarce, which stresses the need for the corridor upgrading activities, in order to improve punctuality (see Figure 52).

Figure 51. Capacity restraints in ERTMS Corridor A



Source: Brugts, 2009.

Figure 52. Average arrival punctuality, selected routes



Definition: average punctuality level (arrival at destination within a 30 minutes time span) for selected relations of: Freiburg - Novara; Rotterdam - Melzo and Köln - Gallarate (all start/ end points of these transport relations are directly located on Corridor A). A level of 80% is the target.

Source: IQ-C, 2008b.

4.4.2 Timeline

The EU policy regarding Corridor A went as follows (IQ-C, 2008a; IQ-C, 2010b):

1) MoU Rotterdam-Milano 9 January 2003;
2) 2004 extension of MoU with Milano-Genua;
3) The MoU contains an action plan with short-term improvements of quality in the corridor. Parties involved are customs agencies, railway safety inspectorates, supervisory boards, infrastructure managers and railway undertakings. Transport develops in a positive way. There is a continuous growth of tons transported by 15 active railway undertakings. But, about 1/3 of all trains is delayed by one hour or more while passing the Swiss Alps;
4) July 2004 1st progress report about the corridor. This contains an additional action point (nr. 10) dealing with the roll-out of ERTMS and an agreement to facilitate EU-Swiss transit customs procedures;
5) 2005 Dutch-German agreement between railway safety inspectorates. Also a study and cost-benefit analysis about roll-out of ERTMS were carried out;
6) March 3, 2006 Letter of Intent regarding roll-out of ERTMS in corridor A as of 2012/2015. Also second progress report, mentioning the need for a continued effort;
7) Consultation with stakeholders leads to a revised action plan as of July 2006. The purpose is to provide sufficient capacity and quality of the infrastructure in Corridor A;
8) 2006-2007 All fields of activities were further developed,including organisation of ERTMS deployment in the corridor, improved cooperation between infrastructure managers, improvement of punctuality and analysis of the causes for delays;
9) June 2007 MOU dealing with the implementation of approval procedures for rolling stock and cross-acceptance of approval procedures of the competent supervisory authorities;
10) June 2007 opening of Betuweroute and Loetschberg Base Tunnel (upgraded rail corridor with increased capacity and high quality performance);
11) July 2007 the Ministries of NL, D, I sent a coordinated request for Ten-T funding of ERTMS deployment in Corridor A to the EU. In December 2007 Euro 89 M was granted for infrastructure and rolling stock;
12) 2007 – 2008 deployment of ERTMS in the corridor. Management Committee set up by infrastructure managers. Foundation of EEIG Corridor Rotterdam-Genoa EWIV;

13) June 2008 Action Plan IQ-C 2006 – 2008 – 2012;
14) July 2008 IQ-C third progress report;
15) February 2009 ERTMS implementation plan 2015 presented by infrastructure managers;
16) Quality improving actions, including KPI. Improved punctuality and analysis of causes of delays;
17) Genoa declaration May 2009.

4.4.3 Action points and other issues

To be discussed is the following: action points, issues specific for the Betuweroute and for ERTMS, respectively.

Action points

Policy-makers have distinguished a number of areas which deserve special attention. They were translated into 13 action points (IQ-C, 2010b): [58]

1) Digital coordination: client access, client needs and implementation of telematics;
2) Services: measuring quality of services, investigation on value added services;
3) Improving punctuality: performance measurement and special instruments;
4) International capacity allocation: improvement of international capacity allocation process;
5) Capacity/bottlenecks: update of infrastructure inventory, development of infrastructure inventory, identification of infrastructure bottlenecks, elimination of infrastructure bottlenecks;
6) Cross-acceptance: mutual recognition of engine drivers and locomotives, cross acceptance of border-zone areas;
7) Market regulations: monitoring of market regulations;
8) ETCS/ERTMS: ETCS baseline 3, ETCS implementation and authorisation;
9) Terminal facilities: terminal inventory, planning, monitoring of traffic etc.
10) Harmonisation of operational rules;
11) Railway noise: noise source abatement;
12) Customs EU-CH: rail freight transit;
13) Rail freight regulation: development of a regulatory framework.

[58] The list is regularly updated.

Issues specific for the Betuweroute

The following Betuweroute projects have been distinguished (ProRail IQ-C Action items no. 6 and no. 10; see also section 3.5.9):

- Zevenaar to border electrification with 15 kV 16.7 Hz (study/decision)
- Third track Emmerich-Oberhausen (NL part) (study, partial finance secured)
- Betuweroute (ready - commercial use)
- Maasvlakte 2 – extension of Rotterdam Port (study)
- Electrification of marshalling yard (commercial use)
- ETCS Barendrecht-Kijfhoek (study)
- ETCS Zevenaar-border (study/decision)
- ETCS rolling stock – Betuweroute (ready - commercial use)
- TAF TSI – fundamental work from WG TAF TSI.

Issues specific for ERTMS

The way ERTMS is introduced in the corridor depends on a long list of factors. To be mentioned are in particular the technical specification of existing signalling systems, the technical and economic life-span and replacement strategy of existing signalling systems, the compatibility of ERTMS with existing signalling systems (in case of dual systems), the percentage of traffic with an international origin and/or destination, funding options and planning issues.

In order to ensure compatibility, a common standard should be installed, a minimum standard, which allows international freight trains a continuous (or at least with with limited delays) trip from country to country.

At the moment, ERTMS baseline 2.3.0d is available in parts of Corridor A. A further roll-out of ERTMS depends on the following (IQ-C, 2008b):

- A harmonised braking curve model (CR 595). This is regarded as a prerequisite for interoperability and performance in Europe;
- Availability of Level 1 LS mode (CR 637). Level 1 is said to have lower costs (there is no major impact on the existing infrastructure, in particular the need to replace interlockings), a higher technical flexibility (Level 1 can in most cases be installed parallel to existing systems). If used with radio infill (as adopted in Italy) a similar capacity level as with Level 2 is possible. Level 1 is regarded as the most economical way to implement ERTMS, in particular for the German/Swiss parts as well as for other corridors and countries. In Germany, the Oberhausen-Mannheim section has very dense and mixed traffic. This requires a performance level, which

is not possible with the present ERTMS 2.3.0 implementation. Baseline 3.0.0 should provide this performance level. It should be available by 2012-15 (if the industry is ready).

Development of baseline 3.0.0 is progressing for some time. It should be backwards compatible in order to keep interoperability with trains equipped with older ERTMS versions.
What is needed is a European approach to specify, test and homologate new ERTMS versions and equipment of different suppliers. This should be well coordinated within the corridors and the ERTMS Users Group with a strong involvement of Corridor A.
It is likely, that there will remain different ERTMS versions along the corridor in future. Germany and Switzerland are likely to install baseline 3.0.0, as the baseline 2.3.0d does not fulfill their requirements (Level 1 LS and harmonized braking curves are not available). Where possible, Level 1 will be installed, as this reduces investment costs. Funding for electronic interlockings and ERTMS in general remains a major issue in the corridor, in particular in Germany (IQ-C, 2010b).

4.4.4 Infrastructure management – Corridor A business plan

General aims
The infrastructure managers in Corridor A have developed a business plan for Corridor A. This plan contains a consistent understanding of all measures planned by infrastructure managers for the corridor, the resulting benefits for rail cargo, the necessary investments and challenges for funding, implementation timeline and the programme organization. Its aim is to become the common leading guideline of all stakeholders to facilitate the successful realisation of the entire set of measures covering all relevant areas, the key strategic approach to achieve significant benefits for rail cargo, especially regarding major transport volume growth and an important modal shift towards rail in Corridor A (Programme Management Group, 2007).
The business plan mentions a long list of instruments, which together should lead to the following improvements:
- a 26% increase in reliability;
- a 52% increase in capacity;
- a 20% reduction in north-south (v.v.) transport time (minus 5 hours);

- a 10-15% cost/unit reduction (operating and maintenance efforts) for infrastructure managers.

Betuweroute specific

As already mentioned earlier, major parts of Corridor A are close to saturation. This means that infrastructure improvements, such as the Betuweroute and the Swiss Alp Tunnel program (NEAT), which are likely to fuel demand for rail transport, will increase pressure on other parts of the corridor to a level far beyond their present capacity. This calls for an investment program, which is estimated to cost some 23.1 Bn Euros, to be spent between 2006 and 2020. Only part of this budget is available. Supporters of this program argue that the investment is to a great part compensated by external cost savings (15.7 Bn Euro) (Programme Management Group, 2007).

For the Betuweroute, the following projects are regarded as necessary to finalise this infrastructure and reap the highest (commercial) benefits from it:

- Removal of 1.5 kV and ATB isles (see section 3.5.9);
- Build a third parallel track between Zevenaar and Zevenaar-border (to be prolonged into Germany);
- Upgrading towards baseline 2.3.0d. (by the end of 2010);

These projects should be ready in 2012-15.

Achievements sofar

As a result of the efforts of infrastructure managers, railway undertakings and other stakeholders the following has been achieved (Brugts, 2009):

Organisational improvements:

a. An integrated working organisation was set up for the corridor;
b. A strategic business plan has been developed as the starting point of all activities;
c. A corridor working group was established;
d. An implementation plan, which contains all actions and measures, was prepared;
e. Monitoring of activities and regular progress reports is done.

Operational improvements:

a) Reduction in average response time of infrastructure managers to information requests from 8.7 to 6.4 days (measured between April 2007 and May 2008);

b) Streamlining of train paths;

c) Harmonisation of time-table adjustments.

Keyrail's demonstration activities have contributed to the operational wins.

4.4.5 Outlook

Corridor A is upgraded via a large number of projects in all the countries involved, which is important for rail traffic, both freight and passenger. Over time, initial plans have become more realistic as regards planning, financing and options to solve technical issues.

5. Feedback from DB Schenker Rail Nederland N.V. [59]

5.1 Introduction

DB Schenker Rail Nederland N.V. 'DBS' [60] (via its predecessors Railion Nederland and NS Goederen) is a long-term user of the Dutch railway network.

In the interview two main topics were discussed: DBS's experience with Chain Management and with the Betuweroute in general.

In section 3.5.4 Chain Management was discussed from the perspective of infrastructure manager Keyrail. This chapter helps to sketch a more balanced picture of Chain Management.

5.2 Experience with Chain Management and SPIN

5.2.1 Chain management

DBS supports the principles behind and sees the need for Chain Management.

Having said this, during the implementation several things went in a way DBS did not like.

In November 2008, the operational rules became definitive. It became clear that some things were not ready.

After six months, an evaluation took place at the management and the operational level, which should have led to adaptations. It took 2 years before this was realised. This is too long and meant a hindrance for operations.

The project had too much top-down steering.

Keyrail and DBS cooperated, but the other parties involved did not show the same level of commitment. As a consequence, the results were less than expected.

Finally, the follow-up of the project was completely unclear to DBS.

5.2.2 SPIN

Working with SPIN started lean and mean. The application was not ready when it was introduced.

[59] This section is based on the interview with Mr. Marc Kampinga. Differences between these opinions and the findings of section 3.5.4 are discussed in the final section of this chapter.

[60] This abbreviation is used to avoid confusion with mother company DB.

Operational staff did not want to use the tool, because it meant that they had to enter the same data twice (in different systems). This meant too much work for these people, who were already under a high workload. A solution would have been to either implement interfaces between the operational systems and SPIN from the beginning or to develop one integral system replacing the existing ones. That system should have (had) proper interfaces and international connections.

Transparency is a good thing. But, how to check whether the data entered is correct? In this respect, one should ask the question who benefits from transparency, and who does not? A terminal owner, for instance, may make a profit by accepting additional containers at the latest possible moment. The impact on other parties in the chain then tends to be neglected. This points to the more general problem of how to deal with different interests in the logistic chain?

Then there is the question of how to influence parties to behave as expected. Take for instance the traction supplier, who does not have a contract with the terminal, what motivates him to supply the required data? A financial incentive may help to do this (addional) work.

The position of Keyrail is an interesting one as well. It has its own interests. The rulings with traction suppliers may influence the behaviour of its shift leaders.

What is needed is a 'rail master', comparable to a 'harbour master' in a port.

5.2.3 Operational rules

The basic idea behind these rules is correct. Thanks to the rules, there is more understanding among the parties involved and more communication.

But, according to DBS, some rules are too complex and demand that you have commitment from the managers and the operational staff to make them work, which is difficult. Oral commitments only are useless. Contractual arrangements, which also include traction suppliers and terminal operators, are necessary. Financial incentives should be used to support the rules. Additional steps are possible to develop a fully functioning intermodal system.

DBS had to change its organization. Staff needed instruction. Issues were detected and solutions found. Operational staff became more aware of what to do and when.

With respect to terminals, it is clear that railway undertakings have little power to withstand terminal operators and rail operators.
There is also a controversy between planning (fixed) and the use of terminal slots (flexible). It is important that the rules facilitate railway operations, but prevent abuse.
So far, shunting is not practiced, hence blocking trains are not removed..

Chain Management is necessary, because traffic intensity increases. It is critical for the success of Chain Management that data is supplied by the parties involved. A mechanism should be found to force parties to cooperate.

5.3 Experience with the Betuweroute

5.3.1 Developments 2007-2010

The Betuweroute offered the shortest and fastest route to/from Germany with enough capacity. These arguments convinced DBS that it should start using the Betuweroute.
DBS gradually shifted trains from alternative routes to the Betuweroute. It started with a few trains in 2007. In 2008 the system allowed ad hoc intermodal services. In this year sufficient interoperable locomotives became available and train drivers received their training.
Because of uncertainty regarding number of available electrical ERTMS Level 2 locomotives, DBS reserved train paths twice in the beginning (at ProRail and Keyrail) in order to have a fall-back option (using 6400 series locomotives).
Decisions about the actual train route were made on a daily basis, at the latest possible moment. DBS could then decide how to route a train. Over time, certainty increased and fall-back became less of an issue.

One important set of trains was still using the Brabantroute – the coal trains between Rotterdam Maasvlakte and Dillingen (Saar) until December 2009. Since December 2009 they have been shifted to the Betuweroute. In the past 151AK series (Germany) and 6400 series (The Netherlands) pulled these trains. They have been replaced by 189 series MSL. Twenty 189 series locomotives have been fitted with automatic couplings instead of conventional screw couplings (and a coupling wagon). This allows two BR189 AK to pull a 5000+ tons coal train in shuttle service. Next to this technical issue, there was an organizational one. The switch from the alternative route (Brabantroute) to the Betuweroute was not so simple. There were long-term contractual arrangements on

German corridor paths. Everything had to be planned very well and after that, the switch could be made. In December 2010 the same shift towards the Betuweroute has been carried out for the iron ore trains.

5.3.2 Issues to be addressed

There are several other issues, which should be solved in order to improve quality of services on the Betuweroute. We will discuss international and national/regional issues.

For international services a major issue is the planning of continguous international paths (path assembly) (see also section 3.5.3). There is the RNE catalogue with train paths, but according to DBS the reservation process is just an exercise on paper. In practice the following situation exists:

- A train can run smoothly on the Betuweroute;
- In Germany, only part of the total capacity is available, due to long-term contracts between DB Netz and main user DB;
- Also in Germany, rail capacity differs for each trajectory. A train is guided step-wise through the network. Local RCC's decide how a train passes their control area, there is no coordination. As a result, punctuality from Germany to Rotterdam is much worse than vice versa);
- due to increase in traffic intensity (passenger and freight) rail capacity in Germany comes increasingly under pressure. DBS calls the Emmerich-Oberhausen trajectory a funnel.

DBS likes to have a more solid train scheduling. It would like to buy a complete set of regular international paths, which would allow it to run trains with a high frequency between Rotterdam and Oberhausen or Neuss. There the locomotives would first be decoupled and then coupled to a waiting train for the return trip.

In The Netherlands DBS experiences the following:

- infrastructure quality, in particular (uneven) settlement of the rails (see also section 3.7 and report DR 5.1);
- out-of-service period for maintenance.

5.4 Evaluation and outlook

DBS is the main user of the Betuweroute. It perceived the benefits of using the Betuweroute, but is also aware of the many issues that are still to be solved. It mentions in particular technical issues (rail infrastructure quality and reliability), organizational issues (cooperation between rail infrastructure managers, cooperation between the parties involved in chain management/SPIN).

With respect to Chain Management/SPIN a major remark is what DBS perceives as the top-down approach in this project and a neglect of remarks made by parties involved during a period of two years. Starting with an incomplete system created problems, which have not been solved later on.

In order to be successful, Chain Management has to find a good balance between the different interests.

Cooperation demands from all parties involved to set aside their commercial interests in favour of an optimized chain, in order to achieve a reliable train product. This is a very challenging goal.

Comparing section 3.5.4, which was largely based on information and opinions from Keyrail, with the opinion of DBS management, one may conclude, that DBS and Keyrail are on the same track with regard to the goals of Chain Management/SPIN and the potential of the Betuweroute. Keyrail's efforts, both at the national level (more intensive following of a limited number of trains, process improvements, technical renewal and upgrading) and international level (e.g., extension of chain management to Duisburg, removal of 'voltage isles', third track in Germany) are signs that it is aware of the obstacles that lie ahead before the Betuweroute can be used as was intended by its designers.

6. Demonstration activities by Kombiverkehr

6.1 Introduction

Kombiverkehr is one of the railway undertakings using the Betuweroute. We will discuss its operational experience with the new infrastructure between 2007 and 2010. We will concentrate on non-technical issues, given our lengthy discussion of technical isues earlier in this report.

6.2 Demonstration activities

6.2.1 Introduction

The Betuweroute is in most northern part of the CREAM service network (see Figure 53).

Figure 53. The Betuweroute in the CREAM service network

The entrepreneurial motivation of Kombiverkehr to start using the Betuweroute was a mix of market opportunities, dissatisfaction with the quality of service provided by its traction supplier DB Intermodal, and logistic requirements and benefits (see Figure 54).

Figure 54. Entrepreneurial motivation of Kombiverkehr

- Access to the railway carrier business and exploration of the market to other connections and trains between Ruhr and Rotterdam
- Raise the unsatisfactory quality (punctuality <30%)
  → Punctuality target >90% (+/- one hour)
- As "profit centre" business with (until now no) low return on investment
- In context of the companies strategy the Rotterdam – Duisburg is increasingly important, because of its network interdependencies (Gateway connections along the CREAM corridor)
- Currently a good basic utilisation of loading units
- Savings in running time by using the Betuwe-Route (from 14.12.08)
  → seamless international train paths
  →more rational operation of traction unit
- Extending business by providing shunting or traction services for other customers

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Since 1999 Kombiverkehr was involved in the process of becoming a railway undertaking (see Figure 55).

Figure 55. Starting up sequence by Kombiverkehr

11.11.1999	First time assignation of German RU-licence, time limited by 30.11.2004
30.11.2004	Extension of the license by 30.11.2019
03.04.2006	Take-over of the intermodal connection Duisburg-Rotterdam by KV At that time the service suffered poor quality with significant delays (30% delay in average and with up to 24 hours)
05.2006	permanent quality meetings and finally ultimatum to DB Intermodal for achieving better quality on this connection
05.2007	Decision of the advisory board: activation of companies license/concession as railway undertaking – immediately start of the preparations
08.10.2007	1st train on its own business as RU from Rotterdam (RSC) to Duisburg (DUSS) by KV, first only on the German section; thus Dutch section first provided by partner RRF
08.11.2007	Increase of the quality rate up to 91,5% after one month of the beginning

Page: 4

All targets for this period have been met. For the sequel, see Figure 64.

In the context of the CREAM project the following activities have been carried out to reach this stage (Petri, 2010):

- Business model "company own traction" established (workpackage RA 2.2);
- Additional operating capacity on CREAM corridor procured (RA 4.2);
- Punctuality clearly updated on Kombiverkehr's own initiative (> 90%) (RA 3.2);
- Concept for using of Betuweroute developed for demonstration 2009 (RA/TA/DA 5.1);
- Demonstration MSL and ongoing continuously improvement (RA/TA/DA 5.2);
- Train concept 2009 requires very high operational quality;
- Continuation of business model subject to continues supervision of advisory board and the current development of the transport quality.

6.2.2 Initial phase

Kombiverkehr was faced with many challenges. Next to the ERTMS implementation, there were issues with operations, leasing of locomotives and IT. Some of them were similar as those experienced by its competitors. It managed to find solutions for each of them (see Figure 56).

Figure 56. Challenges and solutions found by Kombiverkehr

- Quality / punctuality: dependencies on traction / terminals / track closures
  → high requirements on information-management with wide range of process involved parties
- Limited time constrains for implementation vs. long running leasing contracts
  → locomotive procurement on spot-market, instead
- Demanding requirements from terminal side at Rotterdam
  → stand alone IT-solution for automated data transfer
- Kombiverkehr has to solve same problems as its competitors
  → performance driven competition
- Operative constraints require the integration of additional service providers
  → RRF shunting services at Rotterdam (no electric traction in the terminals)
  → company own locomotive (diesel) operates at Duisburg
- Application for terminal slots and for train paths (network)
  → extensive coverage and complex attendance of required application modes

The service concept

A service concept was developed by Kombiverkehr, which linked the combined transport terminals ECT Rotterdam, RSC Rotterdam, Duisburg-Ruhrort Hafen (DUSS) and

Container Terminal Dortmund (CTD). Duisburg was used as a gateway to connect tScandinavia, France, the Iberian peninsula and South- and East European countries (see Figures 57-58).

Figure 57. Concept of the commercial services until 13.12.2008

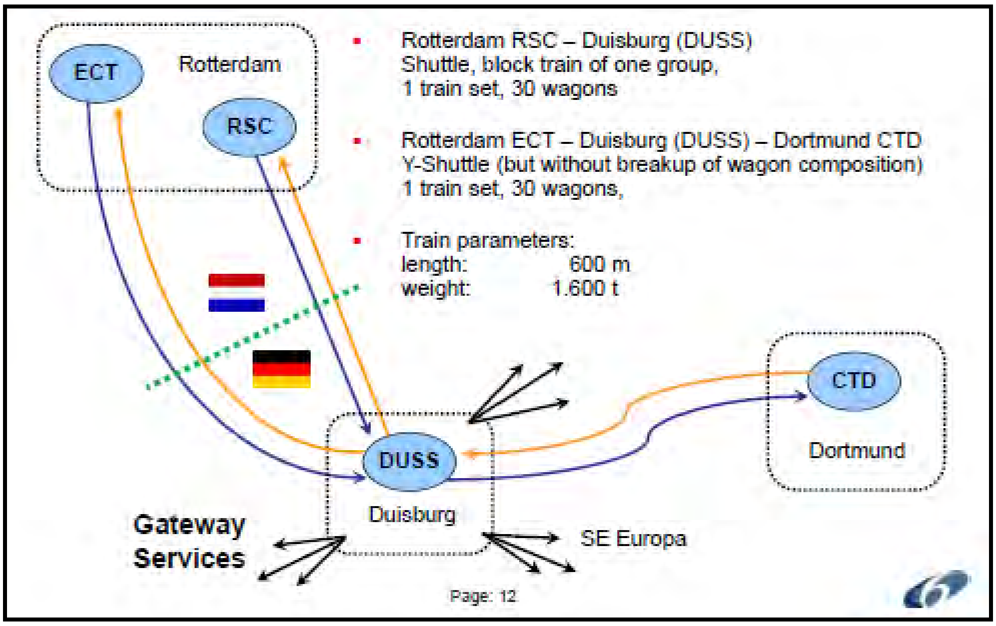
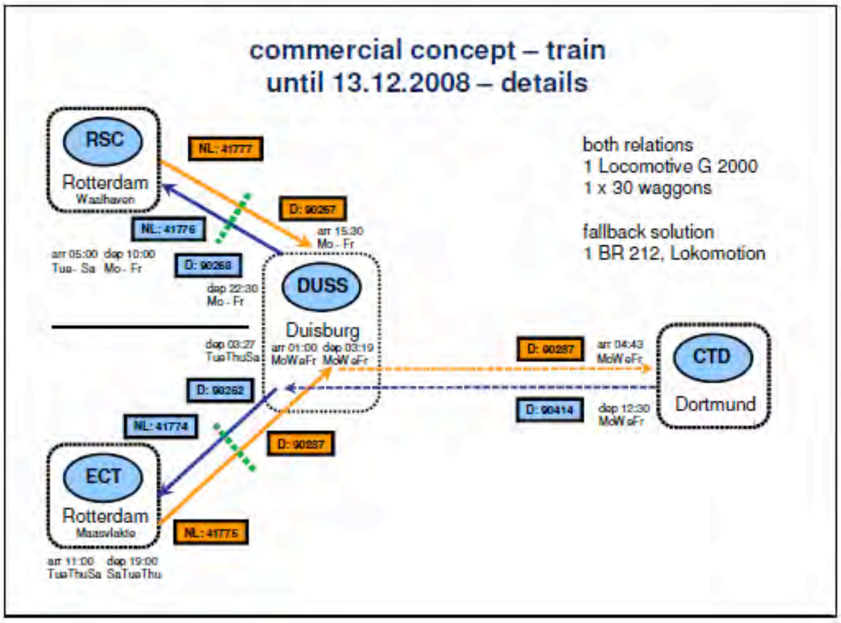


Figure 58. Train parameters



Operational concept of the service

The large number of organizations involved (see Figure 59) required a very high degree of cross-border communication and project management.

Figure 59. Companies and organisations involved

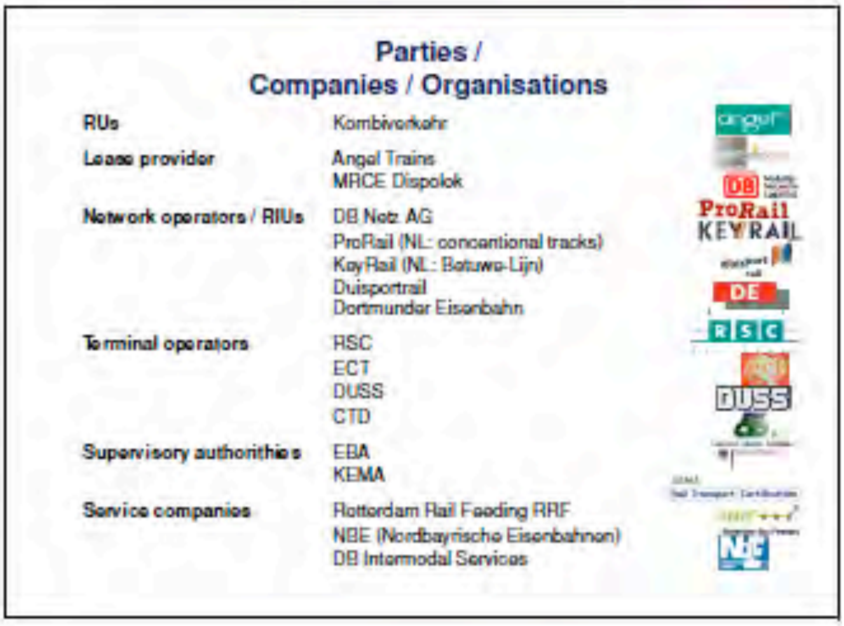
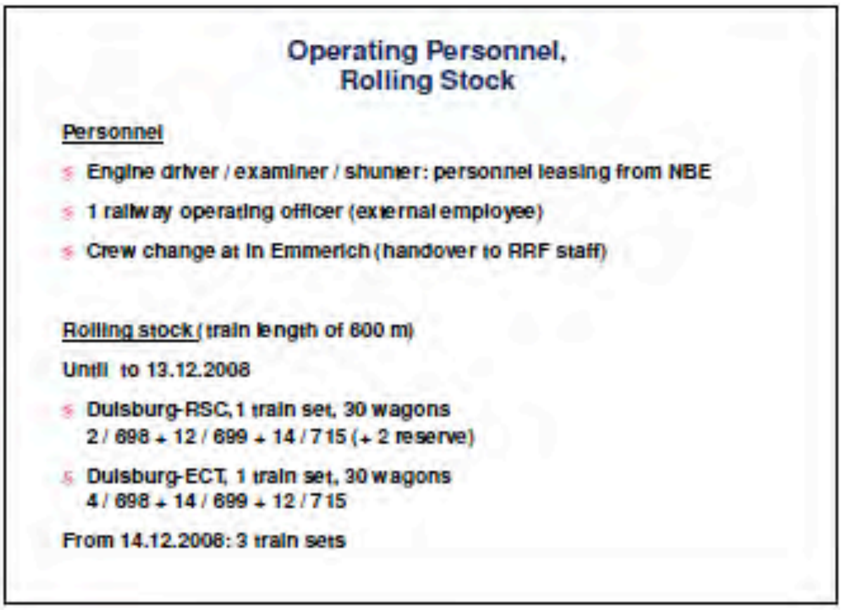
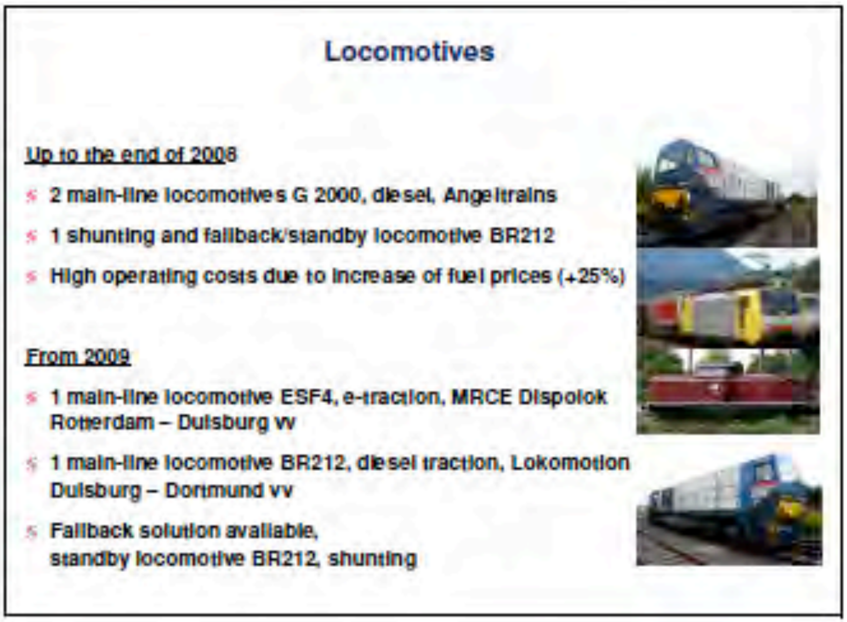


Figure 60. Operating personnel, rolling stock



Since Kombiverkehr started the number of services rose substantially (see Figure 60), while a small external staff was employed (see Figure 61).

Figure 61. Locomotives in use 2008-2009



When it started, Kombiverkehr relied on Diesel traction for running and shunting. High operational costs of diesel locomotives (rise in fuel price) and the availability of new MSL's led to a change of locomotive park. KV uses electrical traction on the Betuweroute.
The planned operating turnaround cycle for 2009 was fixed by detailed train paths (see Figure 62). The capacity utilization risk, however, was taken in its entirety by Kombiverkehr.
Since it started to operate its own trains, Kombiverkehr was able to improve the quality of services and the number of trains significantly. Most of them departed from Waalhaven RSC (see Figure 63).

Figure 62. Time table 2008-2009

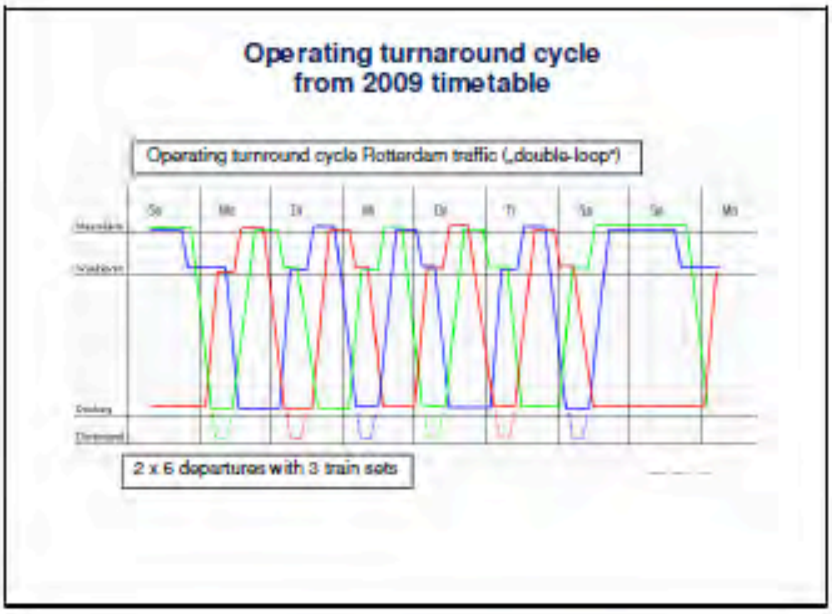
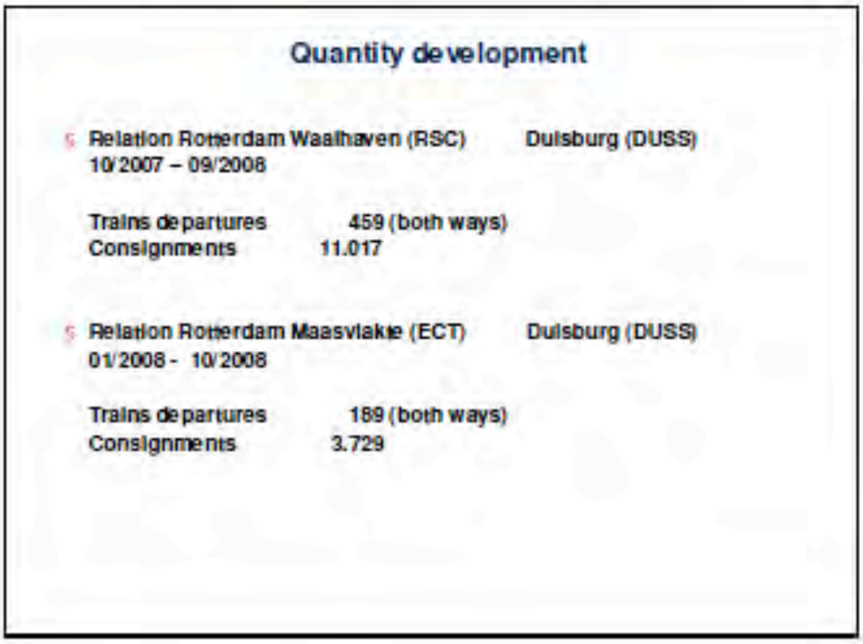


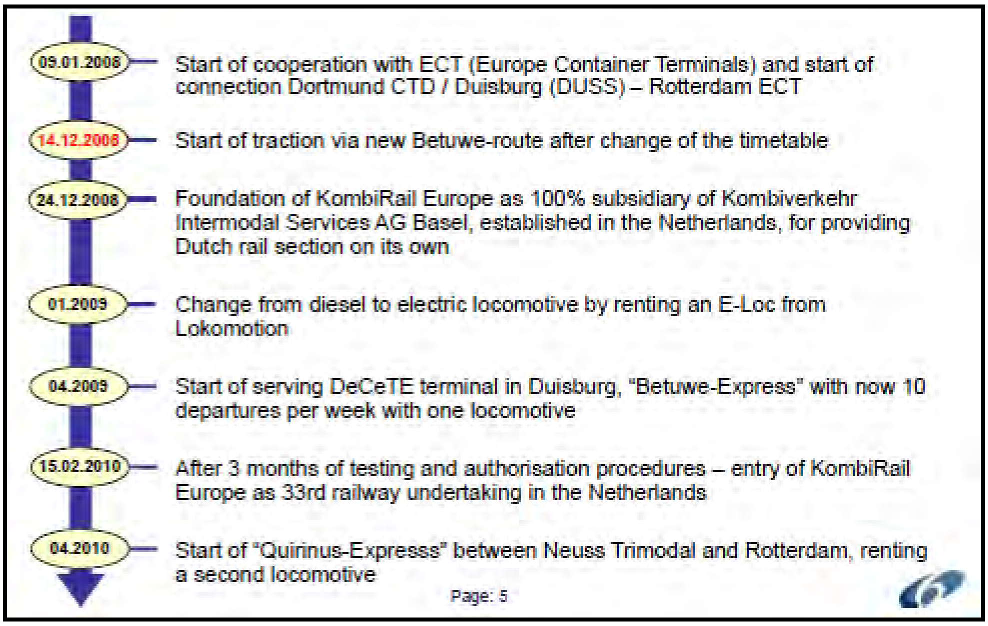
Figure 63. Train services between Rotterdam and Duisburg (DUSS)



6.2.3 Experience 2008-today

After the change of time table by December 14, 2008 and a functioning ERTMS system, Kombiverkehr shifted its trains from the Rotterdam-Gouda-Utrecht-Arnhem route to the Betuweroute. It developed its services as shown in Figure 64.

Figure 64. Development of services 2008- today



Kombiverkehr, changed operations significantly in the Rotterdam port area and in Germany (see figure 65).

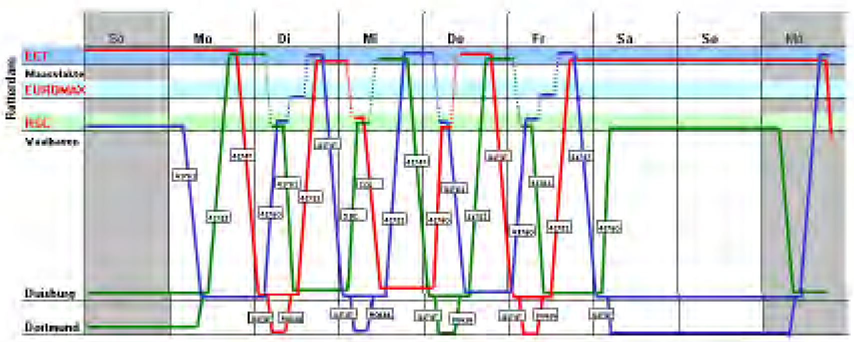
Figure 65. New services between Duisburg/Dortmund and Rotterdam

- Duisburg / Dortmund – Rotterdam:
  - Rotterdam RCS > Duisburg DUSS - block train with one wagon group
  - Duisburg DUSS > Rotterdam RCS / Euromax – Y-shuttle with two wagon groups, but without breaking up the groups
- Duisburg / Dortmund – Rotterdam
  - Rotterdam Euromax / ECT > DeCeTe / CTD – Y-shuttle with wagon groups without breaking up in Rotterdam, but breaking up in Duisburg
  - CTD / DeCeTe > Rotterdam ECT – Y-shuttle with two groups and joining in Duisburg
- Train parameters: Length: 670 m; Weight: 2.000 t; train monitoring by GPS control, Speed: 90 km/h on Betuwe-route, 100 km/h on German section, fastest run: 2:59 h from Waahlhaven to Duisburg pre-railway station

Service frequencies for these destinations can be found in Figure 66.

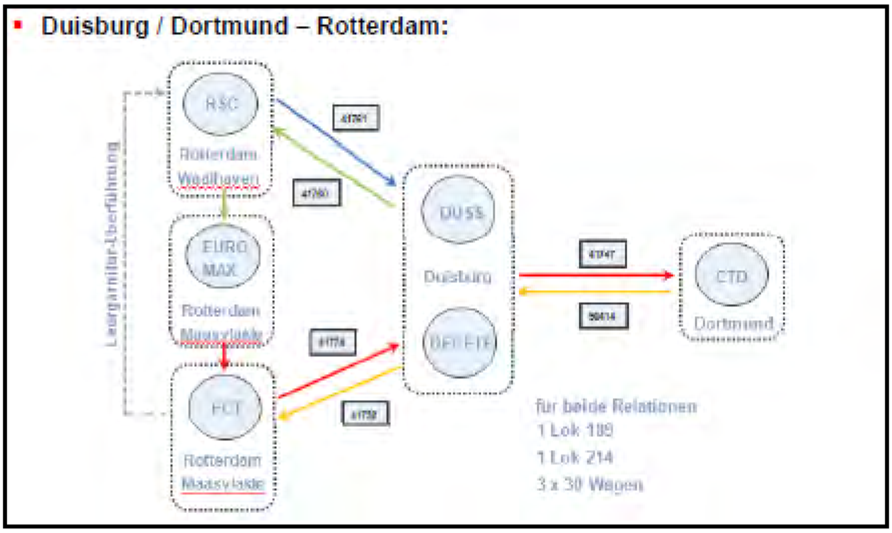
Figure 66. Duisburg/Dortmund-Rotterdam daily services

- Duisburg / Dortmund – Rotterdam:



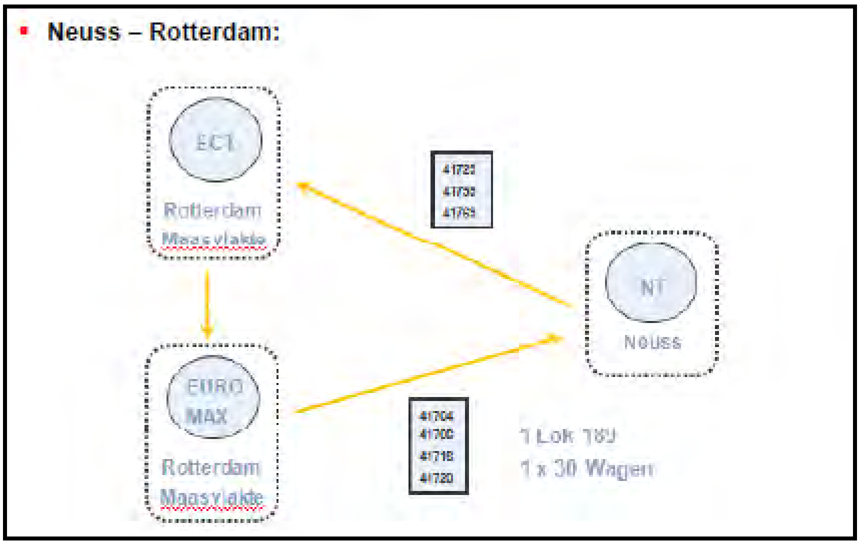
Kombiverkehr now serves three terminals in Rotterdam, two in Duisburg and one in Dortmund (see Figure 67).

Figure 67. Network concept (1)



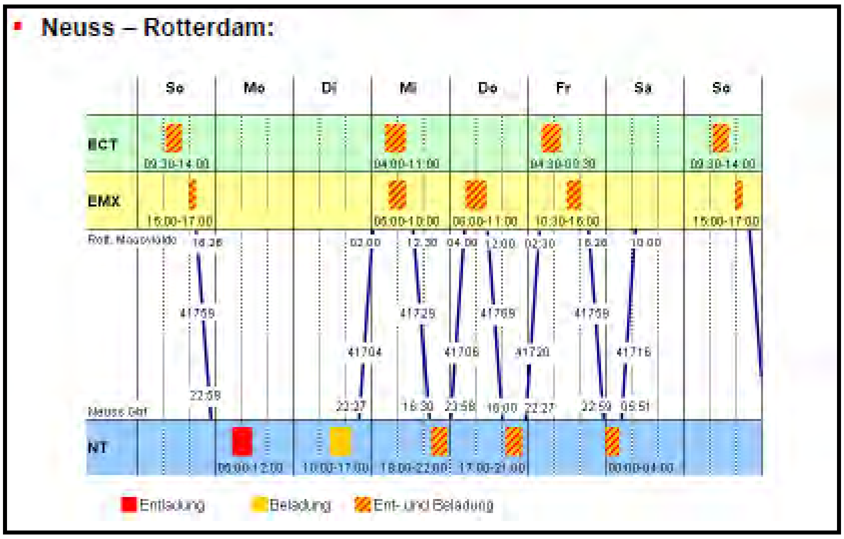
Next to this network, there is also a direct relation between Rotterdam (two terminals at Maasvlakte) and Neuss. This service includes train composition in Rotterdam. The frequency is less than in case of the Rotterdam/Duisburg/Dortmund-service (see Figure 68).

Figure 68. Network concept (2)



Time schedules of this service vary due to inhomogeneous time slots (see Figure 69).

Figure 69. Neuss-Rotterdam services



Due to the extension of the network, the number of actors involved in Kombiverkehrs' service network also increased (Figures 70-71).

Figure 70. Actors involved in the network (1)

Operators	Optimodal (maritime)
	Kombiverkehr (continental)
RUs	Kombiverkehr, KombiRail Europe
Lease provider	MRCE Dispolok
Network operators / RIUs	DB Netz AG (DB Energie)
	ProRail (NL: conventional tracks)
	KeyRail (NL: Betuwe-Lijn)
	Duisportrail
	Dortmunder Eisenbahn
	Neuss Düsseldorfer Häfen

Figure 71. Actors involved in the network (2)

Terminal operators	RSC
	ECT
	DeCeTe
	DUSS
	CTD
Supervisory authorithies	EBA
	IVW
Service companies	Rotterdam Rail Feeding RRF
	NbE (Nordbayrische Eisenbahnen)
	DB Intermodal Services

The corresponding development in the number of staff involved and traction power is shown in Figures 72-73.

Figure 72. Change of staff 2008-2010

<u>Personnel</u>

- Engine driver / examiner / shunter: personnel leasing from NBE
- 1 railway operating officer (external employee)
- Crew change at in Emmerich (handover to RRF staff)

<u>Rolling stock</u>

Until to 13.12.2008

- Duisburg-RSC,1 train set, 30 wagons
  2 / 698 + 12 / 699 + 14 / 715 (+ 2 reserve)
- Duisburg-ECT, 1 train set, 30 wagons
  4 / 698 + 14 / 699 + 12 / 715

From 14.12.2008: 3 train sets

- Neuss-Rotterdam, 1 train set, 30 wagons

Kombiverkehr used the services of one provider, KombiRail, to purchase electricity, traction and personnel. This provided a high level of quality, cost savings and a better insight in its operations.

Figure 73. Locomotives in use 2008-2010

In Figure 74, the development in transport between Rotterdam (RSC and ECT) Duisburg (DUSS) is visualized. No data about volumes was available.

Figure 74. Transport between Rotterdam and Duisburg (DUSS) 2007-2010

- **Relation Rotterdam Waalhaven (RSC) ← → Duisburg (DUSS) 2007 – 2010**

	2007	2008	2009	2010 (01-08)
Trains	100	471	446	263
consignments	2.065	10.881	13.586	10.135

- **Relation Rotterdam Maasvlakte (ECT) ← → Duisburg (DUSS) 2007 – 2010**

	2007	2008	2009	2010 (01-08)
Trains	71		88	13
consignments	403		2.097	242

6.3 Evaluation and outlook

Since it established the business model of a company with its own traction, Kombiverkehr operates as an international railway undertaking. It succesfully demonstrated its concept for using the Betuweroute, including the use of multi-system locomotives. It has fulfilled its targets with respect to expanding its business and improvement of punctuality, and is still improving its operations.

Kombiverkehr mentions the following key experiences from the demonstration:

- reliability and quantity of the services are only attainable with simple production concepts;
- e-traction and the Betuweroute are advantages for a good operation of the services;
- cross-border collaboration is performing well;
- one-stop-shop must establish itself, collaboration between the network operators must be optimised;
- skilled loco drivers with required language skills are hard to find;
- on such short relations it is necessary to run with long trains (1.000 m train) to operate efficiently;
- difficulties with ERTMS during the start-up phase have been eliminated. ERTMS is now running solid;
- communication is very important;
- selling railway services is not a fast selling item, it requires a permanent organisation;
- harmonisation of infrastructure use is still required.

For the near future, Kombiverkehr expects the following:

- extending departures between Rotterdam and Duisburg;
- 44 trains per week in 2011;
- Unbundling of the respective services;
- Further simplification of the operations.

7. Final observations and recommendations

7.1 Introduction

This chapter concludes with a series of observations regarding the many demonstration activities of the Betuweroute. Due to the fact that many technical issues were the direct result of design and financial choices, it is inevitable to refer to the planning and construction phases as well, even though they are not part of the original workpackage description.

7.2 Technical/operational issues [61]

In this area the following issues should be mentioned:

1) A Design & Construct (D&C) contract governed the construction of the A15-trajectory of the Betuweroute. This type of contracting had important negative consequences:

a) Project management. Cost saved during the construction and an inadequate supervisory culture at ProRail led to a lower than acceptable quality of the infrastructure. As a consequence, key systems, such as ERTMS, were not ready when Keyrail started its business. A lot of time and money was needed to raise the quality of the infrastructure to an acceptable level;

b) Issues related with transport were neglected during the construction phase. Railway undertakings and lease companies were not involved in decision-making from the start, which led to lengthy discussions and a tendency to postpone investments in ERTMS equipment by these companies. This led to a slower introduction of ERTMS-certified locomotives and higher costs for the government;

Another important factor was that the project organisation changed during the project.

Finally, due to the many technical issues, commercial operations were delayed by two years.

Recommendations:

- A project like the Betuweroute should be managed as an integral transport project;
- Life-cycle costs should replace investment cost as a key parameter in decision-making during the tendering and the construction phases of a project like this.

[61] Partially based on Klink et al. (2010).

2) The use of innovative technologies changes project risks in several ways:

a) Suppliers are usually too optimistic when offering a new technology to (potential) users. They tend to shift development risks (delays and additional cost) towards infrastructure providers/the government and railway undertakings;

b) Combining several new technologies into one project tends to increase project risks and makes project management very complex;

c) The project faces the problem of becoming an 'open end' project, which by definition leads to higher costs than initially planned.

Recommendations:

- Governments should commission a technical risk analysis before the start of a complex project like the Betuweroute. In case of innovative elements, a proper risk analysis forms the basis for the choice between either to continue and reserve additional budget in order to deal with project risks and unforeseen problems or to use conventional technology;
- The obligation by the EU to apply ERTMS on new lines, while the technology was far from ready for (large-scale) deployment, stimulated technical innovation, but it also introduced major project risks and led to additional costs. A similar situation can be seen by the very complex tunnel technical installations, which have been developed to make tunnels more safe. A study into the real benefits of these technologies and their distribution over the parties involved or influenced by these new technologies is a logical sequel.

The construction of the A15-trajectory faced a rough learning curve. During the *conversion of the Port Line*, the lessons learnt from the A15 experience were used to prevent repetition of the learning curve. Here process management was given adequate attention. This project was managed by a Steering Group consisting of all relevant stakeholders, with specialised subcommittees dealing with specific issues.

Recommendations:

- The growing importance of safety technical issues in rail projects makes it necessary to give the Ministry of Transport, Dpt. IVW (safety) a leading role;
- The separation between infrastructure management and transport operations does not help to make ERTMS system integration a smooth process. A (legal) solution should be found enabling proper monitoring and supervision of ERTMS projects and

communication channels to exchange of information between infrastructure-related and train-related projects;

- A common strategy for passenger transport in Europe for the year 2040 is needed. This goes well beyond the present political discussion, which mainly deals with infrastructure investment programs. Only in this way tracks and rolling stock will be used in the most effective way throughout Europe in future.

4) Communication between technical experts and policy-makers with a non-technical background frequently leads to frustrations on both sides. We have seen a particular example of this phenomenon in the discussion regarding safety of the A15-trajectory. Safety discussions contributed to the complexity of the Tunnel Technical Installations (TTI) and the discussion regarding acceptable working conditions for fire fighters.

Recommendations:
- Future infrastructure projects should not be compromised by including technologies that are still under development. Specs should be based on proven technology and change of scope should be reduced to an absolute minimum;
- It is vital to work within stable and simple institutional arrangements during a project. Since a few years, Dutch legislation has changed drastically, making decision-making simpler and more straightforward (at the cost of a reduced (impact of) public participation).

7.3 Economic issues

The number of trains using the Betuweroute is well below the economic break-even point. A major growth in the number of trains is a necessary condition for a financially sound exploitation of the Betuweroute. Macro-economic conditions have a direct and measurable impact on transport volumes.
Financial tools like rail user charges and other tools like fees and penalties can be used to stimulate changes of behaviour of users. The pricing mechanism is a potentially strong instrument, but it should be used carefully given the small financial margins in rail freight transport. The impact of economic incentives on behaviour of Keyrail's customers is limited. A major cause is the conservative mentality in the railway sector. But also the 'cap' on the fees prevents a more than marginal impact for the time it is in place.

Customers should be aware of the real cost of using the infrastructure (including terminals) and services. They should also be aware that planning should become more strict and understand the consequences of their own optimization efforts for other parties in the transport chain, including their competitors. This is also an inherent issue in Chain Management. Problems have to be put on the table. Then they can be analyzed in depth in order to see where the chances for optimization can be found and to properly divide the benefits among those involved.
Capacity management will evolve over time, as operational experiences become embedded in contractual arrangements and working habits.
The Betuweroute will become better integrated into the European corridors, in particular Corridor A, if infrastructure managers improve they way they cooperate. Harmonization of time tabling and of rules and procedures (including the way local RCC operates) is necessary to achieve this. Integral train paths, reserved by improved OSS, are the way to go.

Recommendations:
- Users of the Betuweroute should become more aware of the chain impact of their own operations and as a consequence adapt their operations;
- Non-discriminating financial incentives can be used for micro-tuning (optimize capacity management) within the setting provided by the macro-economic conditions;
- International rail freight services need international train paths, instead of the current practice in which national or even regional train paths are inefficiently connected. This will help to give these services adequate priority, not only in regular conditions, but in particular in case of delays in rail traffic.

7.4 Feedback from railway undertakings

The Betuweroute has become an important corridor for rail freight transport between Europe's biggest port Rotterdam and its European hinterland.
Despite the advancements made in the period 2007-2010, there are many issues still to be solved, both technical (rail infrastructure quality and reliability) as well as organizational (cooperation between rail infrastructure managers, cooperation between the parties involved in chain management/SPIN).
Keyrail's efforts, both at the national level (more intensive following of a limited number of trains, process improvements, technical renewal and upgrading) and international level (e.g., extension of chain management to Duisburg, removal of 'voltage isles', third

track in Germany) are signs that it is aware of the obstacles that lie ahead before the Betuweroute can be used as was intended by its designers.

Recommendations:

- Cooperation within the transport chain should be improved substantially in order to reap the full benefits of the existing and to be built rail infrastructure;
- Information is vital for capacity management. Current railway information systems are inadequate, as they are largely conceived from a railway technical perspective, insufficiently taking care of logistic demands;
- The idea of a 'rail master' (supervisory authority) comparable to a port master is a topic for further investigation.

Appendix 1: Keyrail's Training and Demonstration Concept

CREAM Partner: Keyrail (BREM)
Workpackage: TA5.1/DA5.1

Confirmed Training and Demonstration concept
(Capable to meet the requirements discovered and documented in the research part / coordinated and agreed with the WPL)

<table>
<tr><td>What will be trained and demonstrated (main topics as bullet points):</td></tr>
<tr><td>Description of improvement measures:

• Achieve a seamless integration process of the Betuweline into the European rail network by structured staff training
• Demonstrate the advantages of an efficient implementation concept of the Betuweline in the incumbent European rail infrastructure; including a maintenance concept for a new high tech infrastructure</td></tr>
<tr><td>Concept for Training:

• Identification of improved processes (as developed in RA 5.1) that require a training of the involved staff:
    o Traffic controllers: deployment schemes
    o Maintenance supervisors: Hand Held Terminal
    o Traffic controllers, drivers: ERTMS level 1, 25 kV traction supply
• Deduction of detailed requirements for the staff training
• Development of a training concept, considering training measures, tools, objectives and schedules
• Selection of potential training candidates of operational, infrastructure maintenance and managerial staff for the integration of the Betuweline
• Performance of training events</td></tr>
<tr><td>Concept for Demonstration:

• General:
    • Step-by-step implementation of the technical / operational implementation plan of the Betuweline
    • Field evaluation of the technical / operational plans and coordination loop with RA 5.1 if necessary
    • Implementation of the economic implementation plan developed in RA 5.1
    • Performance of a coordination loop with the RTD activities if necessary
    • Achieving the required high level of commitment by continuous feedback / coordination procedures with the Railway Undertakings involved
    • Demonstration operational trains Rotterdam-Duisburg/Dortmund by KV
• Specific:
    • Impact of environmental permits for shunting yards, especially Kijfhoek and IJsselmonde
    • 'Ketenregie' on Harbourline: development of ICT tool, pilot, extension to all companies involved
    • Implementation scheme 25 kV traction supply and ERTMS level 1 train</td></tr>
</table>

protection on Harbour line • Availability of ERTMS level 1 equipped locomotives (certification, problems with braking curve) • Analysis and solution of problems with (too) advanced and partly unreliable Tunnel Protection Systems • Test with 1000 m freight train • Introduction and extension of the Condition Dependant Maintenance concept • Evaluation of usage of Hand Held Terminal • Coordination of through-going train paths on the corridor Rotterdam – Duisburg with RU's, DB Netz and ProRail • Increasing capacity in the Sophiatunnel • Availability of ERTMS level 2 equipped locomotives • Monitoring ERTMS system behaviour ('teething problems') • Usage stimulation (fees for electricity, train paths, parking)
Geographical scope of Training / Demonstration (Place / Section / Country or Route): • Betuweroute (A15 + Harbour Line) and connections in NL and extension into Germany
Coordinated and confirmed with the following partners: • OTB and KV

By whom will it be trained and demonstrated:
Companies taking part in Training and Demonstration potentially also including non-CREAM partners (e.g. infrastructure, customs,…): • Keyrail, RU's, neighbour infra providers (DB Netz, ProRail), maintenance subcontractors
Departments responsible for or involved in Training and Demonstration: • Keyrail: staff DLS and AM, management, Operations • RU's: departments responsible for drivers, training and planning • Infra providers: planning departments • Maintenance subcontractors: staff for safety and regulations
Kind of personnel allocated for Training and Demonstration: • Keyrail: traffic controllers • RU's: drivers, maintenance personnel • Infra providers: planners • Maintenance subcontractors: work supervisors

When will it be trained and demonstrated:
Schedule for Training activities (Start / End / Important Phases / …): • 1.1.2008 -31.12.2009: deployment scheme, usage of HHT • 1.7.2009 – 30.11.2009: ERTMS level 1
Schedule for Demonstration activities (Start / End / Important Phases / …): • 1.1.2008 - 30.6.2010: Implementation plan of the Betuweline • 1.7.2008 – 30.6.2009: Impact of environmental permits for shunting yards, especially Kijfhoek and IJsselmonde • 1.6.2009 – 30.6.2010: 'Ketenregie' on Harbourline: development of ICT tool, pilot, extension to all companies involved • 1.12.2008 – 1.3.2010: Implementation scheme 25 kV traction supply and ERTMS level 1 train protection on Harbour line • 1.12.2008 – 1.10.2009: Availability of ERTMS level 1 equipped locomotives (certification, problems with braking curve) • 1.10.2008 – 30.6.2010: Analysis and solution of problems with (too) advanced and partly unreliable Tunnel Protection Systems • 1.7.2008 – 31.12.2008: Test with 1000 m freight train • 1.1.2008 – 30.6.2010: Introduction and extension of the Condition Dependant Maintenance concept • 1.1.2009 – 30.6.2009: Evaluation of usage of Hand Held Terminal • 1.1.2008 – 30.6.2010: Coordination of through-going train paths on the corridor Rotterdam – Duisburg with RU's, DB Netz and ProRail • 1.7.2008 – 30.6.2010: Increasing capacity in the Sophiatunnel • 1.1.2008 – 30.6.2009: Availability of ERTMS level 2 equipped locomotives • 1.1.2009 – 30.6.2010: Monitoring ERTMS system behaviour ('teething problems') • 1.1.2008 – 31.12.2009: Usage stimulation (fees for electricity, train paths, parking)

What is the confirmed budget for Training and Demonstration:
Budget for personnel deployed on Training (Person-months): • 4 manmonths
Budget for personnel deployed on Demonstration (Personal-months): • 16 manmonths

Other expenses (investments, …) allocated for Training and Demonstration (Euro per respective topic): • € 10000,- Training • € 150000,- development ICT tool for Demonstration Ketenregie

Documentation and deliverable (Main content / Delivery date): • TA 5.1 ready end of Q3 2009 • • DA 5.1 ready end of Q2 2010 •
Success Criteria, Performance Indicators and validation methodology: • Preparation of involved staff in view of a successful Demonstration Activity 5.1 (expected result) • Implementation of the concept developed in RA 5.1 in pre-commercial daily operation (expected result)\\ • Cooperation of RU's • Cooperation of neighbour infra providers

We confirm that we have an adequate Training and Demonstration concept in order to secure the smooth implementation of the related activities.

Furthermore, we confirm that the personnel mentioned above are allocated for the Training and Demonstration activities in the given timeframe.

The other expenses stated above are approved by our management!

We confirm that the Training and Demonstration activities will be performed and documented according to the timeframe stated above.

14.4.2009 ________ ______________________________
Date, Place *Signature / Stamp*

Update June 2010

The agreed extension of workpackage DA 5.1 until the end of December 2010 allowed treatment of two additional demonstration/study projects – removal of 'voltage isles' and extension of Chain Management to Duisburg and updating of information about the other demonstration projects.

Appendix 2: Railway safety engineering and ERTMS

A) Elements of a signalling system

A signalling system consists of these vital elements (Bailey, 1995):

- train detection, by track circuits and axle counters;
- control and detection track elements, such as points, crossings etc.
- method of interlocking of points and signals;
- indications to the driver by trackside signals or cab signalling;
- enforcement of signal controls on the train with train stops or ATP;
- braking characteristics of rolling stock using the line.

B) System design criteria

Safety-related technical systems are designed using the following criteria (Pizarro in Bailey, 1995, p. 241):

- "availability (item is in a state to perform a required function under given conditions at a given instant in time or over a given time interval, assuming that required external resources are provided);
- dependability (available and safe);
- maintainability (the probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval, when the maintenance is performed under stated conditions using stated procedures and resources;
- reliability (the probability that an item can perform a required function under given conditions for a given time interval)
- fail-safe (a signalling system installation is said to be intrinsically safe or fail-safe, when a failure affecting safety takes place, the system will then pass to a situation known and accepted as safe, that means freedom of unacceptable levels of risk)."

C) ERTMS system elements

ERTMS train protection and monitoring systems consist of hard- and software systems. We will mention the most relevant here.

C1) Trackside

Eurobalise (ERTMS)

The purpose of the Eurobalise is to store infrastructure data as pre-formatted 'telegrams' (position reference, speed limits, line gradient, works on the line, etc.). The balise is energised by power from the train antenna. When energised it transmits train movement authorities and trackside data (telegrams selected by LEU) to the on-board equipment in order to advise the train driver and the on-board ATP processing unit about the train positioning and the conditions of the track and traffic ahead, and hence take the appropriate actions for train speed and for the protection of the train itself, passengers and infrastructure alike (Ansaldo STS, 2010a, b).

Line Side Unit (LEU)

Purpose of a Line Side Unit (LEU) is to interface with interlockings or automatic block logic or signals, in order to acquire traffic information and to convert this into conditioning messages to be sent to the appropriate balise for retransmission to and subsequent processing by the on-board equipment (OBU). This is accomplished through electronic units called Lineside Encoder Units (LEU) (Ansaldo STS, 2010b).

Balise Transmission Module (BTM)

The BTM supplies energy for telepowering the balises and to receive and decode the telegrams coming from the balises (Ansaldo STS, 2010a).

Radio in-fill Unit (RIU) – Level 1

The purpose of the Radio In-fill Unit is to transmit the message corresponding to the Eurobalise in advance with respect to the Eurobalise placed at the signal. In this way, a train approaching a red signal can revoke braking as soon as the signal clears without the necessity to actually see the signal physically.

The In-fill message is transmitted via radio using GSM-R and Euroradio safety protocols, as in ERTMS Level 2. The use of radio allows a continuous in-fill coverage at unlimited distance from the signal (Ansaldo STS, 2010a).

Odometry (ERTMS)

Odometry uses data about the movement of actuators to estimate change in train position over time.

C2) Trainborne

On Board Unit (OBU)

The main functions of an OBU are (Ansaldo STS, 2010b):

1. Receipt and analysis of the information about trackside status and characteristics of the movement authority (MA) sent by Eurobalise or by the Radio Infill Unit;
2. Calculation of the speed profile in relation to the train characteristics which are already stored on-board;
3. Selection of the most restrictive speed value to be observed at the locations ahead;
4. Comparison between the train's actual speed with the permitted speed and, if necessary, automatic brake application;
5. Display of indications and provision of alerts / warnings to the driver.

DMI (ERTMS)

Vital information relating to the safe control of the train is displayed on the 'driver-machine interface' (DMI) inside the active driving cab. The DMI displays the distance to the EoA and the train's actual speed, as well as the permitted speed and target speed. The colour of the speedometer display changes from white to yellow if a reduction in permitted speed is necessary. If the driver fails to reduce speed as required, the speedometer display changes to orange and a warning horn sounds. If speed remains unchanged, the display turns red and a full emergency braking is automatically initiated.

D) ERTMS operating modes

The common European ERTMS operating modes are explained in Table 7.

Table 7. ERTMS operating modes (European standard)

Symbol	Mode	Description
	Full supervision (FS)	This is the normal non-permissive movement authority, giving full protection. The train is permitted to run at the maximum speed shown.
	On sight (OS)	This movement authority allows the train to enter an occupied section of line. The train must proceed at such a speed that it can stop short of any obstruction. The speed is supervised up to a ceiling speed. On sight mode can be received while the train is in motion.
	Shunt (SH)	This mode is used during shunting. The train's speed is supervised up to a ceiling speed. Display of the Shunt symbol is not an authority to move the train.
	Non-leading (NL)	This mode is selected on the rear traction unit when running in tandem or banking, etc. It provides limited supervision.
	Staff responsible (SR)	This mode allows the train to be moved under the driver's own authority on an ERTMS equipped line. The train's speed is supervised up to a ceiling speed.
	Standby (SB)	This is the default mode, automatically selected when opening or shutting down the driver's desk.
	Unfitted (UN)	This mode is selected when driving on lines not fitted with ERTMS. The DMI will display no information other than the train's speed, in miles per hour, which is supervised up to a ceiling speed.
-	Trip (TR)	This mode is automatically selected in the event of a movement authority being exceeded, until acknowledged by the driver. An emergency brake demand will occur.
-	Post trip (PT)	This mode follows an emergency brake demand, once the driver has acknowledged the trip and the train has come to a stand.
-	Sleeping (SL)	Where a locomotive or unit has more than one set of ERTMS equipment, only one set can be active at any time. The other sets will be in Sleeping mode.
-	System failure (SF)	This mode is associated with failure of the ERTMS system and is accompanied by an emergency brake demand.
-	No power (NP)	This mode is entered when no power is applied to the ERTMS system. It is accompanied by an emergency brake demand.
-	Isolation (IS)	This mode applies when the driver has isolated the ERTMS following a system failure.

Table 1: ERTMS Operating Modes.

Source: http://www.railsigns.co.uk/info/ertms1/ertms1.html.

These modes are explained in more detail below.

Technically supervised mode FS

There is one normal operating mode in ERTMS, which is the technically supervised mode called FS or Full supervision of the train. On the Port Line allowed maximum speed is 80 km/h on running lines and 100 km/h inside the Botlek tunnel. Speed and braking curves are monitored and the driver is overruled by an emergency brake in case of non-compliance.

On sight mode OS

A train driver is allowed to use a track which is partially in use with low speed. MA is used to supervise a certain speed profile until a certain point. Technically comparable to FS mode.

Procedural supervised mode SR

Staff responsible mode. Ability to run a train without MA. Allowance from RCC staff necessary. Technical supervision of maximum speed (40 km/h max or 30 km/h on the A15-trajectory) and maximum distance.

Shunting mode SH

A train driver is allowed to move a train forward and backward and to perform all relevant shunting procedures. Technical supervision of maximum speed and border of shunting area. Automatic braking occurs in case of movement outside shunting areas (sidings). In order to go from a siding to a running line, the driver has to stop the locomotive and restart ERTMS. This causes a delay for the operator and deteriorates line capacity.

SR and SH do not supervise the braking curve. This means that the train driver can pass a red signal if he overrides the ERTMS mode. If the train driver receives a written order allowing him to do so, this is called O-EoA or Override End of Authority. After 60 seconds an automatic emergency braking procedure starts, triggered by the next balise. A restart of ERTMS prevents this automatic braking.

SB/Standby includes braking curve protection, to prevent uncontrolled movement (rolling away).

SF/System failure. In case of system failure, MA will be reduced, but RCC will not be informed. In case of train repairs or hauling of faulty trains, such trains are not allowed to enter the running line again after they left it.

IS/Isolation (ERTMS is switched off in the train). In this case a maximum speed of 30 km/h is allowed. This is also a procedural supervised mode.

RBC Failures:

- NORBC: no connection with RBC. The train driver will not receive MA to continue, and ERTMS will engage an automatic emergency brake. After communication with RCC by GSM-R, RCC can define a train path for this train if necessary because of commercial reasons. Procedural supervision applies. The train driver should monitor if the track ahead is free (OS). The train can run until the next SMB or signal and the procedure is repeated. The procedure is the same as when a train would have passed a non-functioning signal. There is no difference between procedural supervision with and without radio connection; in both cases the train driver should ask RCC for approval before continuing his trip.
- RBC Connecting: Trying to connect with RBC.

Train detection problems are mainly due to rust on the tracks. Additional safety measures will be applied for the selected train path (in Dutch: "VHB's, VHR-E's, ROZ, OS"). Position information is available to check whether the train is in the TAF-window.

ERTMS consists of trainborne equipment and trackside equipment. In case of Level 2, GSM-R is also part of the ERTMS installation. Another part of ERTMS, ETML (European Traffic Management Layer) or centralized traffic management, has not been developed so far.

Running tracks and sidings – Port Line

The Port Line consists of running tracks and sidings. Only the running lines are supervised by ERTMS Level 1. There are signals and (euro)balises in the track. The sidings are defined as SH-areas. To change from a siding to a running line, the train driver has to switch to SR mode. This requires a stop, end of SH mode and selection of SR mode. A fictitious signal is displayed via information from an X-balise. Its function is to ensure braking curve protection until the first signal (Meijer, 2010).

On the A15-trajectory all track sections are supervised, there is no 'free track'.

Movement authority (MA)

In fixed block systems, main tracks are divided into block sections in order to separate trains safely. If trains run according to the time table, then a minimum separation in time (or headway) [62] is established and trains can move safely and swiftly through the rail network.

A train is not allowed to enter a block section until this is cleared by the train in front of it. At any moment in time, there can only be one train in one block. The time a train stays exclusively in a block is called the blocking time.

The blocking time is determined by the following (Pachl in Theeg et al., 2009, p. 53-54):

- "the time for clearing the signal;
- a certain time for the driver to view the clear aspect of the signal in rear that gives the approach aspect to the signal at the entrance of the block section (this can be the block signal in rear or a separate distant signal);
- the approach time between the signal that provides the approach aspect and the signal at the entrance of the block section;
- the time between the block signals;
- the time to clear the block section and – if required – the overlap with the full length of the train;
- the release time to 'unlock' the block system."

In conventional signalling systems, trackside signals indicate if a train may enter the track section beyond that (block) signal. In other words, a train needs a MA. The signal also indicates at what speed the train is allowed to move forward inside the signal block. For speeds higher than OS speed (30-40 km/h max) the stopping distance is in general greater than the distance the driver can see ahead, hence the signal requires an approach (warning) aspect. This is an additional distance, allowing the train to brake safely before a stop signal. The block length is therefore always much longer than the length of the train.

ERTMS transmits a MA to the train, specifying the permitted travel distance and data about the track ahead, such as speed restrictions (variable data) and gradients (fixed data). MA is only possible after a path is defined and given (in Dutch: "rijweginstelling") by Rail Traffic Control (RCC) staff.

The signal colour corresponding with the MA will lit. MA starts after the first balise on the running line is passed. It ends in front of a main signal (or stop marker board (SMB) on the A15-trajectory). So, in order to continue, a train driver needs to have at least two MA's for subsequent track sections.

[62] This principle is called train separation by time spacing (Pachl in Theeg et al., 2009).

A train with MA has braking curve protection. If the actual speed of a train is lower than the release speed, there will be no emergency braking. For supervised signals the release speed is 15 km/h, for P-signals 30 km/h. Stay time in a signal block/section is monitored by means of a section timer. A section timer is a mechanism in ERTMS aimed to reduce the validity period of a MA. It prevents that a train in case of a recall of a signal could still have a MA for the released route in front of the train (Meijer, 2010).

On the Port Line, most balises have their section timer programmed at 120 seconds for P-signals and (route timer – 10 seconds) for managed signals. The timer starts after receipt of an MA by the train. The timer is reset at each following (infill) balise group. As long as a train moves with the intended speed, it will not be 'trapped' in a time-out situation (End of MA or EoA). EoA is only relevant for sections in front of the train, not for the section in which the train already is.

This timer is very relevant for long and heavy freight trains. If a train driver exceeds the 120 seconds mark, he has to contact RCC staff before being allowed to continue his trip. But, the system does not prevent the train driver from departing, because this is a procedural and not a technically supervised mode.

The procedure to switch ETCS equipment on and off is not standardized and may as a consequence vary per train type (supplier).

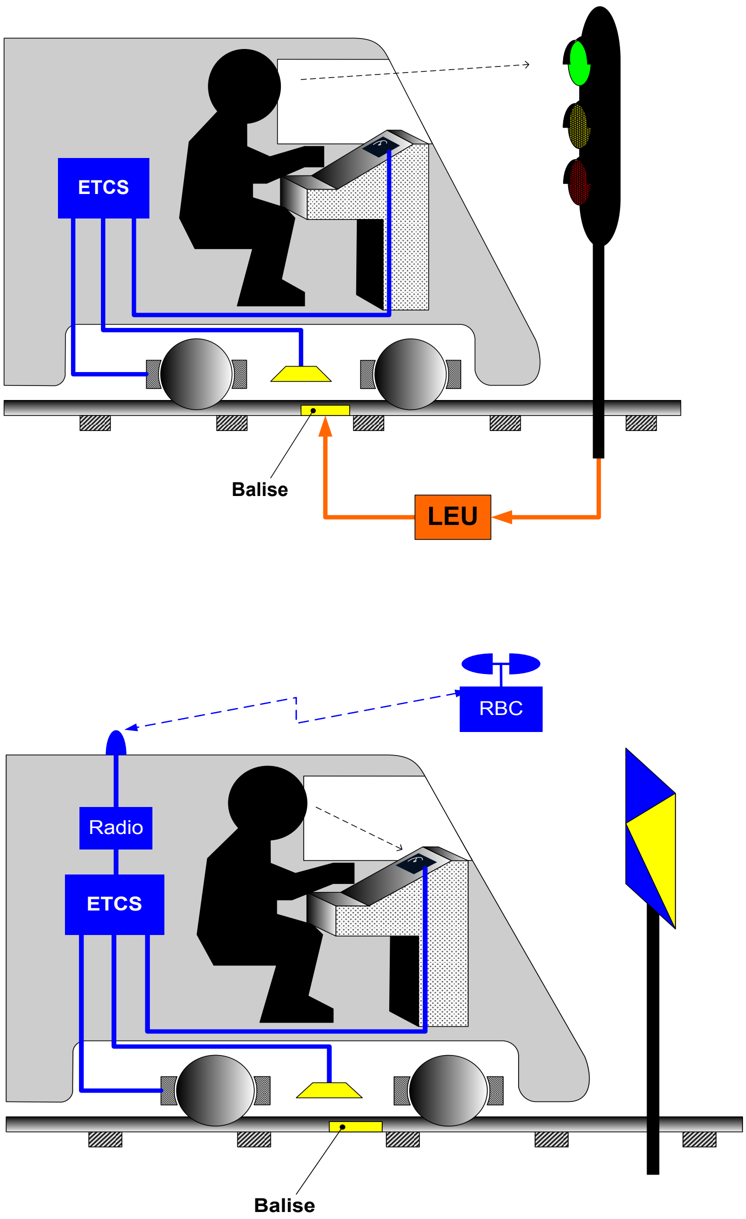
E) ERTMS (Application) Levels

There are three distinct levels of ERTMS. Level 1 and 2 are now operational in many countries in the world (see Figure 75). Level 3 is still in the design stage.

Level 1 and 2 deal with similar operational situations, but the systems consist of different technical elements. ERTMS Level 1 is a Train Control System based on track-to-train communication by an intermittent system (discontinuous information). Its main features are (Ansaldo STS, 2010b):

- Possible Overlay to a pre-existing signalling system;
- Movement Authorities and position reference through Eurobalise;
- Train Integrity & Position by Track Circuit.

Figure 75. ERTMS Level 1 (above) and Level 2 (below)



Level 2 is based on continuous information. Information is also supplied to the train driver in a different way:

- With Level 1, MA's are transmitted via trackside units (balises and LEU). Passive and active balises are used. Active balises are connected by cables. This requires an enormous amount of cabling (700 kms for the Port Line).

- With Level 2 RBC transmits to every train (via GSM-R radio) the speed and the train distance to be observed depending on the position of all the trains present on the line (train distancing) and the constraints imposed by the track, or by any temporary slowdowns at that particular moment. At the same time, the trains send out radio signals indicating their position to the central unit. On the basis of the route set by the interlocking and the position of the train, the RBC transmits *authorisation to proceed* data to the train driver, with details about the free distance and the maximum permitted speed (RFI, 2005). Balises are passive, used for geo-information reference only, not for sending MA's, hence they need no cabling.

Table 8 summarizes the equipment employed in different ERTMS Levels.

Table 8. ERTMS Levels and equipment

On Board			Trackside			
Level	Check of train integrity	Data transmission	LEU	Signals	Track occupancy detection	Radioblock
1	No	Balises + loops (option)	Yes	Yes	Yes	No
2	No	Balises + radio	No	No	Yes	Yes
3	Yes	Balises + radio	No	No	No	Yes

Source: RFI, 2005.

In comparison to the present ATBEG system, the following stays the same on the Port Line (Stuurgroep Ombouw Havenspoorlijn , 2008c; Meijer, 2010):

- Infrastructure-related:
    - All signals remain in place;
    - Eurobalises will be installed inside running tracks only;
    - Sidings belong to the SH area;
    - Free tracks stay in place without supervision;
    - Functionality stays largely the same.
- Regulation:
    - The train driver <u>must</u> follow the instructions shown on trackside signal masts. In case of a conflict, their information supersedes the information on the DMI.

What will change compared to ATBEG is the following:

- ERTMS Level 1 will replace ATBEG:
    - Braking curve protection makes the system safer;
- ATBEG coding will be removed from the infrastructure:
    - Only trains equipped with ERTMS are allowed to enter the Port Line.

Compared to the A15-trajectory, the following is different on the Port Line:

- MA will be issued from a balise located near a signal (on the A15-trajectory via a radio message);
- SH mode must be used at sidings. A change from a siding to a running line is done in SR mode. During this change, the train passes an X-balise in order to allow supervision of the braking curve until the first signal;
- Level 1 must be used in order to start a locomotive;

What stays the same is that locomotives not equipped with ETCS will not be stopped. That is why they are not allowed on the Betuweroute.

Baseline

The term 'Level' specifies a specific use of ERTMS as a train control system. An ERTMS baseline refers to the currently applicable set of technical specifications. The baseline number is usually identical to the corresponding SRS document. The current baseline is 2.3.0d. Baseline 3.0.0 is work in progress. It should be backward compatible (ERTMS, 2010).

The Dutch Level 1 (baseline 2.3.0. d + future CR 504) is not compatible with other national ERTMS Level 1 implementations, such as the one in Switzerland (Stuurgroep Ombouw Havenspoorlijn, 2009h). Whether this is a problem, depends on whether the same locomotive will be used in both countries or not. In practice this is not very likely, given average distances travelled by locomotives and train drivers.

F) ATBEG inherent problem

SPAD/STS passage (ATBEG)

If an engine driver passes a red signal without authorization (in Dutch: "stop tonend sein passage" or "STS-passage") with a speed of less than 40 km/h, ATBEG does not engage a braking procedure. The train will continue its journey into the next signalling section (block). The normal headway of one separation block between two subsequent should allow this. But, if for some reason (like technical failure), this block is still occupied, then a collision is likely. A collision with a train coming from the opposite direction (in case of change of lane or crossing sections) is also possible. This gap in the safety system was meant to enable shunting procedures at stations and sidings or small moves of trains within signalling blocks. The technical complexity of the tracks at stations and sidings also made fail-safe ATBEG installations quite expensive. So, some costs could be saved by this design choice at the expense of safety. In those days, traffic was also much less intense than today, reducing the chance of collisions.

G) Port Line choices

The choice in favour of ERTMS Level 1 was based on a technical risk assessment of Level 2 (Klomp et al., 2008a). This revealed the following:

- a high risk of failing to keep with the project schedule due to development and design issues;
- the commissioning period would have been longer and more risky due to the need for more tests than previously anticipated;
- a high risk of disruption of traffic during a longer period of time.

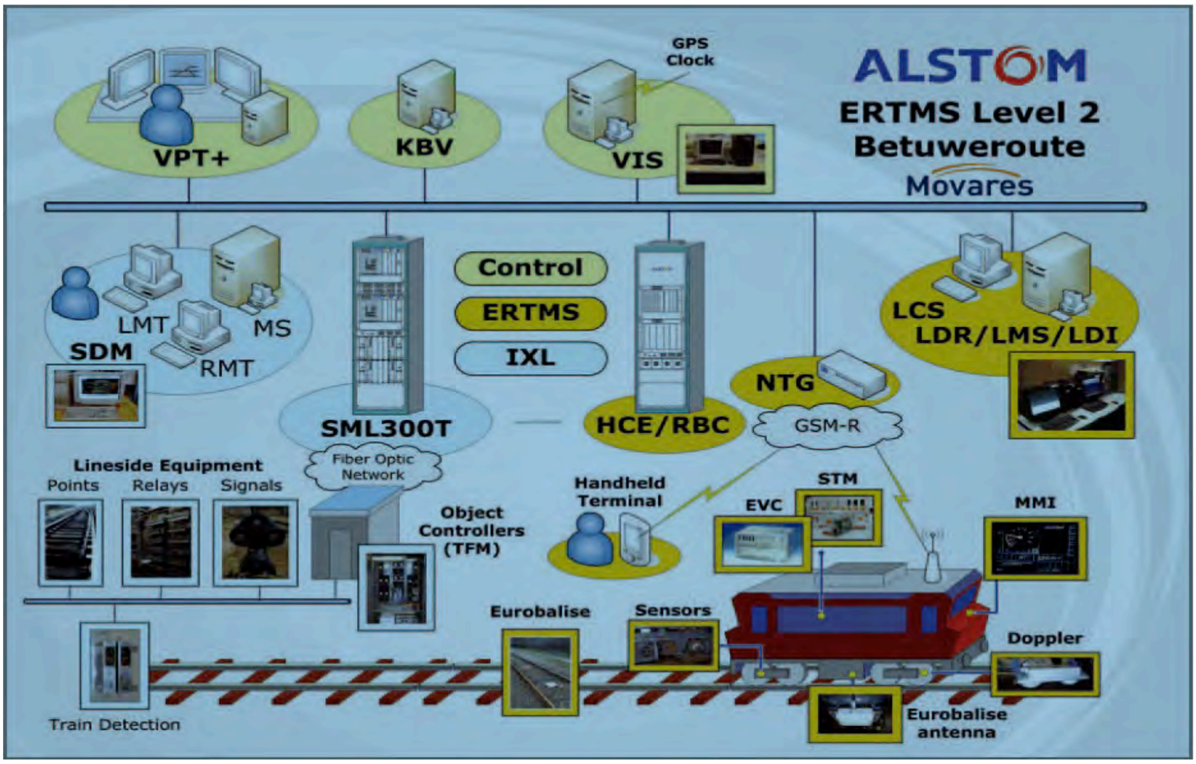
In most of the existing ERTMS implementations – outside the Netherlands - closed systems were involved with a fixed combination of trains, track and OBU. In case of the Betuweroute, the situation is much different. There is diversity of traffic on the line, a highly dynamic route supply and demand process with a flexible timetable and a number of ad hoc services. Finally, there are different ERTMS implementations and different suppliers of OBU.

Crucial for the choice in favour of Level 1 was that the operational processes on the Port Line could remain the same, whereas in case of Level 2 this was not the case. In the latter case, staff would have to adapt, which takes time and introduces the risk of operational mistakes and incidents.
Level 1 is an addition to the existing VPI [63] and automatic block systems. This means that it could be installed more rapidly, without a risky system migration, while testing is easier if ATBEG is still in place. A disadvantage of Level 1 is the large number of cables in the rail infrastructure and the use of infill balises for each signal in order to keep running times and headways the same – a train only receives new information when passing a balise. The large number of pipes and cables in the Port Area was also a reason not to install 1500 V DC, as DC may create stray currents, hence corrosion in pipelines [64].

[63] VPI = Alstom Vital Processor Interlocking.
[64] In practice, this influence depends on distance towards objects, while cathodic protection may neutralize this impact.

Level 1 SH has pros and cons (Klomp et al., 2008b). A design choice was to distinguish between running lines and sidings in order to reduce the safety hazard. Flank protection points separate lines from sidings. ERTMS monitored flank protection prevents that a train running in SH or SR modes can enter the path of a train running in FS mode (on the running line). A train remains in Level 1 mode and must be started in the same mode, making the situation more transparent to the train driver. But, the train driver cannot switch directly from SH to FS or OS. Such a transition demands a stop of the train, restart of ERTMS and re-entering of train data. As a consequence, passing a siding would halt a train. Later analysis showed this to be a rare case.
Changes between modes occur at the last/first signal of the running line (Klomp et al., 2008b). When entering a siding, mode changes automatically from FS or OS to SH mode.

Figure 76. Overview of systems to manage traffic on the A15-trajectory



Source: Van Zandvoort, 2010.

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Interviewed persons

Keyrail, Zwijndrecht

- Ir. Michael den Brok, Advisor QSE, June 19 & October 16, 2009.
- Mr. Michel van Dort, Advisor Development, DLS, October 16, 2009. June 21, September 24, 2010.
- Mr. Cees van Driel, Advisor, DLS, June 19, 2009.
- Ir. Patrick Koolen, Advisor, DLS, June 22, 2010.
- Ing. Guus de Mol, Manager, DLS, June 21, 2010.
- Drs. Bob van der Nat, Commercial Affairs, June 21, 2010.
- Mr. Marcel Rook, Asset manager, June 21, 2010.
- Ing. Koen Runge, Asset Leader / Contract Manager, June 29, 2010.
- Mr. Jerôme Schmidt, Unit manager Operations, June 28, 2010.
- Mr. Sjoerd Sjoerdsma, Managing director, June 28, 2010.

DB Schenker Rail Nederland N.V., Utrecht

Mr. Marc Kampinga, Manager Network Capacity, Utrecht, December 6, 2010.

The interviews were open discussions. Hence, no lists with interview questions are included.

Appendix 3: Railway terminology [65]

Access agreement
Any particular access contract, whether or not entered into pursuant to any directions of the Office of Rail Regulation under the Law, incorporating the Network Code.

Access right
In relation to an Access Agreement, permission to use track for the purpose of the operation of trains on that track by a beneficiary and rights ancillary thereto which are provided or charged for in the Access Agreement in question.

Allocation (of capacity)
The allocation of railway infrastructure capacity by an allocation body.

Applicable speed limit
When running in SR the applicable speed limit is the lowest speed limit of: timetable / Route Book, written order, or the maximum speed for SR.

Arrival date/time (estimated -)
Date (and time) of arrival of means of transport based on current forecast.

Arrival delay (actual -)
The time difference between the arrival date/time actual and the arrival date/time planned.

Arrival delay (expected -)
The time difference between the arrival date/time estimated and the arrival date/time planned.

Authorisation
The formal permission to use a product within specified application constraints.

Authorisation for train movement
An authorisation for train movement can be given by: a trackside signal at proceed aspect or, a Movement Authority or, a written order: to start in SR after awakening or, to pass an End Of Movement Authority or, to proceed after train trip.

Authorisation of placing in service
Formal acceptance of rolling stock by the safety authority of a Member State, on the basis of a technical file and, eventually, test runs on a specific infrastructure.

Authorising the movement of trains
The operation of equipment in signalling centres, electric traction current supply control rooms and traffic control centres that permits train movement. This does not include those staff employed by a Railway Undertaking who are responsible for management of resources such as train crew or rolling stock.

[65] Main source: ERA, 2009.

Automatic block signalling
A form of operation in which fixed block signals are controlled by an automatic block system.

Automatic route setting (ARS)
A system that provides the automatic setting of the proper route when a train approaches a signal.

Automatic train protection (ATP)
- A system that enforces obedience to signals and speed restrictions by speed supervision, including automatic stop at signals.
- A system that transmits information about movement authorities and speed limits from the line to the train to cause automatic braking if the train ignores the valid limits.

Automatische treinbeïnvloeding (ATBEG)
Dutch ATP system.

Axle counter
A track clear detection system consisting of counting points at both ends of a section and a counter connected to the counting points. The occupancy of a section is detected by comparing the number of axles which enter the section with the number of axles which leave the section.

Balise
A transponder that is used as a data point in an intermittent automatic train protection (ATP) system or as reference point for train location in radio-based train control.

Block marker (SMB)
A fixed sign that marks the limit of a block section in a cab signal territory.

Block system
A signalling system that provides a safe spacing of trains. Block systems may be divided into fixed block systems and moving block systems.

Blocking time
The time interval in which a section of track is exclusively allocated to a train and therefore blocked for other trains.

Braking system
System ensuring that the train's speed can be reduced or maintained in a slope, or that the train can be stopped within the maximum allowable braking distance. It ensures also the immobilisation of the train.

Buffer time
An extra time that is added to the minimum line headway to avoid the transmission of small delays.

Cab signalling
A signalling system that displays the movement authorities on the control panel in the locomotive cab.

Capacity of a line
The maximum number of trains that may be operated through a line.

Certification
Procedure by which a third party gives written assurance that a product conforms to specified requirements.

Check before departure
The first level of maintenance that includes the actions of checking and monitoring undertaken before the train departure (pre-departure) or en route.

Coded track circuit (like ATBEG)
A track circuit in which the track current is overlaid by a code that contains signal information.

Collective risk
The total risk to all affected parties arising from a particular hazardous event, measured in Equivalent Fatalities per year.

Collision of trains, including collisions with obstacles within the clearance gauge
A front to front, front to end or a side collision between a part of a train and a part of another train, as well as with:
i. shunting rolling stock,
ii. fixed or temporarily present objects on or near the track (except at level crossings if lost by crossing vehicle/user).

Color light signal
A light signal that displays the aspects by the color of lights.

Combined rail transport
Intermodal transport where the major part of the European journey is by rail by any initial and/or final leg carried out by road are short as possible.

Compliance test
Test used to show whether or not a characteristic or a property of an item complies with the stated specification.

Condition based maintenance
Preventive maintenance based on performance and/or parameter monitoring and the subsequent actions. Performance and parameter monitoring may be scheduled, on request or continuous.

Conflicting routes
Interlocked routes that must not be set up at the same time. Conflicting routes would lock each other by a plain or special locking.

Continuous automatic train protection
ATP system in which the train receives data at all times in order to control the protection system.

Corrective maintenance
Maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function.

Cross acceptance
The status achieved by a product that has been accepted by one Authority to the relevant European Standards and is acceptable to other Authorities without the necessity for further assessment.

Dangerous goods
Substances and articles the transport by rail of which is prohibited or authorized only on certain conditions by the Annex to Directive 96/49.

Delay
Means the time difference between the time the passenger was scheduled to arrive in accordance with the published timetable and the time of his or her actual or expected arrival.

Direct train
A train with related wagons which runs between two transhipment points (initial source — final destination) without intermediate marshalling.

Driver Machine Interface (DMI)
ETCS/GSM-R train borne device to enable communication between the onboard system and the driver.

EC verification
The procedure whereby a notified body checks and certifies, at the request of a contracting entity or its authorized representative established within the Community, that a subsystem:
- complies with the Directive 96/48;
- complies with the other regulations deriving from the Treaty and may be put into operation.

Electronic interlocking
An interlocking system in which the interlocking is achieved by software.

Emergency braking
Application of a predefined brake force in the shortest time in order to stop the train with a defined level of brake performance.

End Of Movement Authority (EOA)
Location where the target speed indicated on the DMI is zero or where the next ETCS marker board is reached when running in SR.

Engineering possession
A section of track which is closed to normal traffic and where the closure is for the purpose of carrying out maintenance which shall include any repair alteration, reconditioning, examination or testing of infrastructure.

ERTMS
European Rail Transport Management System.

ETA
Estimated Time of Arrival of wagons at the customer side.

ETCS
European Train Control System.

European Rail Agency
The European Railway Agency, the European Community agency for railway safety and interoperability.

Failure
A deviation from the specified performance of a system, product or other change. A failure is the consequence of a fault or error.

Failure analysis
Logical, systematic examination of a failed item to identify and analyse the failure mechanism, the failure cause and the consequences of failure.

Failure mode
The predicted or observed results of a failure cause on a stated item in relation to the operating conditions at the time of the failure.

Feeder service
Short sea shipping service which connects at least two ports in order for the freight (generally containers) to be consolidated or redistributed to or from a deep-sea service in one of these ports. By extension, this concept may be used for inland transport services.

Frog
The part of a turnout or a crossing where the rails have an intersection which allows the wheel flanges to cross the running rail.

GSM-R (Global system for mobile communications, subset Rail)
Communication system based on GSM mobile phone and using specific frequencies for railway.

Hot axle box
An axle box and bearing that has exceeded its maximum designed operating temperature.

Hot box detector
Device allowing to control, at the crossing of the trains running at their normal speed, the thermal state of the axle-bearings and to detect the ones for which the temperature is abnormally high, to transmit to a monitoring traffic control centre the elements allowing to appreciate the seriousness of the detected malfunction and to locate the incriminated axle-bearing, in order to make the train stop and to act, for certain installations, on the train stopping signalling.

Individual risk
The individual risk experienced by a person, is their probability of fatality per unit time, usually per year, as a result of a hazard in a specified system.

Infrastructure capacity
Potential to schedule train paths requested for an element of infrastructure for a certain period.

Infrastructure manager
Any body or undertaking responsible in particular for establishing and maintaining a railway infrastructure. This may also include the management of infrastructure control and safety systems.

Interlocking
An arrangement of turnouts and signals interconnected in a way that each movement follows the other in a proper and safe sequence.

Intermittent ATP
An ATP system in which the data is transmitted to the train at discrete points along the track.

International path
A combination of train slots which are contiguous with each other and involve crossing at least one national border.

Interoperability
The ability of the trans-European conventional rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance for these lines. This ability rests on all the regulatory, technical and operational conditions which must be met in order to satisfy the essential requirements.

IQ-C
International Group for improving the quality of rail freight traffic on the North-South corridor.

Keyrail
The infrastructure manager responsible for the Betuweroute.

KPI
Key Performance Indicator.

kV
kilo Volts (traction supply voltage).

Kijfhoek
The largest marshalling yard in the Netherlands and among the larger ones in Europe.

Level of maintenance
The level of Maintenance defines the complexity of activities (inspections, checks, tests, preventive and corrective operations, repairs, exchanges etc.) which are undertaken during the maintenance process. It may be divided in 5 levels:
The first level includes the actions of checking and monitoring undertaken before the departure (pre-departure) or en route.
The second level includes inspections, checks, tests, fast exchanges of replaceable units and preventative and corrective operations of limited duration between two scheduled

journeys.
The third level corresponds to the operations carried out mainly in specialised facilities of a maintenance centre. It includes interventions of preventative and corrective maintenance and scheduled exchanges of components. The vehicle is not in active service during this level of maintenance.
The fourth level comprises the major maintenance operations, generally called overhauls (of modular subsystems or of the complete vehicle).
The fifth level comprises the refurbishment, modifications, very heavy repairs, renewal or upgrading, except where they are the subject to authorisation under the interoperability directives (2001/16 and 96/48).

Life cycle
- Time interval that commences with the initiation of the concept and terminates with the disposal of the item.
- The activities occurring during a period of time that starts when a system is conceived and end when the system is no longer available for use, is decommissioned and is disposed.
[EN 50126:1999 - 3.41].

Line speed
Maximum speed for which a line or a section of a line has been designed.

Loading unit
Handling unit (carton, box, GLT, KLT, mixed pallet, etc) built by the consignor and which must not be split up during transport.

LZB (Linienzugbeeinflussung)
Continuous automatic train control system in Germany.

Movement Authority (MA)
Permission for a train to run to a specific location as a supervised movement.

Network
The entire railway infrastructure owned and/or managed by an infrastructure manager.

Network code
A common set of rules that apply to parties who have a contract (Track Access Agreement, in Dutch: "Toegangsovereenkomst") for rights of access to the track owned and operated by the respective rail infrastructure manager.

Network Statement (in Dutch: **"Netverklaring")**
Statement which sets out in detail the general rules, deadlines, procedures and criteria concerning the charging and capacity allocation schemes. It shall also contain such other information as is required to enable application for infrastructure capacity.

Notified bodies (NoBo)
The bodies which are responsible for assessing the conformity or suitability for use of the interoperability constituents or for appraising the EC procedure for verification of the subsystems (Directive 91/440/EC).

Onboard system
ETCS equipment carried on the train with the aim of supervising vehicle operation according to information received from infrastructure installations, the driver, trackside signalling systems and other, non ETCS onboard systems.

One Stop Shop (OSS)
An international partnership between rail Infrastructure Managers providing a single point of contact for rail customers for the purposes of:— ordering specified train paths in international freight traffic,— monitoring the entire train movement,— generally also invoicing track access charges on behalf of IM's.

Path
A definition of a train's route in terms of time and the locations (marker points) at which it will originate and terminate along with details of those locations en route at which it will either pass or call. The detail might also include any activities that the train will perform en route for example train crew, locomotive or other consist changes.

Path assembly
Joining up of individual train paths to extend path in terms of time and space.

Performance monitoring
The systematic observation and recording of the performance of the train service and the infrastructure for the purpose of bringing about improvements in the performance of both.

Points
The movable parts of a turnout that are operated to set up different routes.

Predetermined maintenance
Preventive maintenance carried out in accordance with established intervals of time or number of units of use but without previous condition investigation.

Predictive maintenance
Condition based maintenance carried out following a forecast derived from the analysis and evaluation of the significant parameters of the degradation of the item.

Preventive maintenance
The maintenance carried out at pre-determined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item.

Proceed aspect
Any signal aspect which permits the driver to pass the signal.

ProRail
The infrastructure manager responsible for the Dutch railway network, excluding the Betuweroute. It is also the owner of all the Dutch rail infrastructure, including the Betuweroute.

PZB (Punktförmige Zugbeeinflussung)
Intermittent automatic train control system in Germany.

Radio block center (RBC)
A control center to supervise and control train movements in a territory with radio-based train control.

Rail Control Centre (RCC)
The Rail Control Centre controls and monitors rail traffic within the concession and (if applicable) on the terminals. The RCC also controls and monitors all railway fixed equipment and other equipment linked to the operation of the system and to safety.

Rail inclination
An angle defining the inclination of the head of a rail when installed in the track relative to the plane of the rails (running surface), equal to the angle between the axis of symmetry of the rail (or of an equivalent symmetrical rail having the same rail head profile) and the perpendicular to the plane of the rails.

Railway infrastructure capacity
The potential to schedule train paths requested for an element of infrastructure for a certain period.

Railway traffic
Any movement of a railway vehicle on lines operated. (When a railway vehicle is being carried on another vehicle only the movement of the carrying vehicle (active mode) is considered).

Railway undertaking (RU)
Any public or private undertaking licensed according to applicable Community legislation, the principal business of which is to provide services for the transport of goods and/or passengers by rail with a requirement that the undertaking must ensure traction; this also includes undertakings which provide traction only.

RAMS
An acronym meaning a combination of Reliability, Availability, Maintainability and Safety.
Reliability: The ability to start and continue to operate under designated operating conditions for a designated period expressed mathematically.
Availability: The time in operation compared to the time out of service expressed mathematically.
Maintainability: The ability of a system to be put back into service after a failure expressed mathematically.
Safety: The probability of a hazardous event being initiated by the system expressed mathematically.

Regular path
Path reserved for which the use is effectively planned by the railway undertaking which booked it.

Release speed
A speed value to allow a train to approach the end of its Movement Authority. Needed for intermittent transmission to enable the train to approach a signal that has cleared in order to reach the balise point. Needed to approach a signal as a buffer stop which is a short distance behind EOA indicated on the DMI.

Restricted speed
A speed that allows to stop short of a vehicle or obstruction.

Revocation of MA
Withdrawal of a previously given permission to move a train.

RFI
Rete Ferroviaria Italia. The Italian rail infrastructure manager.

Risk analysis
A structured process which identifies both the likelihood and extent of adverse consequences arising from a given activity of facility.

Risk management
Systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating and controlling risk.

RNE
Rail Net Europe.

Route
The geographical way to be taken from a starting point to a point of destination.
Route cancellation
A manually initiated release of a locked route.

Route clearing point
A point that a train must have cleared completely until a locked route may be released.

Route locking
The locking of all turnouts as long a route is established.

Running line
A railway line which is not a siding and is ordinarily used for the passage of trains.

Running movement
An engine with or without cars displaying a rear end marker with with the authority to operate on main tracks in accordance to rules specified for train movements.

Safety regulatory authority
Often a national government body responsible for setting or agreeing the safety requirements for a railway and ensuring that the railway complies with the requirements.

Scheduled maintenance
Preventive maintenance carried out in accordance with an established time schedule or established number of units of use.

Scheduled time of departure
Date and time of departure for which the path is requested.

Service braking
Application of an adjustable brake force in order to control the speed of the train, including stop and temporary immobilisation.

Shunting
Operation of moving a rail vehicle or set of rail vehicles inside a railway station or other railway installations (depot, workshop, marshalling yard, etc.).

Signal aspect
The appearance of a lineside signal, as viewed from the direction of an approaching train, or the appearance of a cab signal.

Signal headway
The headway that results from the blocking times of two successive trains in one single block section.

Signal indication
The information that is given by a signal aspect.

Signal passed at danger without authority (SPAD)
A signal showing a stop aspect which is passed without the authority of the person responsible for authorising train movements.

Signalling system
Particular kind of system used on a railway to control and protect the operation of trains.

SPIN
SPoorINformatie systeem. ICT tool to support Chain Management.

Structure gauge
Given swept volume inside which no obstacle must be located or intrude. This volume is determined on the basis of a reference kinematic profile and takes into account the gauge of catenary and the gauge for lower parts.

System Requirement Specification (SRS)
Also known as baseline (ETCS).

Substation
Installation, the main function of which is to supply a contact line system, at which the voltage of primary supply system, and in certain cases the frequency, is converted to the voltage and frequency of the contact line.

Switch diamond
A diamond crossing with movable frogs.

Switches
A unit of track comprising two fixed rails (stock rails) and two movable rails (switch rails) used to direct vehicles from one track to another track.

Technical specification
Document that prescribes technical requirements to be fulfilled by a product, process or service.

Technical specification for interoperability (TSI)
The specifications by which each subsystem or part of a subsystem is covered in order to meet the essential requirements and ensure the interoperability of the trans-European

high-speed and conventional rail systems as defined in Directive 96/48/EC and Directive 2001/16/EC.

TAF
Telematic Application for Freight

Test
Technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure.

Tunnel Technische Installaties (TTI)
All equipment built in and around the tunnels of the Betuweroute and at remote locations (RCC, SMC, GMK) to monitor and guide traffic under regular and irregular conditions (including emergency situations) through these tunnels.

Track Access Agreement (or TAA)
A contract for rights of access to the track of the main rail network, including an option to have such rights of access.

Track circuit
A track clear detection device consisting of an electrical circuit of which the rails of a section form a part. The clearance of the section is detected by a detection device at one end of the section which receives a current from a source at the other end of the section.

Track clear detection
A device that detects the occupation and clearance of a track section.

Trackside signal
Fixed signal belonging to a defined track.

Train control
The method of authorizing train movements.

Train data
Data defining the characteristics of the train.

Transmission Balise Locomotive (TBL)
Belgian ATP system, successor of the older MeMor.

Trans European Network (for) Transport (TEN-T)
The transnational network for freight services consisting of major traffic corridors in Europe.

Transition point
Point where a transition (controlled change) between ETCS levels takes place.

Trip (ETCS)
Irrevocable application of the emergency brakes by the ETCS system until the train is at standstill.

TSI
Technical Specification for Interoperability

Unaccompanied (combined) transport
Transport of a road vehicle NOT accompanied by the driver or an Intermodal Transport Unit, using two or more transport modes.
UIC
Union Internationale Chemin de Fer

Validation
Confirmation by examination and provision of objective evidence, that the particular requirements for a specific intended use are fulfilled.

Voltage Change Over (VCO)
Section in the network where two different traction supply systems come together. Allows a train to go from one traction supply system to another without creating a short circuit. A VCO consists of a 'voltage sluice' with a typical length of at least a normal train.